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Analyses of topical policy issues

Does technological innovation bring better air quality?

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ABSTRACT

This paper analyses the interrelation between technological innovation (*TI*) and air quality (*AQ*) using the bootstrap rolling-window subsample Granger test for China. We find that *TI* has a twofold impact on *AQ*. On the one hand, *TI* brings better *AQ*. This result proves the technique effect, indicating that *TI* can improve *AQ* by directly reducing air pollutants emissions and facilitating clean energy use. On the other hand, *TI* can make *AQ* worse when *TI* mainly focuses on utilising fossil fuels to expand production, which proves the scale effect. In turn, *AQ* can also influence *TI*; the direction of the influence is dependent on the severity of air pollution and the government's response. This study provides important policy implications for coordinating innovation and environmental conservation to achieve sustainable development.

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1. Introduction

The objective of this paper is to examine the interrelationships between technological innovation (*TI*) and air quality (*AQ*) to see whether better *AQ* and sustainable development can be achieved through *TI*. Poor *AQ* threatens human health and has aroused significant public concern globally (Guo et al., 2019). Over 130 economies (including the EU, the U.S., Japan, South Korea, China, etc.) have set carbon neutralisation targets to reduce greenhouse gas emissions and achieve better *AQ* (Van Soest et al., 2021; Su et al., 2023a; Qin et al., 2023a; Zhang et al., 2023). The changes in *AQ* are deeply connected with *TI*. In history, *TI* drove the first industrial revolution and accelerated the consumption of fossil fuels (especially coal), which caused severe environmental incidents such as the London smog episode. Another example is the Los Angeles photochemical smog incident. *TI* has been conducive to the development of the automobile industry, but the massive automobile exhaust emission has also polluted the air in Los Angeles, threatening human health. Hence, *TI* may exacerbate air pollution in the industrial economy driven by fossil fuels. However, the structure of energy investment is changing with the continuous development of *TI* and the depletion of fossil fuels (IEA, 2022). In recent years, *TI* has made using clean energy instead of fossil fuels possible, contributing to better *AQ*. Besides, *TI* improves the efficiency of fossil fuel consumption, thereby reducing emissions of polluting gases. Since *TI* may be vital in enhancing *AQ* and promoting sustainable development, many countries have accelerated clean technology's research and development (R&D) to achieve carbon neutrality. Therefore, *TI* is a double-edged sword in history, whose impact on *AQ* is uncertain and related closely to

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economic growth, energy structure, and people's environmental protection awareness. Conversely, the deterioration of *AQ* has a mixed influence on *TI*. On the one hand, poor *AQ* hinders *TI*. Air pollution may negatively affect inventors' emotions and health, harming their cognitive ability and reducing the output of *TI* (Lin et al., 2021). Besides, air pollution increases firms' cost of pollution control, which crowds out R&D expenditure and impedes *TI* (Tan and Yan, 2021). On the other hand, poor *AQ* is conducive to *TI* by encouraging firms to adopt clean technology when confronted with stringent environmental regulations (Zhang et al., 2020a, 2022). Generally, *AQ* is an essential concern in global sustainable development (Qin et al., 2023b), deeply connected with *TI*. However, the relationship between *TI* and *AQ* differs in different periods, and there is no conclusive result on whether *TI* can bring better *AQ*. Hence, the dynamic correlation between *TI* and *AQ* is investigated to solve this issue. This research has important implications for policymakers coordinating *TI* development and environmental protection under the climate neutrality target.

China is implementing a national innovation-driven development strategy and is one of the world's leading players in terms of some key *TI* indices (Pu et al., 2023; Song et al., 2017; Zhang et al., 2020). The World Intellectual Property Organisation states that China has the world's most patent applications in 2021. *TI*'s improvement changes the industries gradually from labour-intensive to capital- and technology-intensive and is also considered a meaningful way to improve *AQ*. In particular, the carbon peaking and neutrality mean that the government needs to balance economic growth and reduce carbon emissions. As *TI* can curb carbon emissions, improve *AQ*, and promote economic growth, the Ministry of Science and Technology accelerates to formulate the *TI* plan in various fields. For example, it plans to develop key technology such as energy storage and smart grids in the energy field. Besides, it encourages the *TI* of new energy vehicles in transportation. Thus, we can infer that *TI* contributes to better *AQ*. However, not all *TI*s help to improve *AQ*. If the purpose of *TI* is only to expand the scale of production and improve efficiency, it may drive up fossil fuel consumption, thereby polluting the air. For example, in 2015, the number of authorised patents continued to soar under the government's efforts to encourage *TI*, while the indicators of *AQ* in 78.4% of the 338 large cities exceeded the standard[1] (Hansen et al., 2016). It is noteworthy that the country is in the stage of economic transformation. Although it encourages green *TI*, it is still the most significant energy producer and consumer worldwide, whose coal consumption represents more than 50% of its total energy consumption (Liu et al., 2020). This may change the relationship between *TI* and *AQ*. Thus, the discussion about China's *TI* and *AQ* has special significance.

The originality of this paper is as follows. To begin with, previous literature mainly examines the influence of green *TI* on climate (Dzator and Acheampong, 2020), while it neglects the influence of *TI* level on the whole region. As China is implementing a national innovation-driven development strategy, it is meaningful to investigate the impact of the national *TI* level on *AQ*, which will help to judge the effect of innovation-driven development strategies on sustainable development. Besides, most research investigates *TI*'s impact on carbon emission, neglecting the changes in overall air quality measured based on several air pollutants. This paper fills the gaps by examining the interrelationship between the *TI* level on the whole region and *AQ*. Moreover, previous research usually neglects structural breaks in parameters. We examine the dynamic interrelationship between *TI* and *AQ* through the bootstrap rolling-window sub-sample Granger test to solve this issue. This method has three steps as follows. First, we use the residual-based bootstrap (RB) modified-LR statistics to explore the full-sample interrelationship between variables in the Vector Autoregression (VAR) model. Second, we test whether structural changes exist at unknown moments. If structural breaks are proven to occur, the third step is conducting the rolling-window subsample causality test. We find that *TI* brings better *AQ*, demonstrating the technique effect that the emissions of air pollutants can be reduced by adopting *TI*. However, this view is not valid until early 2021, during which *TI* will lead to poorer *AQ* by driving up fossil fuel consumption. Understanding the correlation between *TI* and *AQ* provides a reference for policymakers coordinating stable growth and environmental protection.

The rest of this paper is organised as follows. Section 2 is the literature review. Section 3 analyses the interrelationship between *TI* and *AQ* theoretically. Sections 4 and 5 introduce the empirical methods and the data, respectively. Section 6 analyses the empirical results. The last section is the conclusion.

2. Literature review

The influence of *TI* on climate change is discussed extensively. Hashmi and Alam (2019) demonstrate that the increase in green patents reduces carbon emissions significantly for countries in OECD. Ganda (2019) also suggests that carbon emissions decrease as R&D expenditures rise. Besides, Zeqiraj et al. (2020) reveal that green *TI* affects carbon emissions negatively in European Union (EU) member countries in the long term. Likewise, Shahbaz et al. (2020a) show that *TI* expenditures cut the emissions of carbon dioxide (CO_2) in the UK. Su et al. (2020a) show that green *TI* can reduce the adverse effect of CO_2 growth in the U.S. In addition, Bilal et al. (2021) find that green *TI* is negatively connected with CO_2 emissions in some Asian countries. Gupta et al. (2022) reveal that *TI* and natural resources are conducive to better *AQ* by reducing fine particulate matter (PM2.5) in Bangladesh. Rahman and Alam (2022) demonstrate that *TI* positively affects *AQ* in 60 countries. Moreover, Sahoo and Sethi (2022) find that *TI* improves environmental quality in newly industrialised countries. Ahmad et al. (2023) reveal that *TI* is essential in facilitating sustainable development.

[1] The evaluation of AQ is based on the "Ambient Air Quality Standard" (GB3095-2012). The evaluation indicators are nitrogen dioxide (NO_2), sulphur dioxide (SO_2), fine particulate matter ($PM_{2.5}$), respirable particulate matter (PM_{10}), ozone (O_3), and carbon monoxide (CO). Meeting air quality standards means that the six pollutant concentrations in the evaluation have all met the standards.

Unlike most research that green *TI* improves *AQ*, Samargandi (2017) finds that *TI* has an insignificant impact on *AQ*. Amri et al. (2018) also prove that while *TI* has some impact on energy consumption, it is insignificant in reducing carbon emissions directly. Likewise, Khattak et al. (2020) point out that *TI* cannot reduce CO_2. Besides, Su et al. (2021) show that *TI* can increase CO_2 emissions and worsen *AQ*. In addition, Churchill et al. (2019) reveal that R&D reduced carbon emissions in most periods except 1955–1990. Dzator and Acheampong (2020) suggest that energy innovation decreases CO_2 emission at the lower quantile while it increases CO_2 at the higher quantile. Sinha et al. (2020) also show that *TI* exerts the opposite impact on air pollution at different quantiles. Su et al. (2023b) demonstrate that *TI* can positively and negatively affect CO_2. Furthermore, Erdoğan et al. (2020) find that the influences of innovations on *AQ* are different in various sectors of fourteen countries.

In turn, *AQ* also impacts *TI*, and the conclusion is mixed. Based on cross-country data, Wang and Wu (2021a) show that air pollution reduces the stock of technological inventors, which provides evidence that air pollution hinders *TI*. However, Su and Moaniba (2017) find that more CO_2 emissions from natural gases and petroleum lead to more climate-related innovations. Instead of investigating the direct impact of *AQ* on *TI*, some studies test the Porter hypothesis and point out that stringent environmental policies to control air pollution are conducive to *TI* (Porter, 1991). Johnstone et al. (2012) find that environmental policy positively impacts environmental innovation. Wang et al. (2019) also conclude that environmental policy improves green *TI* in OECD countries. Yang et al. (2020) point out environmental regulations advance R&D in Malaysian and Vietnamese firms. Furthermore, Cheng and Yu (2023) find that environmental regulations reduce air pollutant emissions, which promotes green *TI* but crowds out other *TI*s.

More recent studies intensively examine TI's impact on AQ in China and draw conflicting conclusions. Shahbaz et al. (2020b) point out that *TI* helps to cut CO_2. Yi et al. (2020) prove that *TI* helps to combat air pollution in the long run. Likewise, using firm-level data, Chen et al. (2022) find that *TI* reduces the discharge of air pollutants. In addition, Hu et al. (2021) propose that the *TI* of new energy vehicles brings better *AQ*, which is more significant in areas with higher vehicle and vessel taxes. Moreover, Ma et al. (2022) point out that Green *TI* inhibits the emission of air pollutants in certain regions. Liu et al. (2023) conclude that *TI* alleviates haze pollution. In contrast with the view that *TI* brings better *AQ*, Jia et al. (2018) demonstrate that while technological change contributes to electricity saving, it cannot reduce air pollutants emissions. Besides, Dong et al. (2022) prove an inverted U-shaped relationship between *TI* and *AQ* in the transportation industry. In addition, Yu and Du (2019) find that the influence of innovation on *AQ* is related to economic growth. Innovation increases carbon emissions when the economic growth rate is low and reduces carbon emissions when the growth rate is high. Wang et al. (2019) prove that *TI* in heavy and light industries can increase CO_2 emissions. Wang and Zhu (2020) point out that although *TI* in renewable energy technology innovation reduces CO_2 emission, the *TI* in fossil energy cannot facilitate CO_2 abatement. Zhu et al. (2020) reveal further that renewable energy *TI* helps alleviate the emission of nitrogen dioxide (NO_2) and respirable particulate matter (PM_{10}), while it has no significant impact on sulphur dioxide (SO_2). Zhang et al. (2020b) find that when energy consumption is relatively high, the facilitating effect of *TI* on *AQ* will turn into an impeding effect. Wang et al. (2022) reveal that the *TI* influences ozone (O_3) pollution in different provinces of China.

Conversely, some studies prove that poor *AQ* impedes *TI* by crowding out the funds for innovation (Liu et al., 2021; Tan and Yan, 2021) or by driving skilled workers to move out of the polluted area (Zhang and Chung, 2020; Ai et al., 2022). Wang and Yu (2021) also reveal that environmental externalities depress green *TI*. Zhu and Lee (2021) conclude that fine particulate matter (PM2.5) pollution inhibits regional innovation. Likewise, Liu et al. (2021) estimate that a 1% increase in $PM_{2.5}$ will lead to a 0.293% decline in new parents, suggesting that poor *AQ* threatens *TI*. However, Wang et al. (2020) find that increasing carbon emissions facilitate environmental-related *TI*. Zhao et al. (2021) also reveal that haze pollution raises people's environmental protection awareness, encouraging the government to invest more in technology and improve *TI*. Besides, Sun et al. (2022a) suggest that green *TI* can be facilitated by air pollution collaborative governance. In addition, Sun et al. (2022b) point out that *TI* improved after China began to monitor and disclose the real-time *AQ* when confronted with air pollution. Moreover, some literature investigates the impact of environmental regulation on *TI*, concluding that environmental regulations promote green *TI* (Zhang et al., 2020a; Cai et al., 2020; Mbanyele and Wang, 2022) or have a U-shaped relationship with green *TI* (Pan et al., 2021).

Most existing researchers investigate the impact of green innovation (such as renewable energy *TI*) on certain air pollutants' emissions (e.g., CO_2, PM2.5) (Su et al., 2023a,b), but they ignore the influence of the national *TI* level on overall *AQ*. Hence, no conclusive answer exists as to whether *TI* promotes better *AQ*. In addition, although many studies (e.g., Yang et al., 2020; Mbanyele and Wang, 2022) show that environmental regulation promotes *TI*, they fail to discuss the two-way relationship between national *TI* and *AQ*. Furthermore, related research rarely investigates the structural breaks in the sequences. This paper uses the bootstrap subsample rolling-window causality test (Balcilar et al., 2010; Su et al., 2022a; Qin et al., 2023c) to explore the dynamic impact of *TI* on *AQ*, which provides policy implications to achieve sustainable development.

3. *TI* and *AQ* interaction mechanism

The role of *TI* in improving *AQ* remains unsettled in the existing literature. *TI* can improve *AQ* through the technique effect (Rahman and Alam, 2022). First, *TI* helps to utilise clean energy, such as wind and hydroelectric power, which replaces fossil fuels (Shahbaz et al., 2020a,b; Dzator and Acheampong, 2020). Hence, by changing the energy structure, *TI*

can reduce carbon emissions and improve *AQ*. Second, green *TI*, such as carbon recycling technology, can reduce pollution control costs and help combat air pollution directly, contributing to clean air (Zhang et al., 2020b; Ma et al., 2022). Third, *TI* can not only improve the efficiency of production efficiency but also increase the utilisation efficiency of fossil fuels. As the factor input per output unit is reduced, carbon emissions in the production process will decrease (Churchill et al., 2019).

Contrarily, *TI* can also harm *AQ* through the scale effect (Churchill et al., 2019). To begin with, despite *TI*'s potential to improve efficiency and expand production, the increasing output may raise the consumption of fossil energy, which results in severe air pollution Grossman and Krueger, 1991; Freire-González, 2011; Dzator and Acheampong, 2020; Zhang et al., 2020). In addition, according to the Jevons paradox,[2] *TI* that intends to save resources may lead to more consumption of resources. As *TI* uses coal economically, firms are more willing to consume coal than save it, thereby worsening *AQ* (Gunderson and Yun, 2017).

Therefore, the impact of *AQ* on *TI* is inconclusive, and *TI* can influence *AQ* through technique effect and scale effect. Hence, two hypotheses are proposed as follows:

H1a. *TI* contributes to the improvement of *AQ*, which means the technique effect exists.

H1b. *TI* leads to the deterioration of *AQ*, which implies a scale effect exists.

Conversely, *AQ* has a mixed impact on *TI*. Existing literature shows that air pollution can impede *TI* in several ways. First, poor *AQ* impedes *TI* by crowding out the funds for innovation (Lin et al., 2021). Severe air pollution usually prompts policymakers to formulate strict environmental regulations, which increases firms' costs (Lai and Wong, 2012; Gong et al., 2021) and crowd out the essential funds for *TI*. As innovative activities usually require substantial investment in R&D (Krastanova, 2014), *TI* is inhibited by air pollution. Second, worsening *AQ* hinders *TI* by affecting the health or emotion of inventors (Zhang and Chung, 2020; Wang et al., 2021b; Ai et al., 2022). Air pollution will cause pessimism and anxiety and influence cognitive ability, negatively impacting TI's efficiency (Tan and Yan, 2021). Besides, severe air pollution will drive talented inventors to migrate to other regions with better *AQ*, decreasing *TI* in the polluted area (Lin et al., 2021). Furthermore, worsening *AQ* can reduce people's outside activities, which may impede the diffusion of knowledge, resulting in a decrease in *TI* (Ai et al., 2022). However, the hindrance of poor AQ on *TI* does not always hold. Air pollution will raise environmental protection awareness, prompting the government to allocate more resources to green *TI* (Zhao et al., 2021). Besides, confronted with severe air pollution, the government tends to issue environmental regulations to seek a balance between environmental protection and economic development, which will benefit green *TI* (Mbanyele and Wang, 2022). Hence, the effect of *AQ* on *TI* is complex, and air pollution is not necessarily hinder *TI*.

Based on the above analysis of *AQ*'s influence on *TI*, two hypotheses are proposed as follows:

H2a. Deteriorating *AQ* has a positive impact on *TI*.

H2b. Deteriorating *AQ* has a negative impact on *TI*.

Testing these hypotheses can provide a more comprehensive understanding of the correlation between *TI* and *AQ*.

4. Methodology

4.1. Bootstrap full-sample causality test

The full-sample causality test is based on the VAR model, which is shown in Eq. (1):

$$\mathbf{y}_t = \Gamma_0 + \Gamma_1 \mathbf{y}_{t-1} + \cdots + \Gamma_p \mathbf{y}_{t-p} + \boldsymbol{\varepsilon}_t, t = 1, 2 \ldots, \quad T. \tag{1}$$

$\mathbf{y}_t$ denotes a column vector of variables, Γ_0,... Γ_p are matrixes of coefficients. The number of samples is represented by T. $\boldsymbol{\varepsilon}_t$ represents the white-noise vector, and p stands for the lag length.

As mentioned in the theoretical analysis, the relationship between *TI* and *AQ* is affected by economic growth (Grossman and Krueger, 1991; Shahbaz et al., 2020a). In practice, the growth rate of industrial added value (*IAV*) is a good proxy variable of economic growth in China because the industry is the main sector that promotes China's economic development. Hence, we choose *IAV* as a control variable. Besides, the impact of *TI* on *AQ* is related to the energy structure. When a country mainly relies on fossil energy rather than clean energy to achieve economic growth, the progress of *TI* may lead to worse *AQ*. Only when *TI* facilitates substituting clean energy for fossil fuels can *TI* bring better *AQ* (Acheampong et al., 2022). Hence, we choose the proportion of clean energy investment in total energy investment to reflect the

[2] Jevons paradox states that the more efficiently we use a resource, the more we will use it, rather than "saving" it. This suggests that energy-efficient technologies increase carbon emissions.

changing trend of energy structure (*ES*) and take *ES* as a control variable (Shahbaz et al., 2020b). Therefore, Eq. (2) is shown as follows:

$$\begin{bmatrix} TI_t \\ AQ_t \end{bmatrix} = \begin{bmatrix} \varphi_{10} \\ \varphi_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11}^{(1)} & \varphi_{12}^{(1)} & \varphi_{13}^{(1)} & \varphi_{14}^{(1)} \\ \varphi_{21}^{(1)} & \varphi_{22}^{(1)} & \varphi_{23}^{(1)} & \varphi_{24}^{(1)} \end{bmatrix} \begin{bmatrix} TI_{t-1} \\ AQ_{t-1} \\ IAV_{t-1} \\ ES_{t-1} \end{bmatrix} + \cdots + \begin{bmatrix} \varphi_{11}^{(2)} & \varphi_{12}^{(2)} & \varphi_{13}^{(2)} & \varphi_{14}^{(1)} \\ \varphi_{21}^{(2)} & \varphi_{22}^{(2)} & \varphi_{23}^{(2)} & \varphi_{24}^{(1)} \end{bmatrix} \begin{bmatrix} TI_{t-2} \\ AQ_{t-2} \\ IAV_{t-2} \\ ES_{t-2} \end{bmatrix}$$
$$+ \cdots + \begin{bmatrix} \varphi_{11}^{(p)} & \varphi_{12}^{(p)} & \varphi_{13}^{(p)} & \varphi_{14}^{(p)} \\ \varphi_{21}^{(p)} & \varphi_{22}^{(p)} & \varphi_{23}^{(p)} & \varphi_{24}^{(p)} \end{bmatrix} \begin{bmatrix} TI_{t-p} \\ AQ_{t-p} \\ IAV_{t-p} \\ ES_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}. \tag{2}$$

Eq. (2) shows that when $\varphi_{21}^{(q)} = 0$, ($q = 1, 2, \ldots, p$), *TI* is not a Granger cause of *AQ*. We can also check whether *AQ* is a Granger cause of *TI* by testing the hypothesis $\varphi_{12}^{(q)} = 0$. As residual-based bootstrap (*RB*) corrected Likelihood Ratio (*LR*)-statistics can better ensure the robustness of the Granger test (Shukur and Mantalos, 2000; Qin et al., 2023c), this paper applies such statistics to investigate the causality.

4.2. Parameter stability test

It is assumed in the full-sample causality test that parameters are unchanged over time so that we can get only one causality in all periods (Su et al., 2020b). However, the relationship between dependent and independent variables may undergo structural changes, which may be brought about by demand or supply shocks in the economy, or is the result of institutional shifts. In this situation, it is highly possible that the parameters are inconstant, leading to unreliable results (Balcilar and Ozdemir, 2013). Hence, this paper tests the stability of parameters using the *Sup-F*, *Mean-F*, *Exp-F* (Andrews, 1993; Andrews and Ploberger, 1994), and the *Lc* test (Nyblom, 1989; Hansen, 1992) to check the existence of structural changes.

4.3. Subsample causality test

Previous studies usually divide the samples or use dummy variables based on subjective experience to solve the problem of structural breaks, which still leads to some biases. The bootstrap sub-sample rolling-window Granger causality test used in this paper can avoid subjective biases. Suppose there are *T* observations in the full-sample, and the subsample length is W; then T−W+1 subsamples can be obtained as follows: h−W+1, h−W+2, …, h, where h = W, W + 1, … T. When deciding the size of subsamples, W, no uniform standard exists (Balcilar et al., 2010). The influence of potential heteroscedasticity can be reduced in small samples, but a larger estimated variance will lead to ineffective results. In large subsamples, the efficiency of the estimation is improved, but the heteroscedasticity may result in an unreliable result. It is usually believed that bias-minimising window size should not be less than 20 observations (Pesaran and Timmermann, 2005).

5. Data

The data span is from January 2013 to July 2022. The monthly data of *AQ* was first released in January 2013. At the beginning of 2013, China's air pollution becomes very serious. More than 30 provinces across the country suffered four times smog in January, and there were only five days without smog in Beijing. This prompts the Chinese government to adopt several measures to combat pollution. At the same time, the government began to release cities' Air Quality Index (AQI), a comprehensive indicator based on NO_2, SO_2, PM_{10}, $PM_{2.5}$, O_3, and CO. The larger value of AQI indicates worse *AQ* (Guo et al., 2019). This paper uses the data of the national monthly average AQI to show *AQ*, which is drawn from the CEIC database. The national monthly average of the AQI can be obtained by averaging the AQI of China's 32 provincial capitals. Besides, China has adopted a national innovation-driven development strategy in recent years. *TI* is viewed as a primary driver of productivity and a key method to achieve carbon neutralisation. *TI* is measured by the number of granted patents (Aghion et al., 2019) drawn from the CEIC database. With the granted patents increasing dramatically (Fang et al., 2018), the national AQI decreases yearly. Hence, *TI* might be a push for better *AQ*.

In addition, the relationship between *TI* and *AQ* is connected to economic growth (Grossman and Krueger, 1991; Shahbaz et al., 2020a). We take the growth rate of *IAV* as the control variable (Wang et al., 2019; Li and Yuan, 2021), which is drawn from the CEIC Data.[3] Furthermore, the impact of *TI* on *AQ* is affected by *ES*. In an economy that relies on fossil fuels, the progress of *TI* may raise the consumption of fossil fuels and lead to worse *AQ*. However, when the purpose of *TI* is to utilise clean energy and reduce traditional energy consumption, *AQ* will get better (Acheampong et al., 2022; Su et al., 2022b). Therefore, the trends of *ES* are represented by the ratio of clean energy investment to toral energy

[3] https://www.ceicdata.com

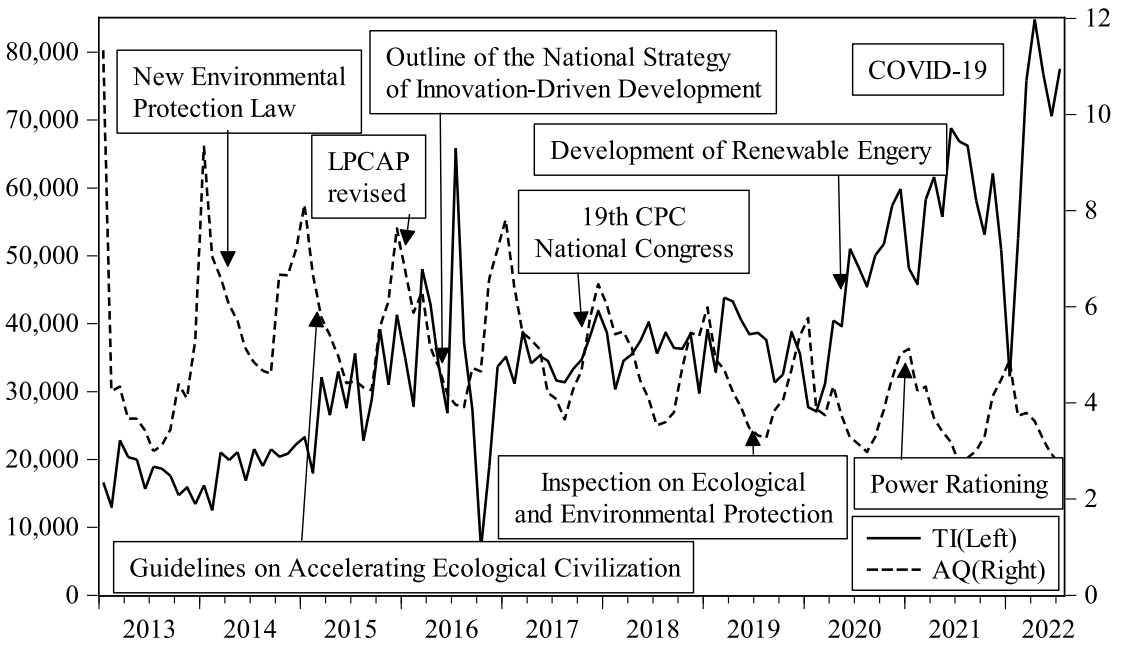

Fig. 1. The trends of *TI* and *AQ*. Notes: LPCAP: Law on the Prevention and Control of Atmospheric Pollution; CPC: Communist Party of China.

investment, which is calculated using CEIC Data. The increase in *ES* indicates more consumption of clean energy in the future.

The trends of *TI* and *AQ* are shown in Fig. 1. It can be observed that *TI* has an overall rising trend despite fluctuation, and it reaches to peak in April 2022. Besides, changes in *AQ* present seasonal characteristics. As *AQ* is affected by climate and residential heating factors, it is usually worse in winter than in summer. Regarding the overall annual trend, *AQ* values are declining, indicating that the overall *AQ* is gradually improving. In addition, a high *TI* coincides with a decrease in *AQ* in most periods. For example, after approving the new Environmental Protection Law in April 2014, *AQ* values dropped, and *TI* increased. Likewise, in May 2016, *TI* skyrocketed because the government encouraged innovation. The figure shows that *AQ* decreases in the corresponding period. The same situation can be observed in the first half of 2020. In April 2020, the government began formulating the 14th Five-Year Plan (2021–2025) to develop renewable energy, which benefits *TI* and *AQ*. During this period, there is an increase in *TI* and a decrease in *AQ*. Therefore, we can infer that *TI* can bring better *AQ*. However, the trends of *TI* and *AQ* are not always the same. From the end of 2020 to the beginning of 2021, *TI* continues to soar as China's economy recovers fast from the COVID-19 epidemic, but *AQ* also rises during this period, showing that *TI* may cause air pollution. Moreover, China's economic growth will affect the relationship between *TI* and *AQ*. When the economy is underdeveloped, the main purpose of *TI* is to expand production, which may cause air pollution. With the further growth of the economy, public awareness for environmental protection increases, which requires green *TI* to achieve sustainable development (Shahbaz et al., 2020a,b). The correlation between *TI* and *AQ* is also related to energy structure (Shahbaz et al., 2020b). The *AQ* may worsen when the *TI* concentrates on utilising fossil fuels. To sum up, the relationship between *TI* and *AQ* is dynamic and is connected with *IAV* and *ES*.

Table 1 presents the descriptive statistics. The means of *TI* indicates that there are 36573.77 granted patents on average each month. The average value of *AQ* suggests that the national average AQI is 4.778. The average monthly growth rate of *LAV* is 0.655%. On average, clean energy investment accounts for 73.465% of total energy investment, showing investors are more optimistic about developing clean energy. Besides, *TI*, *AQ*, and *IAV* show the right-skewed distribution, while *ES* indicates a left-skewed distribution. Furthermore, as the *p*-values of the Jarque–Bera test are less than 1% for all variables, we can infer that they follow the nonnormal distribution, and the estimation is inexact when using the full sample Granger test. A natural logarithm is applied in the subsequent analysis to avoid heteroskedasticity.

6. Empirical results

To begin with, this study performs unit root tests to ensure the stability of the sequences. Results in Table 2 indicate that *IAV* and *ES* are stationary in their levels. *TI* and *AQ* are stationary when taking the first-order differences.

Table 3 presents the full-sample causality results, and the optimal lag length in Eq. (2) is 4. The results show that *TI* and *AQ* influence each other. We perform the parameter stability test because the results are inaccurate when there are structural breaks. Table 4 reports the results. *Sup-F* indicates a shift in the *TI* and *AQ* equation. Besides, the *Mean-F* and

Table 1
Descriptive statistics of variables.

Statistics	*TI*	*AQ*	*IAV*	*ES*
Mean	36573.77	4.778	0.655	73.465
Median	34895	4.458	0.52	72.815
Maximum	84828	11.339	36.56	96.277
Minimum	6878	2.745	−22.1	5.556
Std. Dev.	15927.63	1.430	4.019	11.794
Skewness	0.786	1.390	4.676	−1.733
Kurtosis	3.366	6.234	65.471	11.276
Jarque–Bera	12.494***	87.148***	19118.84***	3385.803***

Notes: The unit of IAV and ES is %. *** denotes significance at the 1% level.

Table 2
Unit root tests.

Series	ADF	PP	KPSS
TI	−1.075 (3)	1.225[9]	1.199[8] ***
△TI	−11.170 (2) ***	−27.623[9] ***	0.055[9]
AQ	−0.221 (2)	−1.455[0]	0.866[7] ***
△AQ	−4.041(8) ***	−11.098[5] ***	0.043[2]
IAV	−11.196(1) ***	−21.422[15] ***	0.107[2]
ES	−2.916(2) **	−7.861[7] ***	0.145[8]

Notes: Numbers in the brackets refers to the bandwidth, which uses the Bartlett Kernel as suggested by the Newey–West test (1987).
Number in parentheses is the lag order, which is selected based on the SIC.
The null hypothesis for KPSS is that the time series is stationary.
***, **and *denote significance at the 1%, 5% and 10% levels, respectively.

Table 3
Results of full-sample Granger causality tests.

	H0: *TI* is not a Granger cause of *AQ*		H0: *AQ* is not a Granger cause of *TI*	
Tests	Statistics	*p*-values	Statistics	*p*-values
Bootstrap *LR* test	18.974	0.000	9.704	0.025

Notes: The null hypothesis is that no causality exists between variables. *p*-values are calculated using 10,000 bootstrap repetitions.

Table 4
Results of parameter stability test.

	TI equation		*AQ* equation		VAR (4) system	
	Statistics	Bootstrap *p*-value	Statistics	Bootstrap *p*-value	Statistics	Bootstrap *p*-value
Sup-F	67.383***	0.000	36.134***	0.001	32.652	0.220
Mean-F	22.016***	0.000	14.946**	0.033	20.434	0.250
Exp-F	29.310***	0.000	13.734***	0.002	13.097	0.210
Lc					3.910	0.088*

Exp-F imply that the *TI* and *TF* equation might evolve gradually over time. In addition, *Lc* shows that parameters fail to obey the random walk process. Hence, we can conclude that the structural mutations exist and the full sample Granger test results are biased. Then, we apply the bootstrap rolling-window sub-sample causality test to improve the estimation accuracy. This paper chooses 24 months as the size of the subsamples to ensure reliability.

Fig. 2 reports the influence of *TI* on *AQ* in different sub-samples. Fig. 3 shows the sum of the rolling-window coefficients for the influence of *TI* on *AQ*. It can be observed that *TI* influences *AQ* negatively in 2017:M12–2018:M9, 2019:M6–2019:M9, 2020:M4–2020:M5, and 2020:M7–2020:M8, suggesting that during these periods, China's *TI* can bring better *AQ*.

The results that *TI* promotes better *AQ* verify Hypothesis H1a proving the existence of the technique effect. In recent years, the Chinese government has implemented many programmatic policies that facilitate *TI* and environmental protection (Ma et al., 2022). In May 2016, the release of the National Strategy of Innovation-Driven Development Outline facilitated *TI*'s rapid growth. The strategic position of *TI* was further highlighted in October 2017 when President Xi Jinping proposed that *TI* should be geared toward economic development and people's health. Driven by the above policies, the number of *TI* patents proliferates, and a considerable number of *TI*s aim to reduce fossil energy consumption and cut carbon emissions (Ma et al., 2022). Hence, *TI* brings better *AQ* in 2017:M12–2018:M9.

Besides, after the above policies are formulated, the government also promotes implementing the policy. In June 2019, the government issued the Regulations on the Inspection of Ecological and Environmental Protection, and it

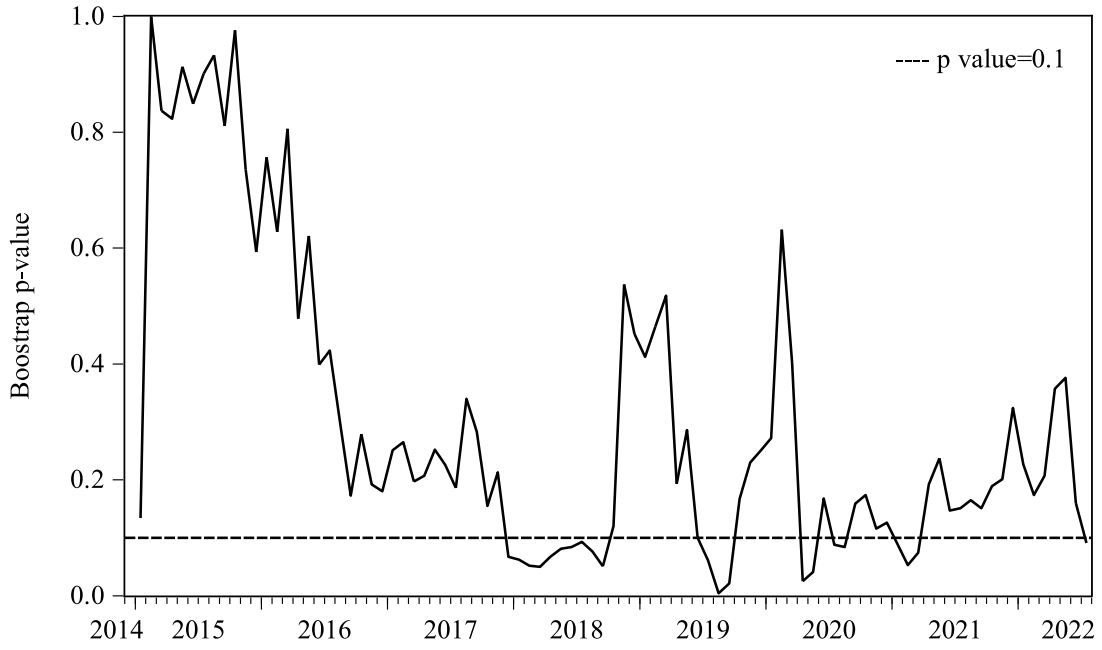

Fig. 2. Results of whether *TI* is a Granger cause of *AQ*.

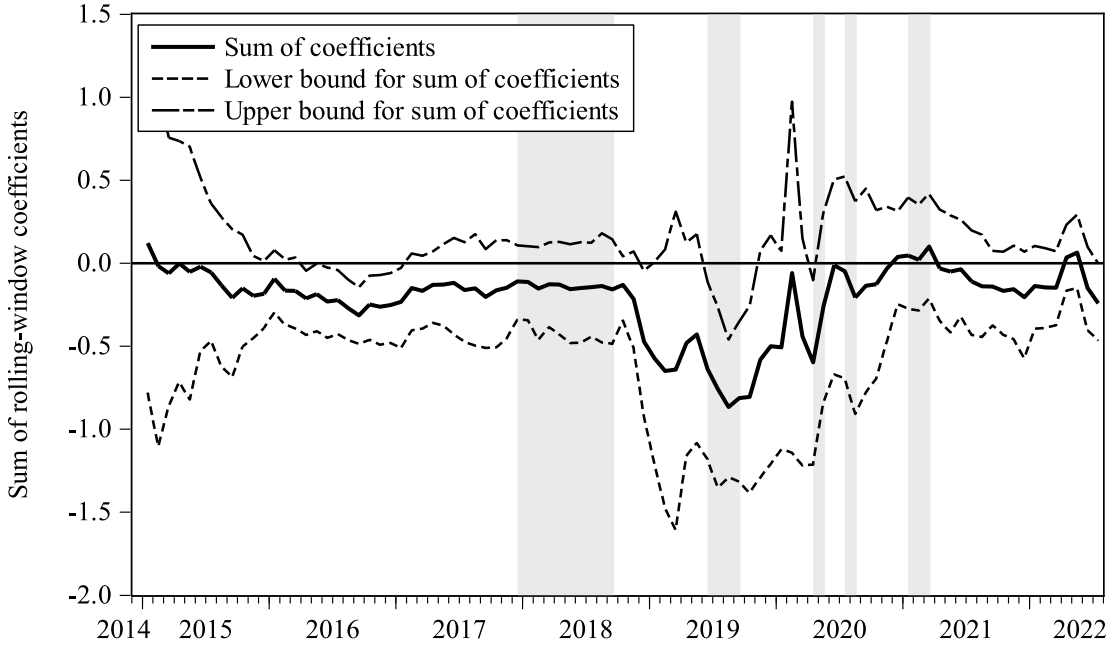

Fig. 3. Coefficients of *TI*'s impact on *AQ*.

launched the second round of inspection in the next month. The assessment aims to ensure that all the firms reduce the emission of pollutants when they produce. Affected by the strict environmental policies, firms pay more attention to reducing pollutant emissions through green *TI* (Ouyang et al., 2020; Yi et al., 2020). Hence, *TI* improves *AQ* during 2019:M6–2019:M9.

Moreover, China has also emphasised the role of *TI* in developing renewable energy. For example, the National Energy Administration began formulating the 14th Five-Year Plan (2021–2025) for renewable energy development in April 2020, proposing increasing renewable energy capacity through *TI* and solving several key technical problems. This leads to the rapid development of renewable energy *TI*, improving the energy structure and cutting carbon emissions (Dzator and

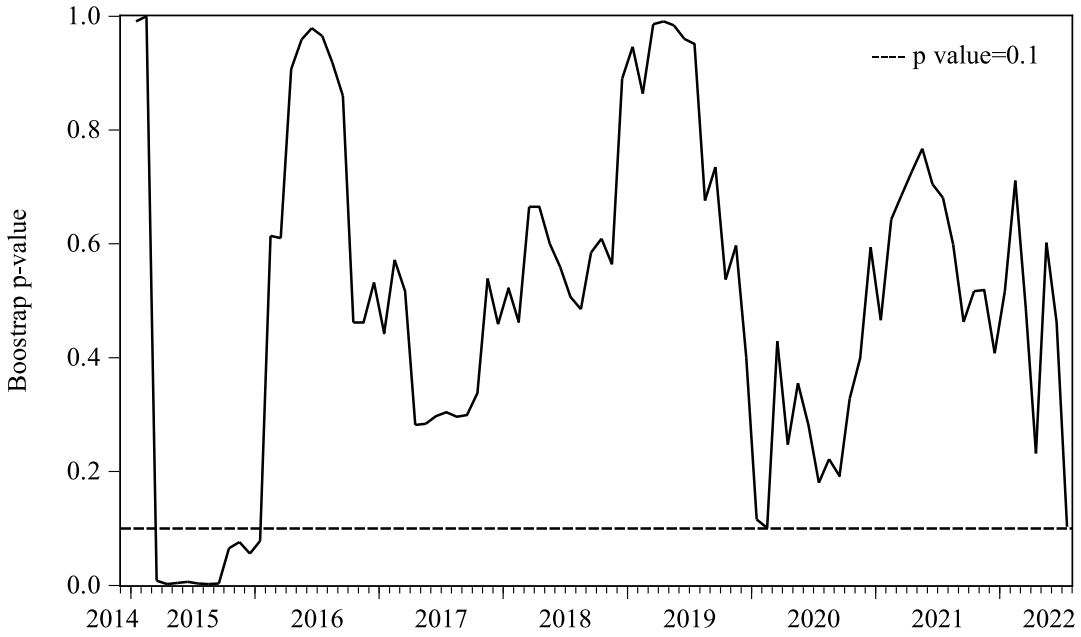

Fig. 4. Results of whether *AQ* is a Granger cause of *TI*.

Acheampong, 2020; Wang and Zhu, 2020; Qin et al., 2022). Hence, *TI* may alleviate air pollutants by upgrading the energy structure in 2020.

However, *TI* makes *AQ* worse during 2021 M1–2021:M3. The reasons are as follows. In early 2021, the high-energy-consuming industry in China obtained several overseas orders, leading to an increase in energy demand. As thermal power takes up more than half of China's energy consumption, the rising demand for thermal power increases the cost of thermal power, leading several provinces (e.g., Hunan, Jiangxi) to ration electricity for industrial use. As a result, firms mainly focus on utilising traditional energy and expanding production efficiently by *TI*, resulting in air pollution. In addition, the equipment for renewable energy power generation cannot normally work due to the low temperature in winter (Zhang, 2020). Hence, *TI* contributes mainly to expanding production using fossil fuels, polluting the air. Therefore, *TI* increases *AQ* during 2021:M1–2021:M3. This finding verifies Hypothesis H1b, proving the scale effect that TI can lead to air pollution by increasing fossil energy demand.

Figs. 4 and 5 depicts the influence of *AQ* on *TI*. We can find that *AQ* positively influences *TI* in 2015:M3–2015:M11, which means more air pollution promotes *TI* in China. Confronted with severe air pollution in 2014 and 2015, the public began to realise the importance of environmental protection, prompting the government to allocate more resources to green *TI* (Zhao et al., 2021). Besides, environmental pollution promoted the government to formulate more than 40 reform plans regarding ecological development after the 18th National Congress of the Communist Party of China. In March 2015, the government introduced the Guidelines on Accelerating Ecological Civilisation to maintain all types of natural ecosystems' security and stability, facilitating green *TI*. This conclusion verifies Hypothesis H2a, showing that poor *AQ* facilitates *TI* by promoting the introduction of more favourable environmental policies.

However, the influence becomes negative during 2015:M12–2016:M1, indicating that air pollution hinders *TI*, which verifies Hypothesis H2b. Severe smog has begun to arouse great public attention since 2015. According to China Environmental Bulletin (2015), large-scale and continuous smog appears 11 times in the country, which is especially serious in winter. On December 8, 2015, the Headquarter of Beijing Municipal Air Pollution Emergency initiated the red warning of air pollution for the first time, which is the highest level of warning. It is suggested that primary and secondary schools and kindergartens should suspend classes, enterprises, and institutions that require employees to work at home, and some polluting industrial firms should stop or limit their production. Severe air pollution not only threatens inventors' health and good emotions (Zhang and Chung, 2020) but also reduces the outside activities of inventors, which may impede the diffusion of knowledge, resulting in a decrease in *TI* (Ai et al., 2022). Besides, severe air pollution hinders *TI* by draining the funds for innovation because it requires firms to spend more money on complying with environmental regulations (Lin et al., 2021). On January 1, 2016, the revised Law on the Prevention and Control of Atmospheric Pollution came into force. Compared with the old version, the newly revised law increases the penalties for illegal acts that cause air pollution and the types of punishment. This prompts firms to use eco-friendly equipment, pay taxes, or buy pollution discharge permits to avoid penalties, thereby increasing production costs. As firms have tighter financial constraints, they invest less in R&D, causing *TI* to decrease. Hence, air pollution hinders *TI* by crowding out the essential funds for *TI*.

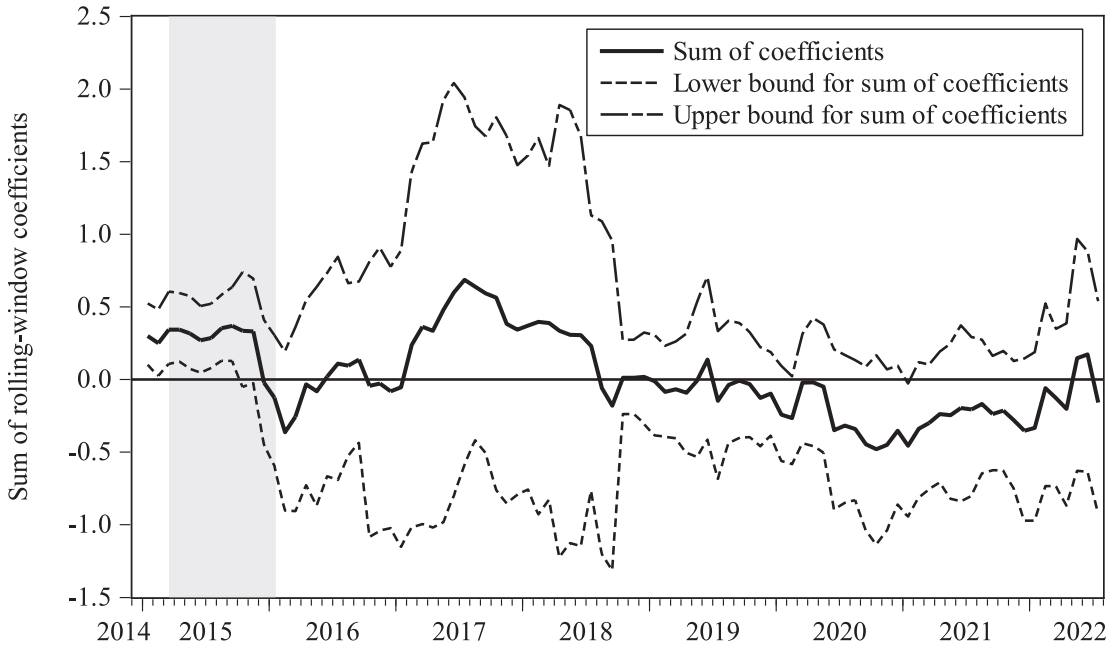

Fig. 5. Coefficients of *AQ*'s impact on *TI*.

To summarise, this paper applies the bootstrap sub-sample rolling-window Granger causality test to discuss the dynamic causal interrelationship between *TI* and *AQ*. We find that the *TI* can bring better *AQ* 2017:M12–2018:M9, 2019:M6–2019:M9, 2020:M4–2020:M5 and 2020:M7–2020:M8. This finding proves the technique effect, suggesting that *TI* can make *AQ* better primarily by reducing the air pollutants emission in the production or facilitating renewable energy consumption. However, *TI* led to worse *AQ* in 2021:M1–2021:M3, during which time the equipment for renewable energy generation cannot normally work due to the low temperature in winter, thereby *TI* mainly focuses on utilising traditional energy and expanding production efficiently, resulting in air pollution. This result verifies the scale effect, showing that *TI* deteriorates *AQ* by increasing fossil energy consumption. Conversely, *AQ* can promote green *TI* during 2015:M3–2015:M11 by prompting the government to formulate more favourable policies, while it hinders *TI* during 2015:M12–2016:M1 by influencing inventors' health and crowding out funds for R&D.

7. Conclusion

This paper discusses whether *TI* can bring better *AQ* and has the following findings. On the one hand, China's *TI* can get better *AQ*. Green *TI* not only promotes the utilisation of new energy but also reduces air pollutants directly. On the other hand, *TI* can also result in air pollution when *TI* increases the consumption of traditional fossil energy. These results verify the coexistence of the technique effect and scale effect. Conversely, significant impacts of *AQ* on *TI* are observed, whose exact direction depends on the severity of air pollution and policy maker's attitude toward environmental conservation.

This paper has important theoretical implications. It extends the research of innovation and environmental protection by considering the impact of the national *TI* level on overall *AQ*. Previous researchers investigate the impact of green innovation (such as renewable energy *TI*) rather than addressing the national *TI* level, which fails to help judge the influence of national innovation-driven development strategies on sustainable development. Besides, Existing research focuses on certain air pollutants' emissions (e.g., CO_2, PM2.5) (Bilal et al., 2021; Gupta et al., 2022) rather than discussing overall air quality. Hence, our finding provides theoretical support for understanding the impact of the national *TI* level on overall *AQ*.

The relationship between *TI* and *AQ* also has practical policy implications. Firstly, as *TI* is conducive to economic growth and better *AQ*, the government must adhere to the innovation-driven development strategy, especially to encourage green *TI* to achieve carbon neutrality. Secondly, as the migration of innovators may occur due to deteriorating *AQ*, policymakers need to formulate environmental policies to control air pollution. Thirdly, recognising that pollution control can squeeze out R&D expenses and reduce *TI*, policymakers can provide green firms with more financing and resource support. Furthermore, the interrelationship between *TI* and *AQ* has important practical implications for firms. On the one hand, firms should realise that innovation is crucial for the growth of both individual firms and the global economy, and they should encourage *TI* by providing more funds and a better communication environment for inventors. On the other hand, firms must comply with environmental regulations to achieve sustainable development in the context of carbon neutrality.

This paper focuses on the interrelationship between *TI* and *AQ* in China while not discussing other economies. According to our theoretical analysis, the impact of *TI* on *AQ* might be the opposite in different periods of economic growth. Hence, future research can use countries with different economic conditions as samples to investigate this issue.

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Can green bond improve the investment efficiency of renewable energy?

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ABSTRACT

There has been a growing focus on the role played by green financing in propelling the high-quality advancement of the green economy in the contemporary period. This study examines the connection between green bond (GB) and the investment efficiency of renewable energy (REIE) by utilizing bootstrap rolling-window subsample Granger causality tests on data spanning from March 2016 to April 2023 in China. The findings reveal a dual effect of GB on REIE. On one hand, GB promotes REIE. This observation aligns with the "promoting effect," which postulates that GB facilitates additional funding for the technological innovation of renewable energy, thus enhancing investment efficiency. On the other hand, GB has an adverse impact on REIE. This outcome validates the "inhibition effect," suggesting that GB impedes REIE due to inadequate project selection and operation. Correspondingly, REIE negatively affects GB as companies with higher investment efficiency find it easier to secure lower-cost funds through alternative financing avenues. This study presents significant implications for policymakers aiming to augment REIE and attain sustainable development through the advancement of GB.

1. Introduction

This paper aims to study whether green bond (GB) improves or hinders the investment efficiency of renewable energy (REIE). The global shift towards a low-carbon economy has encouraged many countries to develop renewable energy, which requires increasing the supply of effective financing instruments. The International Renewable Energy Agency emphasises that achieving the 1.5 °C climate goal established by the Paris Agreement necessitates a minimum of 75% renewable energy in the primary energy mix. This ambitious target requires an annual investment of over USD 4.4 trillion in renewable energy (IRENA, 2023). Green bond (GB) is an important financing option that channels substantial capital into renewable energy investments (Lee et al., 2023a). The World Bank has stated that the issuance of GB has increased exponentially since 2013, reaching $2.5 trillion globally in January 2023. Although GB increases the scale of renewable energy investment (Ye et al., 2022; Wang and Fan, 2023), its impact on renewable energy investment efficiency (REIE) remains unclear. Efficient renewable energy investment can be defined as a unit of investment that increases renewable energy production capacity (Biddle et al., 2009; Gao and Yu, 2020), indicating that funds are fully and effectively utilised. Actual investment efficiency may decrease even with an increasing investment scale (Wang and Wang, 2020), implying that GB for financing renewable energy investment may reduce efficiency. For example, managers may behave based on their benefits and have incentives to increase investment beyond the optimal size when they have more cash from GB, which leads to poor project selection and inefficient investment (Benlemlih and Bitar, 2018; Gao and Yu, 2020). However, the inhibitory effect of GB on REIE does not always exist. With an emphasis on renewable energy development, the financing funds from GB are generally used in renewable energy technology research and development (R&D) (Yan et al., 2021). This phenomenon will provide additional renewable energy projects with increased production capacity for managers to choose from. Hence, GB may improve REIE in the process of energy transformation. In general, REIE is related to GB, but whether GB increases or decreases REIE remains controversial in

Abbreviations: GB, green bond; REIE, renewable energy investment efficiency; *LR*, likelihood ratio; VAR, vector autoregression; R&D, research and development; ADF, Augmented Dickey-Fuller test; PP, Phillips and Perron test; KPSS, Kwiatkowski-Phillips-Schmidt-Shin test; IP, industrial production.

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different periods. Because REIE is vital for carbon reduction and sustainable development (IRENA, 2023), this study explored the dynamic correlation between GB and REIE to fill this gap in the literature.

China is an ideal country for studying the correlation between GB and REIE. The Chinese government is actively advocating for GB and renewable energy. It has officially announced its aim to achieve carbon neutrality by 2060, which will require substantial funds from GB to finance renewable energy. In recent years, China has become the largest GB issuer worldwide (Azhgaliyeva et al., 2020), with US$102 billion GB issuance in 2022. This issuance has led to substantial growth in renewable energy investment such that China's hydropower, wind power, biomass power, and solar power generation capacity ranks first globally (Han and Chang, 2022). Hence, we can infer that GB improves REIE. However, the relationship is not conclusive. At the beginning of 2020, the amount of GB increased, but REIE decreased because the response to the COVID-19 epidemic made investing in and operating renewable energy projects inconvenient (Li et al., 2022). Thus, whether GB promotes REIE remains unclear. Furthermore, China is undergoing economic and energy transitions (Jie et al., 2021) that may change the relationship between GB and REIE. Because increases in REIE are not only beneficial for achieving carbon neutrality but also for energy transition, the discussion on GB and REIE is particularly important for China. The contributions of this study to the literature are listed in the subsequent paragraphs.

The literature has predominantly focused on the influence of green finance on renewable energy production, consumption, and the scale of renewable energy investments (He et al., 2019; Lee et al., 2023a; Alharbi et al., 2023). According to our review of the literature, this study is the first to investigate the impact of GB on REIE. Because the actual investment efficiency may decrease even with increasing investment scales (Liu et al., 2022; Wang and Wang, 2020), our research deepens the understanding of the role of GB in renewable energy development.

Studies have mainly used full-sample causality tests, and have not investigated time-varying interrelationships in cases of structural changes. To explore the evolving connection between GB and REIE, we first construct a vector autoregression (VAR) model, test the stability of the parameters, and find structural changes at unknown moments. We also employ the bootstrap subsample rolling window causality test to examine the causal interrelationships in each subsample. Using monthly data of GB and REIE from March 2016 to April 2023, we find that GB increases REIE, which proves the "promoting effect" that GB provides more funds for renewable energy technological innovation, thereby increasing renewable energy production capacity per unit of investment. This result, however, is not valid at the beginning of 2020, during which GB hinders REIE because the COVID-19 epidemic makes it inconvenient to invest and operate renewable energy projects. This result proves the "inhibition effect", suggesting that GB hinders REIE. Understanding the influence of GB on REIE provides implications for the government to improve the REIE by developing GB. In summary, this study has important implications for governments developing GB that support renewable energy development.

The remainder of this paper proceeds as follows: Section 2 presents the literature review, Section 3 theoretically analyses the relationship between GB and REIE, Section 4 introduces the empirical methods employed in this study, Section 5 presents the data, Section 6 presents the empirical results, and Section 7 concludes the paper.

2. Literature review

Discussions on the substantial role of GB in renewable energy development are increasing. Ng and Tao (2016) suggest that GB reduces barriers to financing renewable energy projects in Asia. Dogan et al. (2022) explore the spillover effects between GB and five renewable energy sources—biofuels, fuel cells, geothermal, solar, and wind—and find that GB significantly benefits renewable energy markets. Rasoulinezhad and Taghizadeh-Hesary (2022) also imply that GB plays a crucial role in providing vital financial support for green energy projects. Alharbi et al. (2023) establish that GB significantly contributes to renewable energy production. Moreover, Wang et al. (2022a) provide evidence that GB is of substantial importance to energy transitions by using a sample of E7 countries. Liu et al. (2021c) provide evidence that green financing has a positive effect on renewable energy generation. Lee and Lee (2022) show that green financing is conducive to green productivity. According to Li et al. (2023), green credit positively affects the efficiency of green investment.

By contrast, He et al. (2019) reported that green finance can aggravate the underinvestment challenges of renewable energy companies. Chang et al. (2023) demonstrate that GB decreases energy efficiency and increase energy consumption in Spain. In addition, some studies have observed that GB does not affect clean energy. Gibon et al. (2020) point out that the funds provided by GB are allocated inefficiently, which can offset the impact of GB on green projects. Hammoudeh et al. (2020) examine the correlation between GB and clean energy and find no significant causality. Madaleno et al. (2022) show that GB affected clean energy only during the COVID-19 pandemic; there was no significant causal effect at any other time.

Several studies have highlighted that renewable energy also affects GB. Li et al. (2021) investigate the causal relationship between green finance and renewable energy investment and find a positive influence of renewable energy investment on green finance. In addition, Nawaz et al. (2021) find that foreign direct investment in renewable energy significantly contributed to green finance. Likewise, Madaleno et al. (2022) suggest that clean energy demand promotes green finance investments. Mngumi et al. (2022) use data from 2005 to 2019 to investigate the interconnections between CO_2 emissions, renewable energy, and green finance. Their research suggests that the expansion of renewable energy usage can play a significant role in promoting the growth of green finance. Ali et al. (2023) point out that clean energy attracts green finance in the long run.

By contrast, studies have also confirmed the negative effects of renewable energy on GB. Liu et al. (2021a) reveal that the clean energy market negatively affects GB. Unlike most studies showing that energy markets, especially renewable energy markets, exhibit strengthened comovement with GB markets (Mzoughi et al., 2022), Reboredo (2018) demonstrates that energy markets have minimal influence on GB prices. Similarly, Tiwari et al. (2022) investigate the transmission of risk patterns between GB and renewable energy stocks and proposed that GB has little effect on renewable energy stocks; however, renewable energy stocks, such as solar energy, are negatively correlated with GB.

The relationship between GB and China-related renewable energy has been discussed but not identified. Ren et al. (2020) demonstrate that in China, green finance promotes clean energy consumption. Du et al. (2023) explore the role of green financial development in the transition towards renewable energy, finding that green finance promotes renewable energy. Liang et al. (2023) indicate that in China, green finance development helps increase renewable energy production. Lee et al. (2023a) highlight that green finance plays a direct role in promoting renewable energy consumption. In addition, green finance indirectly contributes to this development by increasing R&D, enhancing market openness, and promoting economic growth. However, in China, Wang and Fan (2023) show a non-linear relationship between renewable energy development and green financing. They propose that owing to economic development and financing constraints, green finance may no longer exert a prompting influence on investment in renewable energy. Moreover, He et al. (2019) find that the progress of green finance in China has had a restraining effect on bank loan issuance and has somewhat hindered the advancement of REIE. Huang and Chen (2022) suggest that although green finance in China facilitates renewable energy in the local province, it has inhibiting effects in neighbouring areas.

Researchers have mostly studied the influence of green finance on renewable energy production, consumption, or scale of investment

(Wang and Fan, 2023; Liu et al., 2022), ignoring the impact of GB on REIE. The expanding scale of investment might be associated with diminished investment efficiency when the renewable energy output capacity does not increase proportionally. Improving REIE is vital for the success of the renewable energy industry (Zeng et al., 2018) and contributes to sustainable development (Liu et al., 2022). Although some studies have discussed REIE (He et al., 2019; Li et al., 2023), few studies have focused on the GB market. Furthermore, although some studies (Huang and Chen, 2022; Chang et al., 2023) have proposed that green finance may have both positive and negative effects on renewable energy, contingent on the region, there exists a research gap regarding the potential temporal variations in these effects. Thus, in contrast with the literature, this study provides time-varying causality, considers the structural changes in the time series, and uses the rolling window bootstrap method (Balcilar et al., 2010; Liu and Su, 2019) to locate them. Our study not only explores whether GB can consistently promote REIE but also analyses the potential impact of government policies on the causal link between GB and REIE.

3. Theoretical analysis of GB and REIE

We construct an investment efficiency model to explain the impact of GB on REIE. The issuance of GB discloses more information on environmentally friendly projects than conventional bonds and caters to the requirements of eco-conscious investors, which reduces issuers' capital cost (Zhang et al., 2021b; Wang et al., 2022b) and alleviates financing constraints (Morris, 1976; Huang et al., 2022). Typically, funds obtained through GB are directed towards firms for purposes such as R&D of renewable energy technology (Yu et al., 2021; Lee et al., 2023b) and the launch of new renewable energy projects. We let ΔGB be the funds obtained by the firms through the issuance of GB; then, $\Delta GB = \Delta R + \Delta I$, where ΔR denotes the newly added renewable energy technology R&D expense, and ΔI represents the new investment in renewable energy project. We let $\Delta I = \alpha \Delta GB$ and $0 < \alpha < 1$; then, $\Delta R = (1-\alpha)\Delta GB$. We let ΔA be the new renewable energy technology that has the potential to improve renewable energy production capacity (Lee and Lee, 2022), where $\Delta A = g(\Delta R)$ and $\frac{d\Delta A}{d\Delta R} = g'(\Delta R) \geq 0$, which indicates that the increase in expenditure on renewable energy R&D positively influences the technological progress of renewable energy.

The efficiency of investment in renewable energy is denoted as *REIE*. Because efficient investment is defined as a unit of investment that increases production capacity (Biddle et al., 2009), REIE is associated with new renewable energy technologies that have the potential to expand the production capacity of renewable energy (ΔA) and ΔI. Thus, $REIE = f(\Delta A, \Delta I)$ and $\frac{\partial REIE}{\partial \Delta A} > 0$ imply that technological advancements in renewable energy will enhance the production capacity of renewable energy per unit investment and facilitate REIE. In addition, $\frac{\partial REIE}{\partial \Delta I} \leq 0$ implies that ΔI may lead to a decrease in REIE. One reason for this decrease is the moral hazard problem Jensen (1986) proposed: managers behave based on their personal benefits and have incentives to enlarge firms beyond their optimal size when they have access to excess cash. This can result in suboptimal project choices aimed at expropriating existing resources from firms, leading to investment inefficiency (Benlemlih and Bitar, 2018; Gao and Yu, 2020). In addition to moral hazard, some objective factors, such as economic crises and natural disasters, may also make investing in and operating renewable energy projects inconvenient (Li et al., 2022), reducing investment efficiency.

As aforementioned,

$$REIE = f(\Delta A, \Delta I) = f[g(\Delta R), \quad \alpha \Delta GB] = f[g(1-\alpha \Delta GB), \alpha \Delta GB]$$

The impact of GB on REIE is shown in Eq. (1):

$$\frac{dREIE}{d\Delta GB} = \frac{\partial REIE}{\partial \Delta A} \times \frac{d\Delta A}{d\Delta R} \times (1-\alpha) + \frac{\partial REIE}{\partial \Delta I} \times \alpha \tag{1}$$

where $\frac{d\Delta A}{d\Delta R} \geq 0$ and $\frac{\partial REIE}{\partial \Delta A} > 0$; then, $\frac{\partial REIE}{\partial \Delta A} \times \frac{d\Delta A}{d\Delta R} \times (1-\alpha) \geq 0$, which is defined as the ***'promoting effect'***, suggesting that GB provides additional funds for renewable energy technological innovation, which facilitates renewable energy technological progress and improves investment projects, increasing REIE. However, because $\frac{\partial REIE}{\partial \Delta A} \leq 0$ and $\alpha > 0$, $\frac{\partial REIE}{\partial \Delta I} \times \alpha \leq 0$, and GB reduces REIE when managers reject viable projects or invest in unfavourable projects to use additional funds from GB. We define this effect as the ***'inhibition effect'***. In summary, GB has promoting and inhibitory effects on REIE. When the promoting effect outweighs the inhibition effect, GB promotes REIE; otherwise, GB hinders REIE.

Conversely, REIE can also influence GB. On the one hand, as REIE of firms increases, the amount of financing from GB increases (He et al., 2019). Efficient renewable energy investment indicates a lower level of moral hazard problem, more advanced renewable energy technology, higher return, and larger market share in the future, which makes it more attractive to bond investors (Azhgaliyeva et al., 2020). However, firms with high investment efficiency also find that the ease of obtaining low-cost equity financing increases (Majeed et al., 2018), which may crowd out GB financing. In conclusion, despite the interactive relationship between GB and the REIE, the precise direction of causality remains ambiguous.

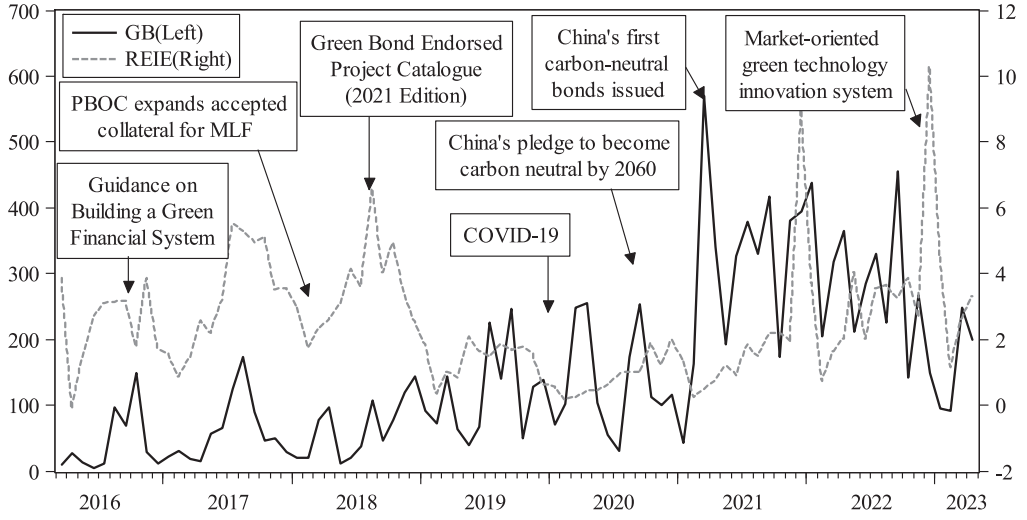

Fig. 1. Trends of GB and REIE.

4. Methodology

4.1. Bootstrap full-sample causality test

The conventional Granger causality test relies on the VAR model, where statistics (e.g., likelihood ratio (*LR*) and Lagrange multiplier) are supposed to follow a standard asymptotic distribution in the whole sample (Su et al., 2020). Nevertheless, the test results are possibly unreliable because they violate the stationarity assumption (Toda and Phillips, 1993, 1994). In this case, the residual-based bootstrap (*RB*) method may be used to increase the accuracy of the estimation (Mantalos and Shukur, 2001). In addition, the adjusted *LR* tests for Granger causality perform well (Shukur and Mantalos, 2000). Hence, this study applies *RB*-based modified-*LR* statistics.

First, the VAR model is shown in Eq. (2):

$$\mathbf{y}_t = \mathrm{Z}_0 + \mathrm{Z}_1\mathbf{y}_{t-1} + \ldots + \mathrm{Z}_p\mathbf{y}_{t-p} + \boldsymbol{\varepsilon}_t, t = 1, 2\ldots, T \tag{2}$$

In Eq. (2), $\mathbf{y}_t$ represents a column vector of variables, $\mathrm{Z}_0 \ldots \mathrm{Z}_p$represent coefficient matrices, $\boldsymbol{\varepsilon}_t$ denotes the white noise vector, T is the sample size, and p is the lag order.

Considering the potential impact of economic growth on GB and REIE (Zeng et al., 2018; Ye et al., 2022; Xiong and Dai, 2023), we introduce a control variable in the VAR model: the industrial production index (*IP*), a reliable indicator of economic growth (Sahoo et al., 2014). This indicator reflects the rate of IP. Finally, we obtained Eq. (3).

$$\begin{bmatrix} GB_t \\ REIE_t \end{bmatrix} = \begin{bmatrix} \theta_{10} \\ \theta_{20} \end{bmatrix} + \begin{bmatrix} \theta_{11}{}^{(1)} & \theta_{12}{}^{(1)} & \theta_{13}{}^{(1)} \\ \theta_{21}{}^{(1)} & \theta_{22}{}^{(1)} & \theta_{23}{}^{(1)} \end{bmatrix} \begin{bmatrix} GB_{t-1} \\ REIE_{t-1} \\ IP_{t-1} \end{bmatrix} + \begin{bmatrix} \theta_{11}{}^{(2)} & \theta_{12}{}^{(2)} & \theta_{13}{}^{(2)} \\ \theta_{21}{}^{(2)} & \theta_{22}{}^{(2)} & \theta_{23}{}^{(2)} \end{bmatrix} \begin{bmatrix} GB_{t-2} \\ REIE_{t-2} \\ IP_{t-2} \end{bmatrix} + \ldots + \begin{bmatrix} \theta_{11}{}^{(p)} & \theta_{12}{}^{(p)} & \theta_{13}{}^{(p)} \\ \theta_{21}{}^{(p)} & \theta_{22}{}^{(p)} & \theta_{23}{}^{(p)} \end{bmatrix} \begin{bmatrix} GB_{t-p} \\ REIE_{t-p} \\ IP_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}. \tag{3}$$

In this study, we apply *RB*-based modified-*LR*-statistics and p values to test the full-sample causal interrelationship between GB and REIE. If the null hypothesis that $\theta_{21}{}^{(q)} = 0$ is rejected, GB is considered to be the Granger cause of REIE, indicating that GB can help predict movements in REIE. Conversely, REIE is a Granger cause of GB if the null hypothesis of$\theta_{12}{}^{(q)} = 0$ is rejected.

4.2. Stability test of parameters

An assumption is that the parameters of the VAR model remain invariant over time in the full-sample causality test, implying singular causality in each period (Zhao and Su, 2023). However, economic shocks or institutional shifts over time may cause structural changes between series, and parameter instability is regarded as a challenge in empirical research (Granger, 1996). Hence, the possible parameter non-constancy may violate the parameter invariant assumption in the Granger test, and the results, in this case, may have insufficient reliability (Balcilar et al., 2010). Therefore, the stability of the test parameters is imperative. To achieve this stability, we utilise the *Sup—F*, *Mean-F*, and *Exp-F* tests proposed by Andrews (1993) and Andrews and Ploberger (1994) to investigate the short-term stability of the parameters. Furthermore, the *Lc* test that Nyblom (1989) and Hansen (1992) have developed is used to investigate the long-term stability of the parameters, enabling us to identify possible structural changes that may occur at an undisclosed time.

4.3. Rolling window subsample causality test

Although methods such as sample division can address parameter non-constancy arising from structural changes, potential biases may persist if the change points are unknown. Such biases can affect the accuracy of results. To overcome the challenge of parameter inconsistency resulting from unknown change points in structural changes, we utilise the bootstrap rolling window subsample Granger causality test.

This test partitions the full sample into subsamples of a fixed size. Assuming an entire sample size of T and using a rolling window of H observations, we can create$T - H + 1$ subsamples, denoted as $\psi - H + 1$, $\psi - H + 2, \ldots, \psi$, where $\psi = H, H + 1, \ldots, T$. This method allows the causality between series to vary over time, and by using rolling window estimation, we may capture these changes and avoid possible biases from structural shifts across subsamples (Su et al., 2021).

Nevertheless, there is no universally established criterion for determining the optimal subsample size (Balcilar et al., 2010). Although small subsamples can reduce the impact of potential heteroscedasticity, they may result in larger variances and less accurate results than those of large subsamples. Additionally, a larger subsample can improve estimation validity but may compromise reliability due to heteroscedasticity. Because of these conflicting demands, a bias-minimising window of at least 20 observations is generally believed to be necessary (Pesaran and Timmermann, 2005). Referring to the literature (Zhao and Su, 2023), the rolling subsample data consist of 24 months of observations to ensure the robustness of the test. Subsequently, we can employ an RB-based modified LR causality test to examine the interrelationships in each subsample.

5. Data

Monthly data of GB and REIE from March 2016 to April 2023 are used in this study. In 2016, the development of green finance became part of a national strategy. The release of the 'Guidance on Building a Green Financial System' by the People's Bank of China (PBOC) marks a significant advancement in GB (Zhang et al., 2021a). We measured GB by using the monthly amount of corporate GB issuances. The wind data for GB were first recorded in March 2016. Additionally, to represent REIE, we use the newly installed renewable energy power capacity divided by the newly added renewable energy power investment each month. According to the Renewables 2022 Global Status Report, most of the energy provided by renewable sources is used to produce electricity. The World Energy Investment report (2022) from International Energy Agency also states that renewable energy power generation is one of the fastest growing energy investments. Therefore, we were able to use renewable energy power data to measure REIE. A unit of renewable energy investment that increases the generation of power capacity implies that the investment is efficient (Benlemlih and Bitar, 2018; Gao and Yu, 2020), and vice versa. The data on newly installed renewable energy power capacity and renewable energy power investment are obtained from CEIC Data. Moreover, we use the industrial production index (IP) in China as the control variable. IP is widely recognised as a robust

Table 1
Descriptive statistics of the sequence of *GB, REIE*, and *IP*.

Statistics	*GB*	*REIE*	*IP*
Observations	86	86	86
Mean	147.385	2.446	110.682
Median	105.365	1.994	108.382
Maximum	569.8	10.270	139.828
Minimum	4	−0.097	87.551
Std. Dev.	127.206	1.806	12.854
Skewness	1.093	1.655	0.328
Kurtosis	3.538	7.280	2.436
Jarque–Bera	18.154 ***	104.872***	2.681

Table 2
Unit root tests.

Series	ADF	PP	KPSS
GB	−3.919 (0) ***	−3.824 [8] ***	0.090 [1]
REIE	−5.363 (0) ***	−5.416 [3] ***	0.190 [5]
IP	−2.422 (1)	−0.311 [12]	0.833 [6] ***
△*IP*	−13.727 (0) ***	−16.901[14] ***	0.115 [12]

Notes: Numbers in parentheses indicate the lag order, which was selected based on Schwarz information criterion.
Numbers in brackets refer to the bandwidth, which uses the Bartlett Kernel as suggested by the Newey–West test (1987).
*** and * *denote significance at the 1% and 5% levels, respectively.
GB: green bond; *REIE: investment efficie*ncy of renewable energy. *IP*: industrial production. ADF, Augmented Dickey-Fuller test; PP, Phillips and Perron test; KPSS, Kwiatkowski-Phillips-Schmidt-Shin test.

indicator of economic growth (Herrera et al., 2011; Sahoo et al., 2014). This index is a significant gauge of the speed of IP. Because the industrial sector constitutes a high and rising share of China's economy and accounts for a substantial share of energy consumption (Liu et al., 2021b), IP is used as the control variable. An increase in IP indicates increased production and energy consumption, which can affect GB and REIE.

Fig. 1 illustrates the trends in GB and REIE. In general, GB has a rising trend, with some fluctuations. After President Xi Jinping announced China's carbon-neutral goal in September 2020, the value of GB surged. Subsequently, GB continued to rise and peaked in 2021. In addition, the value of REIE fluctuated year-round, with some local peaks in 2018, 2021, and 2022. Moreover, high GB coincides with an increase in REIE in some periods. For example, when the number of GB increased in 2018, REIE also increased rapidly. The reason for this may be that during the corresponding period, ecological civilisation was written into the Constitution of China in March 2018, and the PBOC began to accept GB as collateral for the medium-term lending facility, which promoted GB and REIE development. Similar changes were observed in 2021 when GB showed an obvious rising trend, and REIE increased. This can be attributed to a series of GB support measures, such as the release of the Green Bond Endorsed Project Catalogue (2021 edition) and the issuance of carbon-neutral bonds in the first half of 2021. Therefore, we infer that GB promotes REIE. However, the trends in GB and REIE sometimes differ. At the beginning of 2020, despite the increase in the size of GB, the response to the COVID-19 pandemic led to a reduction in energy demand (Tsao et al., 2021), reducing REIE. A similar situation is observed at the beginning of 2023. Although GB decreases sharply, REIE increases. Furthermore, economic growth can affect the relationship between GB and REIE. The development of GB can benefit economic growth and lead to rising demand for renewable energy (Tolliver et al., 2021; Li and Umair, 2023), which stimulates renewable energy technological R&D to increase renewable energy capacity and ultimately improve REIE (Li et al., 2023). In addition, an increase in REIE increases energy production, which contributes to economic growth and changes individuals' requirements for sustainable development (Shafik and Bandyopadhyay, 1992; Panayotou, 1993), influencing GB (Zuo and Ai, 2011; Gu et al., 2023; Zhou et al., 2020). In conclusion, temporal variations are observed in the relationship between GB and REIE, which are also affected by the dynamics of economic growth.

Table 3
Full-sample Granger causality tests.

	H0: *GB* is not a Granger cause of *REIE*		H0: *REIE* is not a Granger cause of *GB*	
Tests	Statistics	*p* values	Statistics	*p* values
Bootstrap *LR* test	0.638	0.418	0.080	0.774

Notes: The null hypothesis is that no causal relationships exist between the variables. p values are calculated using 1000 bootstrap repetitions.
GB: green bonds; *REIE*: investment efficiency of renewable energy; *IP*: industrial production; *LR*, likelihood ratio.

Table 1 presents the descriptive statistics for *GB*, *REIE,* and *IP*. The mean *GB* is 147.385; thus, an average of RMB 1.4 billion in GB are issued monthly in China. The means of *REIE* indicate that RMB 1 million invested in renewable energy in China generates an average of 2446 kWh of new renewable energy power capacity. The means of *IP* suggest that the average industrial production index is 110.682 (2015 is the base period, with an *IP* value of 100). These three variables have a positively skewed distribution. Both *GB* and *REIE* exhibit a leptokurtic distribution, with kurtosis values greater than 3. *IP* displays a platykurtic distribution with kurtosis values less than 3. Moreover, according to the Jarque–Bera test, *GB* and *REIE* are not normally distributed at a significance level of 1%. Consequently, the traditional VAR models-based Granger causality test may lead to inaccurate parameter estimation. To mitigate potential heteroscedasticity and instability, we used the natural logarithms of *GB* and *IP* by employing the first difference in the following analyses.

6. Empirical results

This study has utilised unit root tests to assess the stability of the time series. The results (Table 2) indicate that all series exhibit stationarity.

Moreover, this study has constructed VAR models; conducted a causality test on the full sample; and determined a lag order of 1 via an evaluation using three information criteria: the Schwarz information criterion, Akaike information criterion, and Hannan-Quinn information criterion. The outcomes of the causality analysis on the full sample (Table 3) show that GB and REIE do not influence each other, which is inconsistent with the investment efficiency model used in our theoretical analysis (Hammoudeh et al., 2020).

As aforementioned, the Granger causality test in the full sample assumes constancy of all parameters. However, owing to structural changes, the causality between GB and REIE may vary over time. Thus, investigating the stability of these parameters and detecting the structural changes are critical. Table 4 presents the results of various tests employed in this study to evaluate the stability of the parameters.

The statistics of *Sup-F* test reveal significant structural changes in the *GB* equation, *REIE* equation, and VAR system at a significance level of 1%. Furthermore, the null hypothesis that the parameters conform to a martingale process is rejected based on the results of the *Mean-F test* and *Exp-F test*, indicating the time-varying behaviour of the corresponding equations and VAR system. In conclusion, the parameters exhibit instability, and structural breaks occur in the full sample. Thus, to improve the accuracy of this issue, we applied *RB*-based subsample modified-*LR* causality tests.

Fig. 2 illustrates the rolling bootstrap results of the *LR*-statistics' *p* values when *REIE* is the dependent variable. Our findings reveal *GB* as a Granger cause of *REIE* during the periods 2018:M5–2018:M7, 2020:M2–2020:M5, and 2021:M7–2021:M11. Fig. 3 shows the sum of the rolling window coefficients depicting the influence of *GB* on the *REIE*. By integrating the information from the Figs. 2 and 3, a positive influence of *GB* on *REIE* was observed during 2018:M5–2018:M7 and 2021:M7–2021:M11 because the *p* values were below the significance level of 0.1. However, this influence becomes negative in 2020:M2–2020:M5,

Table 4
Parameter stability tests.

	GB equation		*REIE* equation		VAR (3) system	
	Statistics	Bootstrap *p* value	Statistics	Bootstrap *p* value	Statistics	Bootstrap *p* value
Sup-F	47.325***	0.000	48.990***	0.000	44.477***	0.000
Mean-F	17.080***	0.000	17.857***	0.000	24.661***	0.002
Exp-F	20.291***	0.000	21.780***	0.000	18.345***	0.000
Lc					3.177***	0.005

Notes: *p* values are calculated using 1000 bootstrap repetitions. ***indicates significance at the 1% level. Lc shows the results of the Hansen–Nyblom parameter stability test for all parameters in the VAR.
GB: green bond; *REIE*: investment efficiency of renewable energy; VAR: vector autoregression.

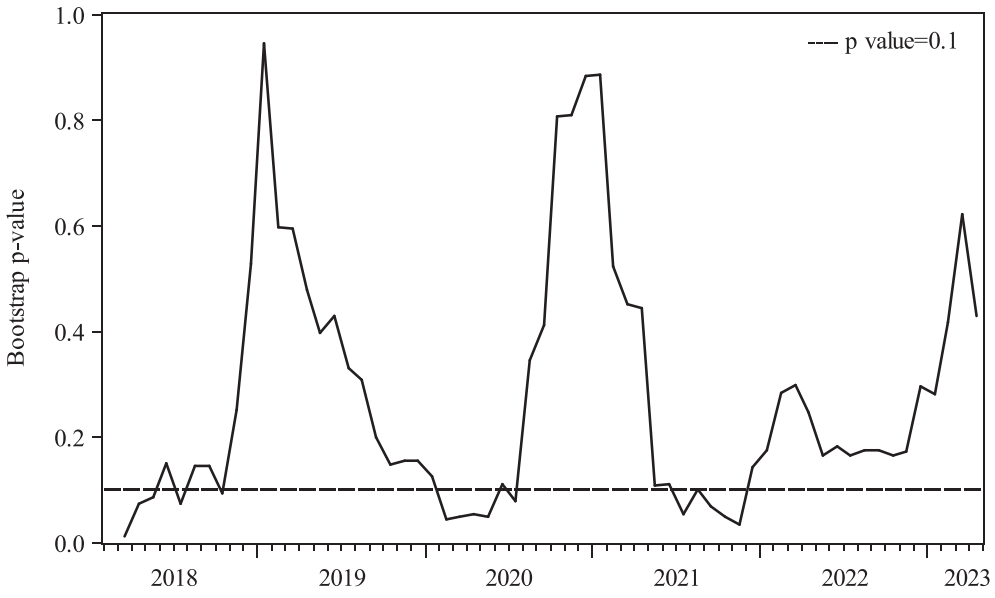

Fig. 2. Bootstrap *p* value of the statistics (the null hypothesis is that *GB is* not a Granger cause of *REIE*).

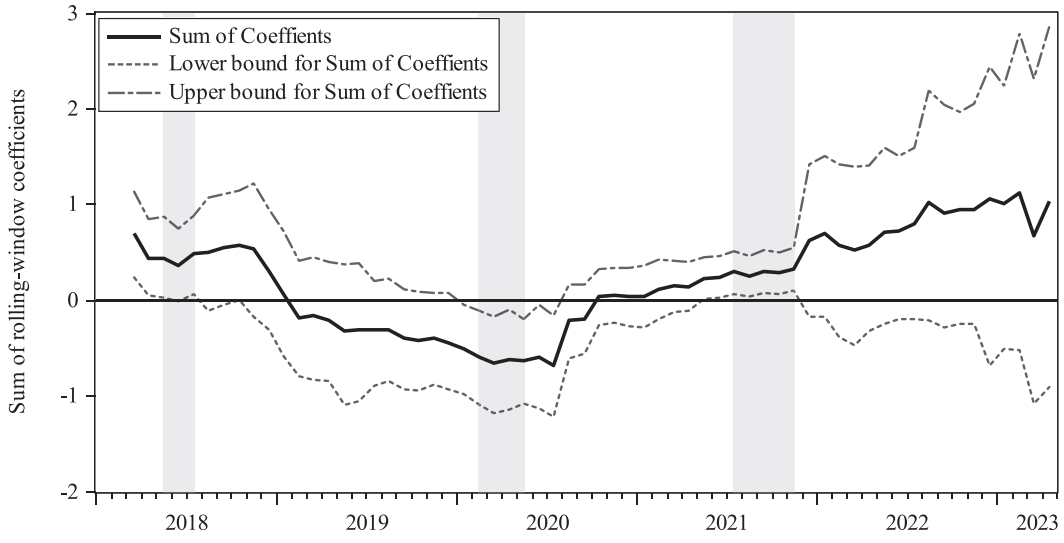

Fig. 3. Sum of rolling window coefficients of *GB*'s influence on *REIE*.

indicating that GB reduces REIE.

The reasons why GB improves REIE in 2018:M5–2018:M7 are as follows. In March 2018, the addition of an ecological civilisation to the Constitution of China marked a significant milestone in the country's commitment to advancing sustainable development. At the National Conference on Ecological Environment Protection held in May 2018, President Xi Jinping proposed that 'building an ecological civilisation is of fundamental importance for the sustainable development of the Chinese nation'. Against this background, the PBOC added GB rated AA

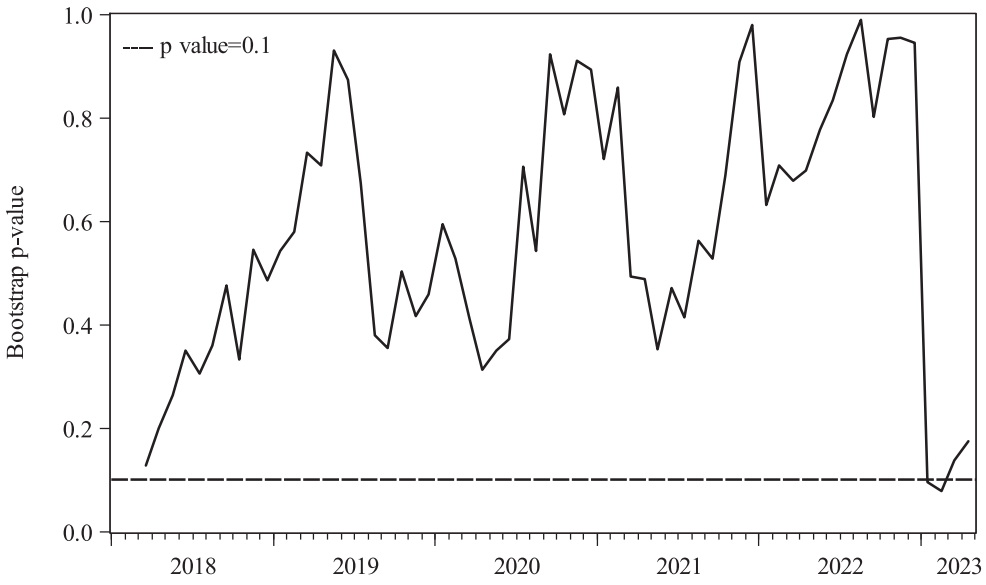

Fig. 4. Bootstrap *p* value of the statistics (the null hypothesis is that *REIE* is not a Granger cause of *GB)*.

and above as accepted collateral for its medium-term lending facility,[1] aiming to increase financial support for the green economy. This policy has boosted the development of GB, thus increasing the funds for renewable energy technological progress (Yu et al., 2021; Lee et al., 2023b) and improving renewable production capacity per unit of investment (Lee and Lee, 2022). This result supports the 'promoting effect' in the theoretical analysis, implying that GB provides additional funds for innovation, promote advancements in renewable energy technology, and thus increase REIE. Therefore, GB has a positive influence on REIE from 2018:M5 to 2018:M7.

The promoting effect of GB on REIE is also observed in 2021:M7–2021:M11. In September 2020, China committed to achieving carbon neutrality by 2060, necessitating sufficient funds to support the energy transition and renewable energy technological innovation (Polzin and Sanders, 2020; Yu et al., 2021). In July 2021, the Green Bond Endorsed Project Catalogue (hereafter 'the new catalogue'; 2021 Edition) was implemented. The new catalogue no longer supports high-carbon-emission projects. Moreover, the new catalogue unifies the green standard in China, increasing the number of green GB investors. This allows an increased amount of funds obtained through GB to be invested in renewable energy projects and technological innovations. Thus, because technological progress can increase the production capacity of renewable energy and improve projects, REIE tends to rise. In addition, a series of supporting policies were released to achieve the carbon neutrality target in the first half of 2021, contributing to the promoting effect of GB on REIE from July 2021. China issued the first batch of carbon-neutral bonds in the first half of 2021. Because the money raised from carbon-neutral bonds is dedicated to green projects that reduce carbon emissions, they provide strong support for renewable energy projects and promote innovation in renewable energy technologies. As a result, REIE can be increased (Bai et al., 2023). Moreover, the 14th Five-Year Plan (2021–2025) for national development, released in the first half of 2021, proposes facilitating green technological innovation. This plan is conducive to directing funds from GB to renewable energy technology innovation, increasing REIE. This result confirms the 'promoting effect', indicating that GB promotes renewable energy technological innovation, which facilitates renewable energy technological progress, improves investment projects, and increases REIE. These findings are consistent with those in the literature (Zhang et al., 2021a; Ye et al., 2022; Wang and Fan, 2023), but those studies have primarily examined the scale of renewable energy investment rather than REIE.

However, GB has a negative influence on REIE in 2020:M2–2020:M5. In early 2020, despite an increase in the number of GB, the response to the COVID-19 pandemic led to a decrease in energy consumption (Tsao et al., 2021). This decrease reduces managers' incentives to allocate funds to higher-capacity renewable energy projects (Tsao et al., 2021; Hoang et al., 2021), decreasing REIE. In addition, the pandemic prompted the government to issue lockdowns and stay-at-home orders, which extended the completion period of renewable energy projects due to equipment delays and employee layoffs. In such a situation, projects financed through GB may also experience inefficiencies (Eroğlu, 2021; Siddique et al., 2021; Pradhan et al., 2020). Hence, GB reduces REIE during 2020:M2–2020:M5. This result is in line with the 'inhibition effect', suggesting that GB reduces REIE when managers reject viable projects or allocate funds to less favourable projects to use up the additional funds from GB. This finding aligns with those of He et al. (2019) that green financial development inhibits REIE; however, they do not focus on the GB market.

Fig. 4 shows the rolling bootstrap *p* values of the *LR* statistics, where *GB* is the dependent variable. Fig. 5 illustrates the sum of the rolling window coefficients that signify the impact of REIE's influence on GB. The analysis of the information in Figs. 4 and 5 shows that REIE has a negative influence on GB during 2023:M1–2023:M2.

In December 2022, the Chinese government released an implementation plan to improve market-oriented green technological innovation systems. This plan emphasises the strengthening of equity support for green technological innovation. This suggests that firms with advanced renewable energy technological innovations will find equity financing easier and more cost-effective than other firms(Majeed et al., 2018), which crowds out GB. Hence, although REIE increases, GB decreases during 2023:M1–2023:M2. In January 2023, the PBOC announced it would continue promoting the carbon-reduction support tool, which provides low-cost green loans to firms in key carbon-reduction fields. Consequently, renewable energy firms can obtain cheaper funds through green loans than by issuing GB. Therefore, REIE hinders GB in 2023:M1–2023:M2 because firms with higher investment efficiency can borrow lower-cost funds more easily through other financing methods. This result differs from that of Li et al. (2021), that renewable energy investment promotes green finance. Different from

[1] A medium-term lending facility is a monetary policy tool that provides liquidity for financial institutions.

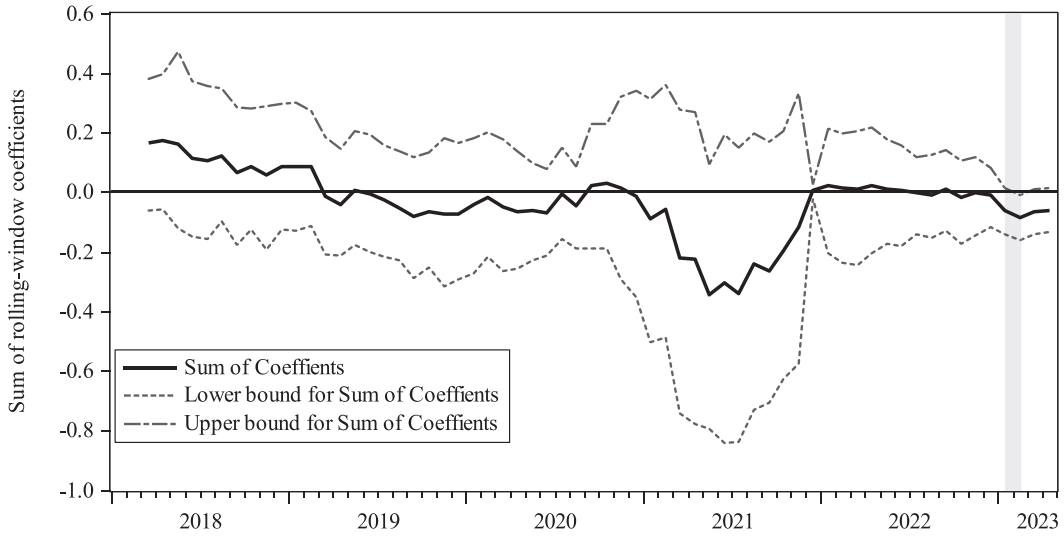

Fig. 5. Sum of rolling window coefficients of *REIE*'s influence on *GB*.

the findings of Li et al. (2021), our findings indicate that impact of REIE on GB, green equity, and green loan financing differs, which has important implications for developing GB.

In summary, we have investigated the time-varying causal relationship between GB and REIE across various subsamples by applying a bootstrap subsample rolling window Granger causality test. A positive effect of GB on REIE is observed in 2018:M5–2018:M7 and 2021:M7–2021:M11, indicating that GB promoted REIE during these periods. This result suggests that GB can provide additional funding for renewable energy technological innovation, which facilitates renewable energy technological progress and improves investment projects, increasing REIE. However, GB hinders REIE in 2020:M2–2020:M5. The reason for this result is mainly that the declining demand for energy during the COVID-19 pandemic causes poor project selection and decreases the investment in renewable energy technological innovation, decreasing REIE. In addition, the response to the COVID-19 pandemic made investing in and operating renewable energy projects inconvenient, reducing REIE. These results demonstrate that GB has a dual effect on REIE, which is consistent with the 'promoting effect' and 'inhibition effect' in the theoretical analysis. Thus, the effect of REIE on GB is negative in 2023:M1–2023:M2, suggesting that firms with higher REIE have easier access to lower-cost financing (Majeed et al., 2018), which can crowd out GB financing and decrease the attraction to GB.

7. Conclusion

This study explores the causal interrelationship between GB and REIE by using a sample from China. Rolling window analysis reveals a bidirectional causal relationship between GB and REIE in the subsamples. First, in 2018 and 2021, when the GB market is developing rapidly under policy promotion, GB improves REIE mainly by providing additional funds for technological innovation in renewable energy. This result complies with the 'promoting effect', indicating that GB facilitates the technological progress of renewable energy and improve investment projects, increasing REIE. Second, in 2020, the negative causal relationship between GB and REIE is mainly due to the response to the COVID-19 pandemic making investing in and operating renewable energy projects effectively inconvenient. This result aligns with the 'inhibition effect', implying that GB reduces REIE when managers reject favourable projects or invest in unfavourable projects to use up the additional funds from GB. This result also proves that the 'promoting effect' weakened during the COVID-19 epidemic when managers decreased the funds allocated to the technological innovation of renewable energy. Third, the increase in REIE will decrease the issuances of GB in 2023, indicating that firms with higher investment efficiency are more willing to obtain lower-cost financing, which may crowd out GB financing.

This study has theoretical implications. One implication is that we extend the research on green finance and renewable energy development by considering the efficiency of renewable energy investment. By contrast, the literature has focused on the influence of green finance on the scale of renewable energy investment (He et al., 2019; Li et al., 2021). Because investment efficiency may decrease even with an increasing investment scale (Liu et al., 2022; Wang and Wang, 2020), our research deepens the understanding of the role played by green finance in renewable energy development. Another implication is that this study extends the research by using a bootstrap subsample rolling window causality test to examine the dynamic interrelationship between GB and REIE. Notably, further research can apply this approach to discuss time-varying interrelationships when structural changes occur.

Insights into the interplay between GB and REIE also hold practical implications for policymakers. First, policymakers should realise that the issuance of GB not only increases the scale of renewable energy investment but also improves REIE, which is conducive to achieving carbon neutrality. Hence, developing GB and improving REIE are necessary. For example, policymakers can optimise the identification and information disclosure of GB. Second, the results show that managers may use the funds obtained from GB for inefficient investment projects, which is detrimental to the progress of RE. Hence, policymakers should guide managers to invest funds in more efficient green projects by implementing inventive policies such as tax reduction and financial subsidies. Third, policymakers should realise that improving REIE may crowd out GB by enabling firms to acquire other lower-cost financing. Therefore, while encouraging the development of various green financial instruments, regulatory authorities should endeavour to reduce the risks and costs of GB issuance. For instance, policymakers can encourage GB issuers to adopt insurance, guarantees, collateral, and credit risk mitigation instruments to enhance the credit of GB and increase the number of GB investors.

This study has limitations that have inspired our recommendations for further research. First, we focus on GB market, but do not consider other green financing methods, such as green equity. China has strengthened its equity support for green technological innovation and renewable energy. However, because green equity financing is in its early stages and there is insufficient high-frequency data, empirically investigating its impact is difficult. Hence, further research could study

the impact of green equity financing on REIE and compare the results with those of GB. Second, we use the sample from 2016:M3–2023:M4 and find that REIE will hinder GB in 2023; this is probably because the Chinese government encourages other low-cost green financing instruments such as green equity and green loans, thereby crowding out GB. However, with the maturity of GB, we cannot determine whether this conclusion holds. Thus, further research could investigate whether this phenomenon exists.

CRediT authorship contribution statement

Qian Zhao: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Chuan Qin:** Data curation, Methodology, Visualization. **Longfei Ding:** Software, Investigation, Validation. **Ying-Yue Cheng:** Formal analysis, Data curation, Writing – original draft. **Sorana Vătavu:** Writing – review & editing.

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CAUSES AND CONSEQUENCES OF SHADOW ECONOMY AND ITS IMPACT ON ECONOMIC DEVELOPMENT

Abstract. *This research examines the shadow economy's impact and implications on the economic development at the level of the European Union, from 2009 to 2020, employing the MIMIC Model. The statistical analysis has revealed two contradictory outcomes, which also reflect the suppositions that were found in the literature. Namely, the shadow economy and economic development are at the same time strongly correlated, whilst also being weakly correlated, strictly depending on the chosen variables. Therefore, from a statistical point of view, we conclude that the shadow economy directly impacts economic development, but there is a lack of transparency on behalf of the European Union member states when providing data related to the informal sector. However, by employing the MIMIC Model, we discovered that the causes leading most to work in the informal sector are the lack of quality in public administration institutions and reduced government efficiency, which at least theoretically, affects the economic development of any country. The paper contends that, with a strong framework of public policies, the size of the shadow economy can be diminished.*

Keywords*: Shadow economy, economic development, MIMIC Model, causality, regression*

JEL Classification: O17, O52, D78

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1. Introduction

The shadow economy is a complex and difficult issue, difficult to describe and quantify but has far-reaching implications for a country's economic and social life. Various approaches have been proposed for estimating the size of the informal economy; most methodologies, on the other hand, look at only one indicator to account for all of the effects of the informal economy. Studies attempting to measure the shadow economy's extent have failed to establish a consensus on how to characterise this complicated economic trend. Moreover, the ways of computing and overall assessing the informal sector are so different that we do not know for sure how big exactly is the underground economy compared to the formal one. However, current worldwide events (such as trade disputes, climate change, or migration waves) have raised interest once again in assessing the size of shadow economic activities within economies. Additionally, its size is difficult to determine, as the players who take part in these activities want to remain unnoticed.

In recent years, the literature relied mostly on the Multiple Causes Multiple Indicators (MIMIC) Model, when computing the size of the shadow economy, which considers that the informal sector is affected and affects different economic indicators while being treated as an unobserved component. Therefore, in our paper, we have also computed our own MIMIC model, based on the indicators used by Schneider in his most recent research.

The political and economic significance of the shadow economy has prompted a demand for information on its size and evolution over time. Furthermore, total economic activity, which includes both official and unofficial production of goods and services, is critical in the establishment of fiscal policies that adapt to changes in the economy over time and space. Moreover, the size of the shadow economy is an important factor in determining the level of tax evasion and, as a result, making decisions about how to effectively manage it. The core of the informal sector is both corruption and tax evasion, which are a permanent problem for any country of the European Union, especially the ones from the ex-soviet bloc, which are a direct determinant of the shadow economy. Furthermore, corruption and informal activities have always coexisted in all economies of all sizes and forms, even though many policies were adopted in the hope of reducing it. The increasing burden of taxation and social security payments, together with increasingly extensive government regulatory operations, appear to be the primary driving causes behind the shadow economy's size and expansion. The findings suggest the importance of the rule of law in limiting both corruption and associated shadow economic activity. Therefore, the weak and arbitrary administration of laws and regulations increases shadow economic activity. The development of the shadow economy can be reduced if institutions are strengthened and fiscal policy moves closer to the regular voter's preferences. The informal sector developed as a result of political institutions' failure to promote an efficient market economy, which drove entrepreneurs to go

underground due to the inefficiency of financial institutions and the lack of motivation to respect the government and its policy frameworks.

Our research initially presents the concept and various definitions surrounding the informal sector that can be found in the literature, followed by an attempt in measuring the size of the shadow economy of the European Union (EU) member states. However, our intention is to showcase the impact and relationship between the shadow economy and economic development. Our paper contributes to the literature related to two aspects: first, we measure the size of the informal sector in a rather recent time period of 12 years (from 2009 until 2020) by computing a MIMIC Model based on the indicators presented in Schneider (2006, 2012, 2018); nonetheless, we adjusted the initial indicators of Schneider, as the data was limited for this period. Secondly, with the help of the correlation and regression analysis, we observed the relationship between the shadow economy and economic development. The reason for this empirical evidence is that we found a gap in the literature in terms of this supplementary analysis. We have discovered that the literature does not present the impact of the informal sector on economic development, but often focuses on the repercussions at an individual level. Most studies are inconclusive in explaining how the informal sector affects economic growth. Some argue that the shadow economy has a negative impact on GDP growth. They claim that reducing the shadow economy will raise income tax, causing an increase in government expenditures, particularly on infrastructure and services that promote production expansion, and hence a rise in the overall economic growth rate.

2. Literature Review

This section will present the main shadow economic activities as well as the main reasons an individual may want to perform its activity in the informal economy. We observed that the literature does not offer a proper analysis of the repercussions brought by shadow economic activities in terms of economic development, but more of a presentation of the different opinions and views of the researchers in regard to the informal economy. As a more general definition, the informal sector is the process that generates income based on activities that are not regulated by governmental authorities; moreover, it is the outcome of avoiding taxation and regulations, which are imposed by the state.

A rise in the informal sector could result in lower state income, reducing the quality and quantity of goods and services offered by the government. In the end, this can lead to higher tax rates for businesses and individuals in the official sector, which is frequently accompanied by a decline in the quality of public goods (such as public infrastructure) and administration, creating even stronger incentives to participate in the shadow economy. As a result, the availability, and, more importantly, the quality of public sector services, are critical causative variables in people's decisions to work or not in the shadow economy.

Faced with financial constraints, authorities are likely to look for effective tools to regulate the informal sector in order to expand their tax base and alleviate their fiscal constraints. Reforming the tax and social security systems, as well as lowering the regulatory load, are well-known and commonly utilised policy instruments for improving the formal economy's dynamics. However, in most countries, failing to register or pay taxes is a criminal violation, and governments attempt to track down unregistered agents.

Previous research indicated that the quality of the financial institutions is another factor that triggers the growth of the shadow economy (Schneider and Buehn, 2012; Schneider and Williams, 2013). Even more essential than the real burden of taxes and regulations, the government's efficient and discretionary administration of the tax code and rules plays a critical impact in the decision to work underground. A bureaucracy with highly corrupt government personnel is related to more unofficial activities, but an excellent rule of law improves the benefits of being formal by protecting property rights and contract enforcement. Efficient policies are defined by a specific amount of taxation, the majority of which is spent on productive public services. In reality, the formal economy gains from an increased supply of productive public services and is severely impacted by taxation, but the shadow economy has the reverse effect. The development of the shadow economy can be reduced if institutions can be strengthened, and fiscal policy moves closer to the regular voter's preferences. The informal sector developed as a result of political institutions' failure to promote an efficient market economy which droved entrepreneurs to go underground due to the inefficiency of financial institutions and the lack of motivation to respect the government and its policy frameworks. This concluded in undefined and unsafe workplaces, irregular incomes and unhealthy working conditions, such as long working hours, medium to low productivity, and the deficiency to develop as an employee. In other words, the shadow economy is the effect of a system that does not work or does not promote decent work. In this regard, it fires back at the government, as the informal sector has a negative influence on public revenues, companies, policies, fair competition among the market players, and the face of financial and political institutions.

Because it influences tax morale, the efficiency of the public sector has an indirect effect on the degree of the shadow economy. Tax compliance is governed by a "tax contract" that comprises rights and duties on the part of taxpayers and citizens, as well as the state and its tax agencies. If they receive good public services in return, taxpayers are more likely to pay their taxes honestly. Taxpayers, on the other hand, are honest even when the benefit principle of taxation does not apply, such as in the case of wealth redistribution, if such political decisions are made in a fair manner. The way the tax authority treats taxpayers is also important. Taxpayers will be more likely to adhere to the psychological tax contract's responsibilities if they are treated as partners in a (tax) contract rather than as subordinates in a hierarchical relationship (Feld and Fray, 2007, Feld and Schneider, 2010).

Schneider and Buehn (2012) drew a comparison between tax evasion and the shadow economy, the conclusion being that the two concepts are not necessarily similar, but most cases referring to the underground economy point towards tax evasion (either direct or indirect) – more than that, the same authors recognised that the aspects that affect tax evasion have similar but more prominent effects when speaking about informal sector. They developed a model using the following seven causal factors to describe the shadow economy based on this rationalisation: obligations of tax and social security contributions, institutional quality, rules, public sector services, tax morale, and discouragement. This method allowed the authors to use a variety of possible metrics of shadow economic activities at the same time. Official working hours or labour force participation, official GDP, and currency demand are all good indications of shadow economic activity.

Tax evasion is a crime regarded by most countries because it includes the misappropriation of government funds, whereas tax avoidance is the adoption of all techniques by a taxpayer to guarantee the payment of taxes if the law requires it. The literature presents several reasons that might justify the act of tax avoidance in the present times. For instance, Folayan and Adeniyi (2018) indicated that regulatory quality, which is emphasised by the corruption of public authorities and the disinterest of tax officials, is the key factor regarding tax evasion. Moreover, Obafemi (2014) pinpoints social factors, such as illiteracy and the inability to understand the overall tax systems, as the basis for tax avoidance. Schneider (2016) describes that the higher the discrepancy between the cost of labour and the income generated by labour hours, the higher the enticement for tax evasion will be or the desire to work in an environment created by the shadow economy. The discrepancy is caused by the existence of the tax burden and the mandatory social security contributions, the main determinant being the tax burden. As presented in their study, Schneider and Buehn (2012) state that it is rather difficult to measure the tax burden in relationship with social contributions, as the two are different among nations. In addition, the ageing population, differences in the labour market productivity or corruption cause gaps in the socioeconomic development of countries (Pirtea et al., 2019; Cristea et al., 2022), also reflecting differently in the level of the shadow economy.

From a moral point of view, certain types of lawful tax evasion are just as unethical as fraudulent evasion and should therefore be treated in the same way. In practice, there is often no rupture between legal and illegal, but rather a continuation, successive attempts to take advantage of the loopholes of the law by leading the taxpayer from legal to illegal. It is human nature to oppose to the concept of taxation. We observed that the most recent literature continuously stressed the importance of taxpayers' attitudes and beliefs towards tax evasion in regard to their fiscal decisions. According to Frey and Torgler (2017), tax evasion-related activities are not influenced by rational cost-benefit analysis, but more by social pressures, generated by taxpayers' compliance with fiscal obligations. It seems that society regards tax evasion as one of the less severe offences, becoming an entirely common practice.

According to the latest paper of the International Monetary Fund regarding the shadow economy (2019) in most European Union member states, this counts for a large proportion of GDP, fluctuating from less than 10% to more than 40%. In developed countries, the informal sector inclines to be reduced, averaging roughly from 10 to 20% of GDP; however, developing countries have larger levels of the shadow economy, accounting for 30-35% of GDP. Whereas the median size of EU's shadow economy has been relatively stable since the mid-2000s, the dynamics vary greatly between nations. Since the early 2000s, the shadow economy has grown in several countries (e.g., Croatia, Cyprus, Greece), while it has dropped in others (e.g., the Czech Republic). In most nations, the shadow economy grew from 2008 to 2010, then reverted to the pre-crisis levels.

In most developed countries, both as a percentage of GDP and as a percentage of employment, the underground economy is much less. Across multiple nation samples and historical periods, the percentage of the shadow economy is substantially inversely linked with per capita income. Tax evasion and undeclared labour in registered enterprises dominate the informal sector in more industrialised nations, as according to Schneider and Buehn (2012). The main idea that is persistent in the literature is that the shadow economy is higher in emerging countries as there is a shortage of opportunities in the formal economy. Informal businesses are more likely to be replaced by new or existing registered businesses as the economy grows, rather than transitioning to the official sector.

3. Data and Methodology

The MIMIC model, which is a type of structural equation model with latent variables, was created as a measurement method for shadow economy (Fray and Week-Hannemann, 1984). It looks at the correlation structuring identifiable causes and criterion variables in order to figure out how they relate to a non-observable concealed variable. The MIMIC model is a good complement to the existing direct and indirect methodologies, since it is widely acknowledged that the shadow economy may be regarded as a latent variable. In contrast to the latter, its main benefit is that it distinguishes between causes and indicators, and, most importantly, it analyses the numerous causes of the shadow economy when measuring it. MIMIC models are frequently used to assess the size and evolution of the shadow economy over time, reflecting time series data. The problem with false regressions may develop because most macroeconomic variables do not meet the underlying assumption of time series analysis. Researchers commonly solve this challenge by using a different operator to turn the temporal series into stationary ones. If the variables were cointegrated and there was a fixed long-run connection between them, an error correction model (ECM) may be estimated instead. In recent years, this technique has gained popularity in applied economics. However, in MIMIC model examinations of the shadow economy, the previous technique is still applied.

Our research focuses on assessing the size of the shadow economy by utilising the Multiple Indicators Multiple Causes - MIMIC Model, to pinpoint the predictors and indicators of the model. Second, we determine the relationship between the informal economy (expressed as a % of GDP and as the total amount, in million euros) and the economic development (expressed as the growth of GDP based on year-over-year – YoY – analysis, and the total amount of GDP, in million euros). Therefore, the hypothesis we test is that the economic development is impacted by shadow economic activities. And if we confirm it, in which manner and how is the shadow economy at the level of the European Union? How large would the discrepancies between developed and developing countries be?

In our research, we study the shadow economy in the EU, taking into consideration all 27 member states at the moment of the study (Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden). The research was performed over a period of 12 years, from 2009 to 2020, and shadow economy data was based on the latest research available from Schneider (2021) and from the Eurostat and World Bank databases (data presented in Table 1).

Table 1. **Description of indicators (causes and predictors) of shadow economy**

Indicator	Definition	Unit of measure	Source
Direct Taxes	The percentage of direct taxes from the overall gross domestic product.	% of GDP	Eurostat
Indirect Taxes	The percentage of indirect taxes from the overall gross domestic product.	% of GDP	Eurostat
Social Security Contribution	The percentage of social security contributions from the overall gross domestic product.	% of GDP	Eurostat
Regulatory quality	An index that measures public opinions of the government's capacity to develop proper policies.	Estimate of governance (ranges from -2.5 to 2.5)	World Bank Data
Control of Corruption	An index that measures people's opinions of how much authorities uses its power for personal gain.		World Bank Data
GDP per capita	An indicator that estimates a country's economic development per person.	Annual, % in million Euros	Eurostat
Employment	The percentage of employment from the overall labour force.	% of Labour Force	Eurostat
Unemployment	The percentage of unemployment from the overall labour force.	% of Labour Force	Eurostat
Average Working Hours	The total number of average working hours calculated per week.	Total, per Week	Eurostat

Indicator	Definition	Unit of measure	Source
GDP per capita at Purchasing Power Parity (PPP)	The GDP divided by population and transformed to US$ by purchasing power parity rates.	GDP per capita, PPP ($)	World Bank Data

Before defining the MIMIC model for the most recent data available and test causality and regression analysis to observe the most influential indicators for the economy, we visually analyse the hierarchy of EU countries. Figure 1 depicts the level of shadow economy in Europe, from 2009 until 2020, based on a weighted average. The results revealed that the highest levels of shadow economy calculated as a percentage of GDP (Figure 1a) arise in developing countries from Central and Eastern Europe (such as Bulgaria, Czech Republic, Latvia, Poland, and Romania); however, we observed some highly developed countries with high values of shadow economy, such as France or Germany, which can easily be observed in Figure 1b. The countries that kept an overall low level of shadow economy throughout the years are Austria, Belgium, Denmark, Finland, Lithuania, and Malta. This proves that shadow economy is present in all EU member states, fluctuating its levels with economic development and, moreover, affecting smaller countries in development.

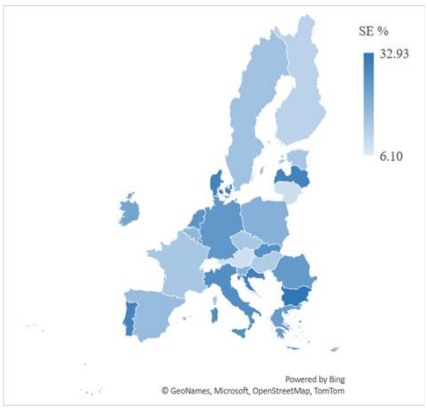


Figure 1(a). SE: % of GDP

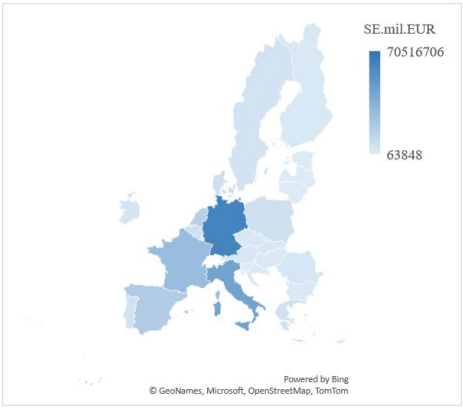
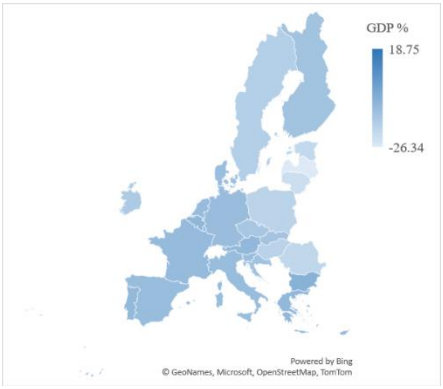


Figure 1(b). SE: total, in million Euros

Figure 1. Shadow Economy in EU, 2009-2020 (weighted average)
Source: authors' computation in Excel

Regarding the economic development indicators presented in Figure 2, we can observe that the growth in GDP based on a year-on-year (YoY) analysis (Figure 2a), is not as significant as anticipated. Our research period revealed that the EU member states did not have large discrepancies when looking from the perspective of developed and emerging countries. Most countries have maintained a growing trend during the period analysed, with negative values in 2012 and 2015. Greece is

the country with most negative values in regard with the GDP growing trend, followed by Italy. As expected, the most developed countries of the European Union registered the highest amount of GDP expressed in million Euros (Figure 2b), i.e. Germany and France, followed by Italy and Spain. On the other side of the spectrum, most countries that have a lower GDP are from the Eastern European region (e.g., Romania, Bulgaria, Greece, Hungary).



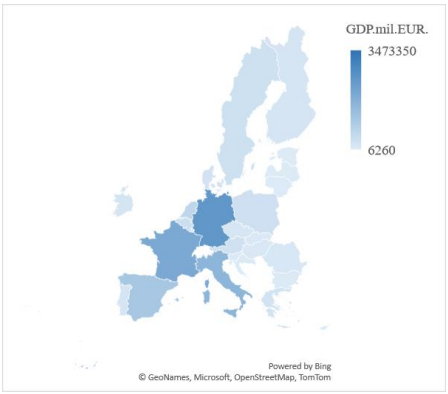


Figure 2(a). GDP: % growth YoY Figure 2(b). GDP: total, in million Euros

Figure 2. Gross Domestic Product in EU, 2009-2020 (weighted average)
Source: authors' computation in Excel

Overall, we observe that if the European Union consistently demonstrated economic differences among its member states, it is primarily due to the admission of new member states, with much lower levels of income than the EU average.

4. Results and Discussions

Informal activity is difficult to precisely assess because of its concealed nature, and hence the scale of the shadow economy has been measured using a variety of approaches. Tax auditing, surveys, and other regulatory procedures are used as direct approaches. Such techniques enable for the collection of extensive information on the underground economy's structure. However, the information collected may not be representative or consistent between nations. Indirect approaches, such as the difference between income and spending (in terms of the GDP) or the inconsistency between the money demand and actual money circulating are rather perceptive of underlying conjectures (i.e., money velocity, elasticity, etc.).

The MIMIC model approach conducted by the pioneers Frey and Week-Hannemann (1984) and further developed by Schneider in his research showcases the informal sector as an index with the causes and indicators presented briefly

above, which are also measured. The index is employed in two equivalences: firstly, as a variable in which the causes represent the explanatory variables, and secondly, as a descriptive variable for the indicators. These two equivalences are assessed together, and the final values of the index are utilised in order to calculate an approximation of the size of the underground economy, as a proportion of GDP. We also need to take into account that this approach has its flaws, such as the vulnerability to variations in data, sample, and preliminary values. The MIMIC model has been frequently utilised in the literature. However, its flaw is related to the combination of GDP and GDP per capita, as a cause variable, as Schneider (2016) presented in his research, and therefore we assumed one as a predictor and one as an indicator.

The target objective is to pinpoint the differences in shadow economy for developed and developing countries, as the hope is to foreshadow the large variance between the two. With this in mind, the estimators used were the ones from Schneider, with a few changes, more precisely for causes we substituted "Tax morale" with the "Control of Corruption" and the "Burden of state regulation" with Regulatory Quality; as for indicators the change was rather minor as we used "GDP at Purchasing Power Parity per capita" instead of "Change of local currency per capita". Driven by literature and previous models conducted by Schneider, we have chosen taxation, social security contribution, regulatory quality, control of corruption, unemployment rate and GDP per capita as causes, and average working hours, employment rate and GDP at PPP per capita as indicator variables. We may compare shadow economy estimates across nations and undertake panel data analysis using the MIMIC technique. While the MIMIC model has limitations and has received considerable criticism, its value lies in the dataset's large coverage and concurrent validity.

The results estimation for the MIMIC Model can be observed in Table 2 and Figure 3, both evidencing the influence of the causes over the shadow economy (Y in Figure 3), and the level of implications of the shadow economy over the indicators. They contain the estimates for all EU member countries. Moreover, all variables have the expected signs, similar to Schneider's model, only a few of them being insignificant from the statistical point of view (social contribution and control of corruption) as the p was higher than 0.1. The most important outcome is that all indicator variables (meaning average working hours, employment, unemployment, and GDP per capita at purchasing power parity) have high statistical significance. The indicator that is most affected by the informal activities is employment. We can say, with a 95% confidence level, that the employment as a share of GDP is decreasing with an estimate of -4.094. Another significant outcome of shadow economic activities is the increasing unemployment, with 2.387 for all European Union member states. It is worth mentioning that these estimates may be impacted by the discrepancies between developed and developing countries among EU member states.

Table 2. Predictor and Indicator Coefficients: MIMIC Model

				95% Confidence Interval		
Predictor	**Estimate**	**Std. Error**	**z-value**	**p**	**Lower**	**Upper**
Direct.Tx.	0.045	0.017	2.659	0.008	0.012	0.078
Indirect.Tx.	-0.073	0.027	-2.749	0.006	-0.126	-0.021
Soc. Contrib.	-0.012	0.018	-0.63	0.529	-0.047	0.024
Reg.Qual.	-2.519	0.267	-9.439	< .001	-3.043	-1.996
Ctrl.Corrup.	-0.04	0.101	-0.398	0.691	-0.238	0.158
GDP.capita	-0.027	0.008	-3.44	< .001	-0.042	-0.012
Indicator	**Estimate**	**Std. Error**	**z-value**	**p**	**Lower**	**Upper**
Avr.Wrk.H.	0.724	0.073	9.903	< .001	0.581	0.868
Empl.	-4.094	0.28	-14.643	< .001	-4.643	-3.546
Unempl.	2.387	0.169	14.104	< .001	2.055	2.718
GDP.capita.PPP	-0.277	0.16	-1.725	0.085	-0.591	0.038

Source: authors' computations in JASP software

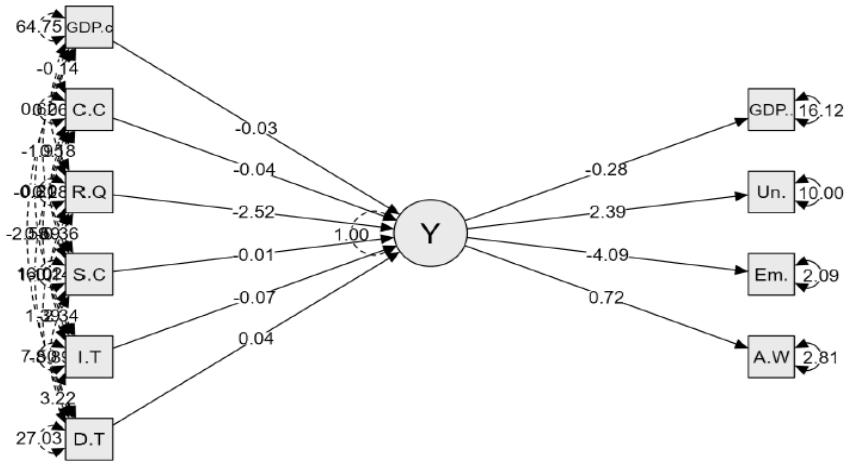


Figure 3. MIMIC Model for Shadow Economy in the EU
Source: authors' computations in JASP software

Nonetheless, our MIMIC approach needs to have further correction as the model is uncertain; the literature suggests that different models must be computed until a proper one is conducted and can be used further. Therefore, in order to move forward with our statistical analysis regarding the impact of shadow economy on

economic development, we have chosen the most recent data regarding the level of shadow economy provided by Schneider in his most recent 2021 paper. Based on Schneider's data, if we concentrate strictly on the European Union, the size of the informal sector from the GDP is approximately 19%, with the highest percentage in Bulgaria (38.5%) and the lowest one in Austria (with 7.55% of GDP on average).

Even though the size of the shadow economy is bigger than initially anticipated, the researchers of the IMF observed a falling trend until the COVID-19 pandemic's first stroke, especially in less developed countries. The initial decrease is not as significant per ensemble (from 17% to 16% as the average of the European Union), but was followed by an increase in 2020; however, taking into consideration the economic challenges that were upon us after the Financial Crisis in 2008, we can confidently say that the informal sector will slowly diminish in the following years. Going further with our empirical analysis, we assess the relationship between the shadow economy and economic development through causality and regression analysis. The granger causality results presented in Table 3 prove that the shadow economy is a strong cause of economic development. We tested both indicators as expressed in million Euros and also as a percentage (% of GDP for shadow economy and % change from the previous year for GDP). In addition, the causality is reflected as stronger when we consider the indicators measured in millions of euros.

Table 3. Granger causality tests between shadow economy (SE) and economic development (GDP)

	measures in mil. euros		measures in %	
W-bar	6.3723	2.9676	1.0436	0.3216
Z-bar (p-value)	19.7390 (0.0000)	7.2293 (0.0000)	0.1602 (0.8727)	-2.4926 (0.0127)
Z-bar tilde (p-value)	10.4966 (0.0000)	3.4043 (0.0007)	-0.6035 (0.5462)	-2.1075 (0.0351)
	H0: GDP does not Granger-cause SE.	H0: SE does not Granger-cause GDP.	H0: GDP does not Granger-cause SE.	H0: SE does not Granger-cause GDP.
	H1: GDP does Granger-cause SE for at least one panel.	H1: SE does Granger-cause GDP for at least one panel.	H1: GDP does Granger-cause SE for at least one panel.	H1: SE does Granger-cause GDP for at least one panel.

For regression analysis, we tested the influence of shadow economy on GDP, considering all the EU countries and also two smaller datasets, one consisting of the most developed countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, and Sweden) and another one for emerging countries (with the rest of the EU member states). The regression results are presented in parallel in Table 4.

Table 4. Linear regression analysis for the influence of shadow economy (SE) on economic development (GDP)

	measures in mil. euros			measures in %		
	all EU	**EU - developed countries**	**EU - emerging countries**	**all EU**	**EU - developed countries**	**EU - emerging countries**
SE	0.0468***	0.046***	0.0445***	-0.0010	0.0003	-0.0016**
t-stat.	52.97	28.67	52.47	-1.64	0.27	-1.99
Const.	59689***	143271.9***	28814.72	0.0239*	0.002	0.0337**
t-stat.	4.04	3.78	3.16	1.87	0.1	2.02
F-test	2805.36***	822.2***	2753.03***	2.68	0.08	3.96*
Adj. R-sq.	0.8967	0.8734	0.9313	0.0052	0.0078	0.0144
N	324	120	204	324	120	204

* p<0.05, ** p<0.01, *** p<0.001

The R-squared evidences a significant model for describing the relationship between the shadow economy and economic development when both are expressed in million euros. Its value is 0.89, confirming a direct relationship between these indicators. In addition, the regression coefficient of the shadow economy is statistically significant at 1% level for the EU and also for the two datasets consisting of developed versus emerging EU member states, with small differences across the coefficient values. In terms of the adjusted R-squared, we observe that the changes in the level of the shadow economy can explain a little bit more of the changes in GDP when compared to the developed countries. Based on these significant relationships, at the European level, we assume that when the GDP is growing, the level of the shadow economy is growing as well, but also increasing informal activities within an economy, which might lead to better economic development.

5. Conclusions and Policy Implications

The first objective was to offer a clearer view of the implications of the shadow economy and how to measure it at the level of the European Union, through the MIMIC Model, considering the shadow economy as a latent variable. The analysis emphasised several causes, such as the tax system, corruption, the quality of public authorities, and economic growth. The research met some limitations in the literature, especially regarding the usage of the MIMIC Model when estimating the size of the shadow economy at a smaller level, i.e. the European Union. As observed from previous statistics obtained by Schneider (2016, 2018, 2019, 2021), the informal sector has its peaks in emerging economies, such as Bulgaria (which has the highest level of the shadow economy, i.e. 32.93% of the GDP, registered for

2020), followed by most Eastern European Countries. Our results may be seen as complementary to the studies realised by Schneider and Buehn (2012), Schneider (2016), or Medina and Schneider (2018). Although these adopted a similar approach to the MIMIC Model, their data sample and research period were larger and therefore needed more correction coefficients.

The size of the informal sector has decreased across the European Union in recent years, but is still considerable, with an average of 19% of GDP over the 2009-2020 period. Since the 2008 Financial Crisis, when shadow economies have peaked in most countries, there has been a decline in most member states. Nonetheless, in developed economies, the level of the shadow economy accounts for 10 to 20% on average, whereas in developing countries (such as East-European countries), it accounts for almost 30% of the GDP. The second objective was to present the direct relationship between the shadow economy and economic development, whilst trying to determine whether or not there is a clear connection between these two. We observed that this relationship is rather uncertain and fairly sensible to the time span and the size of the study conducted. When taking into account the shadow economy and economic development expressed in million euros, we obtained a strong connection between the two, with a direct influence. Accordingly, we could state on a 95% confidence level that when the GDP is growing, the level of the shadow economy is growing as well, but also increasing informal activities within an economy, might lead to increased economic development. However, the analysis with shadow economy as % of GDP and economic development as % change from the previous year returned a Pearson correlation that was not statistically significant.

Our analysis contributed to the literature by emphasising the fact that the shadow economy in the EU is still significant, but its implications and repercussions are uncertain. By highlighting the importance of shadow activities inside the formal economy, we provide the starting point for the policymakers to consider informal activities further when designing and developing policy regulations. As a result, our findings may be used to improve the efficiency of authorities when judging the complexity of the shadow economy sector. A variety of policies should focus on the most important variables in each country. Income per capita is highly and inversely connected to the size of the informal sector, and more effective institutions would play a major role in accomplishing development goals. Better tax administration, reduced regulatory burdens, and increased openness would lessen the incentives for illegal activities.

It is widely acknowledged that more qualitative regulators create more equitable and long-term prosperity and seek economic development. To address blockages in the business climate, promote the rule of law, improve government performance, and combat corruption, regulatory and institutional changes are necessary. Measures intended to increase revenues may also aid in the reduction of the shadow economy. Implementing initiatives in order to strengthen fiscal transparency and public management can improve citizens' perceptions of regulatory quality and the link between revenues and expenditures, resulting in increased compliance behaviour. Tax avoiders might be publicly identified, with direct

participation of trade associations, advisory programs, clear information on areas of noncompliance, follow-up audit programs, and conviction of the worst offenders are all examples of industry-based measures that might be beneficial. In terms of the quality of their legal systems and private property, most developing countries still fall behind developed EU member states, and institutional quality progression has been inconsistent among countries. Although baseline circumstances (such as resource allocation) and external variables (such as EU membership) are significant, policies aimed at increasing public administration quality, openness, and accountability contribute to establishing positive feedback among EU citizens.

Optimising the collection, audit, and registration process might also increase the level of tax compliance. The process of registration can be improved by simplifying the informational framework among governmental authorities. Another policy that could curtail informality within an economy would be the automatisation of fiscal procedures. By simplifying the tax system and the social security system, the tax compliance costs will be reduced without reducing tax rates, hence economic growth will also follow. It is possible to enhance collections and decrease VAT fraud by advocating online payments. Several governments have recently made it mandatory for firms to record payments and money transfers using fiscal instruments.

Although the possibility of development in tax administration differs throughout Europe, most nations are focusing on issues such as poor automation of procedures, organisational structure, and operational effectiveness. An efficient policy framework should address those working in the underground economy, in order to determine them to shift to the formal sector, particularly in the member states where informal and shadow activities act as an incentive for the "social safety net". Lowering the administrative and regulatory costs, encouraging transparency and enhancing government performance, as well as strengthening tax compliance, automating activities, and encouraging online payments, are among the most important policies to improve economic development as well as to reduce shadow economy activities. Additionally, public policies which focus on the private sector and human capital development would assist both employers and employees out of the informal sector by encouraging inclusive growth.

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IS FISCAL POLICY ONE OF THE MOST IMPORTANT SOCIO-ECONOMIC DRIVERS FOR ENTREPRENEURIAL ACTIVITY IN EUROPEAN UNION COUNTRIES?

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Abstract. This research highlights the extent to which fiscal policies, along with government effectiveness, trade, economic growth, and education, influence the entrepreneurial environment, starting from the assumption that the effectiveness of public policies and the public administration support for entrepreneurship has proven to be a trigger for development and a means of reducing social inequalities and increasing well-being. Our analysis is based on a panel threshold regression model, which returns parameters for the predictors, in which there is a changing point in fiscal policy as the threshold variable on entrepreneurship activity. The database consisted of annual data from 2002-2019, referring to the European Union's member states, presented visually based on the data mapping process to evidence the hierarchy of the EU countries for each of the analysed phenomena. Our results evidenced tax policy, trade, and government effectiveness as significant influential factors in stimulating entrepreneurship in EU countries. Although GDP growth and education positively influenced entrepreneurial activity, the statistical tests did not confirm it. Therefore, Governments can encourage entrepreneurial opportunities through harmonised tax legislation with EU regulations and a lighter regulatory burden and policies that foster competition, lower taxes, increase transparency and provide open access for all businesses.

Keywords: fiscal policy, governance, education, entrepreneurship, dynamic panel threshold model, European Union.

JEL Classification: H21, H32, C24

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Introduction

Since the beginning of this century, the objectives of the European Union have focused on strategies related to entrepreneurship: creating a prosperous business environment and a positive attitude in society towards new businesses, developing education in entrepreneurship and promoting entrepreneurial culture, setting up a support fund and facilitate the access to finance for new businesses and those trying to create. These strategies and principles were set up by the "Small Business Act" for Europe (Commission of the European Communities, 2008) to bring added value at the EU level and improve the legal and administrative environment while considering the role of SMEs as central in the EU economy. Recently, the "Entrepreneurship Action Plan 2020" went forward towards building a prosperous business environment, supporting entrepreneurship by reducing administrative burdens, facilitating access to finance, and highlighting entrepreneurship's social and environmental impact. Overall, the latest focus of the EU legislation and policies promoting entrepreneurship was on supporting entrepreneurship education and training (Xavier, 2013).

The literature on developing public policies promoting entrepreneurship is vast in countries worldwide. The efficiency of the public policies and the support from public administration towards entrepreneurship triggered economic development, technological progress, competitiveness, and means of reducing social inequalities and increasing well-being (Dima et al., 2016). The concept of well-being and its relationship to businesses has been promoted for a long time in terms of welfare entrepreneurship for regional and economic development. And even though there are certain dichotomies between the public and private sectors, we may observe common ideologies for welfare provision and efforts to ensure the delivery of goods and services, including public and social ones, from public authorities and markets to citizens and society. We can refer to income growth and higher employment in regions with an environment supporting entrepreneurship and areas providing more significant support from channelling public resources to welfare. In developmental states, the local authorities acted as effective agencies for the social and economic development of an area; the entrepreneurial states are the revived version, activating the institutional response and proving adaptability as a response to market opportunities, especially for emergent markets, in need for foreign investors (Blecher, 1991; White, 1996). Overall, taxes influence the activities and performance of companies to such a great extent that taxation may be considered to have an even more substantial influence on entrepreneurship than public spending. Therefore, the subject of how fiscal influences entrepreneurship has become an interesting research setting. In this regard, De Schoenmaker et al. (2014) affirms that local taxes can hamper the company's financial performance. Accordingly, more recent studies proved local taxes' negative impact on those regions' financial performance, firm performance or employment growth (Gatsi et al., 2013; Fang et al., 2022). Still, they indicated that aggregate public spending, supporting infrastructure, education, or safety, increases firm profitability (Duranton et al., 2011; De Schoenmaker et al., 2014).

The economic theories developed over time, referring to fiscal policies and performance, productivity, or business sector development. If firms react differently to taxation, a flexible corporate tax and investment model is expected based on specific features such as size or

economic activity. For example, small companies rely on retained profits, while large companies may easily access borrowed funds. If the level of taxes on profits indirectly influences the net profits earned by companies, fiscal policies supporting investments and business development would be the key to an entrepreneurial environment. The Schumpeterian "creative destruction" concept, linked to the fact that economic development comes as a natural result of open markets, dynamic processes and profitable opportunities, brought a new taxation theory based on aggregate productivity growth, resulting as a consequence of the replacement of low-productivity firms by the new businesses, or by those that manage to survive based on consistent productivity (Peretto, 2007).

Overall, especially for new businesses, taxes influence the risks undertaken by entrepreneurs, subject to two types of taxes, tax on capital and tax on labour income. Therefore, if tax policies may influence the entrepreneurs' decisions to start their businesses or not, the economic theory suggests that higher tax rates constrain entrepreneurial activity. Still, the tax code might support the private sector in employing special treatment for losses or capital investments. Of course, the effectiveness of fiscal policies makes the difference across countries and times (especially in times of financial instability). This is why investigating the government expenditure, tax revenue, GDP growth, trade, and level of education concerning entrepreneurial activity in terms of threshold makes this research innovative, going beyond the study of one state to the level of the European Union.

Based on these underpinnings, the general objective pursued in this research is to assess the influential factors for entrepreneurial activity, especially in terms of fiscal policies, as well as how these factors can positively or negatively influence entrepreneurial activity in the EU Member States, with essential spillovers on supporting sustainable entrepreneurship development.

The methodological endeavour embeds a complex procedure, with a detailed analysis of the EU-27 Member States, and an advanced econometric technique, respectively, the single threshold regression model based on Hansen's panel threshold regression model, over the period 2002–2019. Hence, this paper explores the relationship between the socio-economic drivers for entrepreneurial activity, with an emphasis on fiscal policy. Based on these facts, it can be argued that our research is set to bring new evidence on the perspective of the development of entrepreneurial activity in terms of fiscal policies. Furthermore, our paper enriches the existing literature with an integrative, updated and complex assessment of the relationship between entrepreneurial activity, fiscal policy that comprises government expenditure and tax revenue, GDP growth rate, trade, education attainment, and government effectiveness.

Based on advanced empirical analysis, we chose to analyse the panel of 27-EU Member States since there is a wide array of specific and complex differences among them by capturing the dataset that covers the timespan between 2002–2019, is compiled based on the chosen variables. Moreover, our research examines the effects of fiscal policy on total entrepreneurial activity, also adding some specific variables in order to capture certain credentials in addition to the ones comprised by fiscal policy, respectively government expenditure and tax revenue, as follows, for example, GDP growth rate, trade, education attainment, and government effectiveness. Therefore, our paper contributes to the existing literature with a double

perspective: (i) new insight on the level of all included variables among the EU-27 countries with a complex graphical representation through data mapping; and (ii) based on updated data, the paper assesses the influences of fiscal policies, along with several variables carrying potential impact, respectively GDP growth rate, trade, education attainment, and government effectiveness on total entrepreneurial activity. Additionally, the results can sustain future research, promoting the understanding of the discussed topic, and being able to contribute to new fiscal policies that support entrepreneurial activity and economic growth.

This paper consists of several sections. Following this introduction, the second section considers a brief review of the literature on the relationship between public policies, emphasising fiscal policy and entrepreneurial activity. The following sections refer to data, methodology and the main results obtained for panel data of EU member countries. The fifth section concludes by offering several recommendations and policy implications.

1. Literature review

In recent years, decision-makers' attention has led to entrepreneurship determinants, especially in the actual context of a turbulent economic environment characterised by financial and economic crises. Research studies put the spotlight on fiscal policy since it has become a fundamental tool for entrepreneurial activity (Djankov et al., 2010; Harju & Kosonen, 2012). Furthermore, entrepreneurial activity entails the need for government interventions, leading to expansive fiscal policies that can stimulate business activities and aggregate demands (Cumming & Li, 2013; Cullen & Gordon, 2007). We will focus on the relationship between fiscal policy and entrepreneurship, but the literature presents various influential factors for entrepreneurship, helpful in analysing the main relationship described.

In reference to fiscal policy and the development of entrepreneurship, Keynesian economics considers aggregate spending (consisting of business investment, consumer spending, net government spending etc.) as a driver for economic growth and performance. Governments may adjust spending and tax policy to cover the shortfalls in the private sector, which stabilises the business cycle. The tax smoothing theory (Barro, 1979) predicts that government spending increases during booms and decreases in recessions. Accordingly, the government should smooth tax rates and finance the temporary difference between tax revenues and government spending (borrowing in recession and repaying in boom periods). Tax policy became a key factor for startups and corporate investment decisions, reflecting the willingness of investors or companies to engage in risky situations. Therefore, a neutral tax policy, simpler and more efficient for taxpayers, could remove some of the barriers for entrepreneurs and the dynamism in entrepreneurship.

The recessions induce a shift toward progressive taxation to collect more fiscal revenues. However, flat tax rates are usually considered to simplify the enforcement of the tax system and the compliance of contributors. Following the financial crisis of 2009, the European Union established a strict framework in terms of fiscal policy, updating most fiscal rules and applying various fiscal criteria for all European Union countries, along with a set of initiatives that aim to foster and stimulate many essential pillars, especially entrepreneurship and economic growth. Previous research found evidence of a moderate influence of corporate taxes

on firm births (Duranton et al., 2011; Da Rin et al., 2011; Brülhart et al., 2012). More recently, studies proved that simplifying the tax code and not necessarily reducing the corporate tax brackets would promote entrepreneurship. In addition, tax progressivity is preferred by risk-takers and may be appealing to some entrepreneurs. New firms are indicators of a dynamic entrepreneurship environment and are more likely to rise in large municipalities, regions developed in terms of infrastructure, or those with higher levels of public expenditures. Successful tax reforms are linked to lowering the average tax burden, especially the one related to corporate income, but maintaining tax progressiveness which positively influences the birth of new firms (Bacher & Brulhart, 2013). Additionally, Ono (2019) suggests the need for a debate focusing on the most effective and adequate fiscal policies that will bring important benefits to the entire economy of the EU member states. Accordingly, the EU countries have been differently impacted by the fiscal policy (Busch et al., 2013), and following the crisis, there has been a need for a new policy agenda which involves more support for entrepreneurship leading towards economic growth (Szabo & Herman, 2012; Copeland & James, 2014). Since 2013, the corporate tax policy in the EU has shifted its focus from avoiding double taxation towards better governance and anti-abuse legislation for aggressive tax planning, tax avoidance, harmful tax competition or transfer pricing (Roland, 2019).

Reconsidering the existing fiscal problems and preventing tax evasion through tax reforms ensures the long-term sustainability of the public finances. The dynamics of public debt and reduction in government expenditures should ensure an efficient allocation of public resources, increased tax revenues based on better tax collection with greater tax compliance, and reduced corruption. Especially for emerging countries, harmonising the tax legislation based on the EU regulations helps increase competitiveness at the national level (Hackler, 2012). In addition, investment in education and infrastructure increases national competitiveness, a critical factor in emerging markets to absorb technologies from abroad (Lunina et al., 2020). This knowledge may be transferred to small businesses, and entrepreneurial activity can bloom with preferential tax treatment for these companies. Tax incentives or enhanced deductions for innovation or R&D costs could be significant fiscal measures that strongly impact development and entrepreneurship over the medium and long term.

Public underfunding may constrain economic growth and inhibit human development due to underbudgeting education or health systems, negatively affecting economic development and fiscal perspective. However, effective governance is linked to engaged entrepreneurship, as citizens are more willing to take risks and invest in new businesses when governance ensures specific political, social, and economic conditions that favour development (Parker et al., 2012). Fiscal policies were also proven to enhance citizens' well-being by ensuring equal distribution of capital through progressive taxation in terms of incomes and securing full employment and additional help for citizens who cannot provide for themselves, supporting the welfare state idea (Vatavu et al., 2019).

Martínez-Rodriguez et al. (2019) evaluated the economic factors, along with a series of socio-cultural drivers, that can have relevance and influence on total entrepreneurial activity. In this light, the authors examined and explored a sample of 32 countries, considering two different periods, one pre-crisis and the second one with the recovery period. The results suggest that expansive fiscal policy should relate to education improvements and reducing

the tax burden, while total entrepreneurship activity is largely explained by both the necessity and opportunity drivers of entrepreneurship. In addition, the authors found significant implications to support the design of effective and specific policies to promote entrepreneurship and successfully contribute to economic growth.

Leitão and Capucho (2021) engaged a series of determinants of entrepreneurial activity, as follows: (i) institutional; (ii) economic; and (iii) socio-economic factors. Results suggested the need for new efficient public policies, encouraging a high level of entrepreneurial activity, along with correct measures that the policymakers could implement. More specifically, trade produces a positive and significant effect on entrepreneurial activity, being able to stimulate and create more entrepreneurial activity. In addition, the authors evidenced a need for new public policies oriented on different competencies, valences, and skills for entrepreneurship and viable measures designed to strengthen institutional effectiveness and improve institutions' quality.

Depending on the business cycle phases, previous studies also evidenced a specific behaviour for total entrepreneurial activity – driven by necessity or opportunity (International Monetary Fund, 2016). The necessity entrepreneurs are those who start a business because they have no other jobs available, while opportunity entrepreneurs undertake an opportunity for a new business, also having a strong desire to be their manager and develop new products or services. In the first case, entrepreneurs may set their work in a primary environment, with less human capital and lower-income regions, while the second type is often described as having higher levels of education and needing to discover business opportunities with agility. For necessity entrepreneurs, in times of expansion, fiscal policies should promote tax burden reduction and education improvement. During crisis and recovery periods, fiscal policy should not establish other tax burdens, especially for entrepreneurs with low incomes and no job alternatives. The government should reduce interest rates, especially for opportunity entrepreneurs who want to expand. Regardless of these two, the level of education, creativity, and social skills are all essential for the success of the entrepreneurs' businesses (Parker et al., 2012). Education is also significant for social mobility, reducing income inequalities, catalysing and fostering business creation, and directly influencing economic growth (Tsapko-Piddubna, 2021). Although the level of education may be crucial for entrepreneurs to be able to acquire skills and possess knowledge, strong abilities have a role in ensuring business success (Peña et al., 2014). Consequently, the decision to become an entrepreneur is not necessarily influenced by the level of education (Grilo & Irigoyen, 2006) but is more dependent on other capabilities, like social skills (Baron & Markman, 2003) or creativity skills (Weitzel et al., 2010). Besides education, tax system and fiscal policies, we expect a significant impact on entrepreneurship from better governance, whilst effective governance is connected to people's positive intentions in engaging in entrepreneurship and creating a new business under favourable political, economic, and social conditions (Van de Ven, 1993).

Fiscal policy and entrepreneurship also seem sensitive to the harmonisation of taxation. In a recent study on the Economic and Monetary Union (EMU) countries, Liargovas et al. (2022) clearly pointed out that the existing literature sustains two major directions, respectively that fiscal stability carries a positive effect on entrepreneurship and competitiveness and an increase in public debt has no impact on growth rates. In this light, due to the de-

pendence on national policies, a special focus should be on entrepreneurship and competitiveness rather than fiscal convergence and balance. Dima et al. (2013) emphasised that the democratic framework, legal basis, and social fairness are the most critical factors supporting entrepreneurship within the European Union Member States. Although the EU preserves an open but unified market, political crises, economic uncertainties, or labour market rigidity all inhibit entrepreneurial activity. However, perceived opportunities and capabilities strongly encourage private sector development based on public institutions' intellectual capital and governance efficiency.

At a national level, entrepreneurial activity is correlated with the economic development of countries (Carree et al., 2007; Freytag & Thurik, 2007; Wennekers et al., 2008). Moreover, economic growth has a particular priority in the Sustainable Development Goals set up by the Agenda 2030 (Garcia et al., 2020): it is now linked to sustainability to reduce the gaps and inequalities between regions and countries. Tax benefits or specific tax treatments may offer protection of profits or other advantages to increase attractiveness for businesses with expansion and growth opportunities, setting up a framework for sustainable development in line with the economic, social, and territorial cohesion to reduce disparities in wealth and development between the regions. In addition, the government increased its role in encouraging firm productivity, setting up tax policies that support capital or R&D investments or other means of enhancing productivity through investments. These measures seem to impact large firms more, as small businesses have a lower productivity gap. Due to the heterogeneous effects of taxation across countries and firms, tax should be treated as related to small or large firms, primarily based on the companies' rate of productivity growth (Gemmel et al., 2018; Garcia et al., 2020).

The residential location also dramatically impacts the decision to set up a business, particularly for entrepreneurs. For example, new start-ups are often home-based, especially when linked to e-commerce or affordable information technologies, as the statistics indicated after the recovery from the recent financial crisis; in the USA, in 2012, approximately two-thirds of the new businesses started by the owners' homes. In addition, local fiscal decisions targeting entrepreneurship and small firms influence regional development by helping small businesses grow (Guo & Cheng, 2018). But even previous research on entrepreneurs' choice of new business locations also indicated their tendency to keep their business in the residential areas to cut labour costs (Figueiredo et al., 2002; Stam, 2007). These are all subject to the Tiebout competition model (Tiebout, 1956), according to which citizens, as consumers of public goods, will choose to settle and consume the public goods from the region in which they pay taxes. Considering this model for companies, we expect start-ups to bloom and operate in countries or regions where local taxes are in their favour. Foreign direct investments from multinationals seem to support economic development, while an increase in the number of new businesses will reflect, over the long run, lower unemployment, increased demand, and consumer spending (Acs et al., 2007; Anyadike-Danes et al., 2011).

With these strong influences from entrepreneurship on economic and social development, policymakers at all levels should set up a framework for an ecosystem of innovation and entrepreneurship, ensuring economic recovery, sustainability, regional transformations, and job creation (Tiebout, 1956). Moreover, innovation is an essential factor in economic

growth and entrepreneurship. And although entrepreneurship and innovation may both be considered a source of tax, local governments should look for means of creating and incentivising the risk-takers, making public and private funding available for entrepreneurs and small and new businesses, increasing the capacity of the local economies to absorb innovation. Likewise, mitigating the comprehensive effects of the Covid-19 pandemic crisis requires taking appropriate decisions. Regarding this aspect, Braunerhjelm (2022) highlights the need to adopt measures aimed at innovation, the effort to modernise and update knowledge and entrepreneurial processes in the context of the current crisis caused by the COVID-19 pandemic. Furthermore, the author proposed a realignment in terms of policies, not only at the micro level but also at the macro level, aiming at increasing the potential of economic growth and the rethinking and resilience of economies that followed the crisis, along with the need to reactivate fiscal policies.

Furthermore, the business environment characterised by corruption, uncertainty and constant change of fiscal policies leads to the reluctant attitude of entrepreneurs who want to employ resources under conditions of good governance and rational policies that allow the creation of a stable business environment. Withal, Lobonț et al. (2022) attested that although improving the level of education can stimulate entrepreneurial activity, there are still various factors, such as governance effectiveness, that can have a negative effect on entrepreneurship, a fact caused by the existence of the multitude of barriers to entrepreneurship that are characterised by excessive regulations and taxes that hinder the motivation of entrepreneurs and their predisposition towards entrepreneurial activity. Under certain circumstances, on the one hand, the business innovation process can be boosted (a positive impact) by corruption, and on the other hand, corruption can have a negative impact on company innovation (Pirtea et al., 2019). Hence, the support of public administrations, along with effective public policies, can stimulate entrepreneurship. Regarding this aspect, Costea et al. (2022) applied a scientific data mapping analysis evidencing the relationship between public policies and entrepreneurship.

After overviewing the literature on the topic, we propose two research hypotheses:

Hypothesis 1. Fiscal policy, along with government effectiveness, trade, economic growth, and education, can encourage people to start businesses and stimulate entrepreneurial activities overall.

Hypothesis 2. After reaching a certain level, fiscal policy may negatively influence entrepreneurial activity.

Acknowledging the various indicators with potential impact on entrepreneurship, we expect entrepreneurial activity to be significantly impacted by government expenditures and tax revenues, supporting its development through the allocation of public funds and favourable public policies. We also expect education to play a vital role in entrepreneurship, as highly educated individuals would be more successful in their entrepreneurial activities. Considering that good performance of the economy and government would propel entrepreneurship, we also add in our analysis proxies of trade, economic growth, and government effectiveness, expecting significant positive influence towards the development of the entrepreneurial activity.

2. Methodology

2.1. Data

We consider total entrepreneurial activity (EA) to proxy the entrepreneurial activity as the dependent variable. Pinillos and Reyes (2011) presented this indicator as the most representative one to reflect the entrepreneurial phenomenon within an economy, being retrieved from the Global Entrepreneurship Monitor (GEM). EA is specific to countries and represents the percentage of individuals between 18 and 64 who are actively engaged in starting or managing a new business. According to Bygrave et al. (2003), if individuals are involved in both starting and managing new businesses, they are counted only once. The threshold variable is fiscal policy, including government expenditure and tax revenue. These variables were chosen as fiscal policy refers to the efficient use of government spending and public policies related to taxation that influences macroeconomic conditions related to the demand, inflation, employment, or economic growth (Mankiw, 2014; Taylor, 2017).

The control variables refer to GDP growth, trade volume (as % of GDP), education, and government effectiveness. Although entrepreneurial activity refers to the individual level, it also relies on the business environment and macroeconomic conditions. Accordingly, we expect good governance and healthy economic situations to propel entrepreneurial activity. Higher economic growth rates should signal higher investment returns and attract people to start a business. Also, international trade should positively impact entrepreneurial activity. However, in developing countries, previous research (Acs et al., 2008) highlighted a negative relationship between entrepreneurial activity and economic growth. While human capital was proven to support entrepreneurial activity (Burton-Jones & Spender, 2011), we expect education to play a vital role in accumulating human capital and, therefore, a strong relationship between education and the level of entrepreneurial activity. The government's effectiveness reflects perceptions of the quality of different dimensions (i.e., public services, civil service, policy formulation and implementation) and the credibility that the government inspires regarding its dedication to the promoted public policies.

Hence, the analysis is made for the 2002–2019 period, capturing three different types of variables, as follows:

i) total entrepreneurial activity (EA) as a dependent variable;
ii) fiscal policy comprising government expenditure and tax revenue for threshold variable;
iii) GDP growth rate, trade, education attainment, and government effectiveness as control variables.

The summary statistics of every variable (Table 1), and the graphical representation (Figure 1) of the dependent (EA), threshold (government expenditure and tax revenue) and control variables (GDP growth rate, trade, education attainment, and government effectiveness) were processed in Stata. According to the p-values of Skewness, Kurtosis and Shapiro-Francia tests in Table 1, all the variables in our analysis are subject to the non-normal distribution.

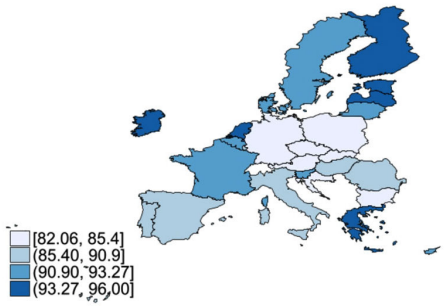
Table 1. The summary statistics of the variables in the overall data sample (EU-27, 2019) (source: authors' own process in Stata 17)

Variables	Mean	Standard Deviation	Min	Max	Skewness	Kurtosis	S-W test (p-value)
EA	89.71	4.33	82.06	96.00	–1.28	4.48	0.00
Government expenditure	42.43	6.82	25.36	55.38	–0.45	5.21	0.00
Tax revenue	21.48	4.80	11.49	34.04	2.41	13.96	0.00
GDP growth rate	2.72	1.43	0.34	5.55	–0.37	9.22	0.00
Trade	1.39	0.69	0.60	3.82	1.89	7.31	0.00
Education Attainment	1.14	0.20	0.89	1.56	1.74	5.97	0.00
Government effectiveness	1.05	0.55	-0.28	1.94	–0.14	2.43	0.00

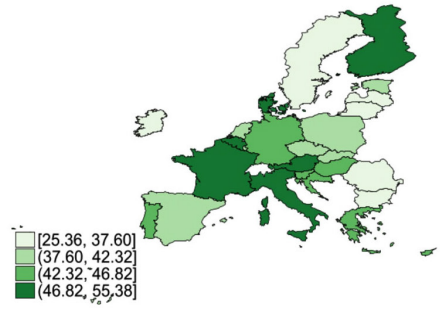
Note: The S-W test denotes the Shapiro-Francia test (Shapiro & Francia, 1972) examining the data normality. For a p-value lower than 0.05, we reject the null hypothesis of normality.

To comprise the hierarchy and to highlight the specificity of the variables included in our model at the level of EU Member States in 2019, a data mapping technique was applied, as presented in Figure 1. This graphically highlights the total entrepreneurial activity (EA) (a), government expenditure (b), tax revenue (c), GDP growth rate (d), trade (e), educational attainment (f) and government effectiveness (g) in 2019 for the EU-27 states. The most significant total entrepreneurial activity (EA) occurs in Finland, Latvia, Estonia, Netherlands, Ireland, and in Greece. On the opposite side, we can see countries like Slovakia, Poland, the Czech Republic, Austria, Croatia, and even Germany, registering the lowest proportions of total entrepreneurial activity (EA) in the EU-27.

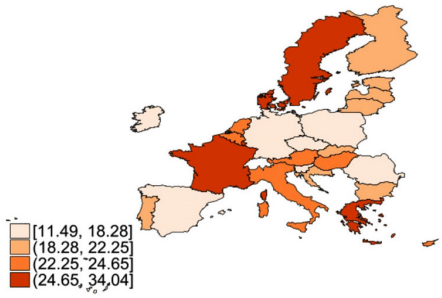
In reference to government expenditure, the graphical representation highlights that this variable has the highest level in Denmark, Finland, Italy, Austria, France, and Belgium. Furthermore, the medium values were registered in Germany, Hungary, Croatia, and Slovenia. Government expenditure was at the lowest level in Ireland, Sweden, Lithuania, Romania, and Bulgaria in 2019. Tax revenue maintains high levels in countries like Sweden, Denmark, France, and Greece. The lowest tax revenue in relation to the EU-27 average occurred in Spain, Romania, Poland, the Czech Republic, Germany, and Ireland. We observe that the GDP growth rate has prominent values that occur in many European Union countries, namely Hungary, Poland, Lithuania, Estonia, and Ireland. With reference to the trade variable, the highest degree was registered in Hungary, Slovakia, Belgium, Ireland, and also Spain, Netherlands, the Czech Republic, Lithuania, and Estonia. Moreover, the lowest values within the EU-27 in 2019 were observed by Italy, France, Germany, Finland, Romania, Greece, and Portugal. Furthermore, educational attainment was notable within the EU-27 in 2019 (particularly in Sweden, Finland, Denmark, Ireland, Belgium, and the Netherlands). Along the same lines, the lowest values of education attainment were observed in several countries, such as Slovakia, Austria, Romania, Bulgaria, and Croatia. Moreover, government effectiveness presents the highest value in Finland, Sweden, Germany, Denmark, and the Netherlands.



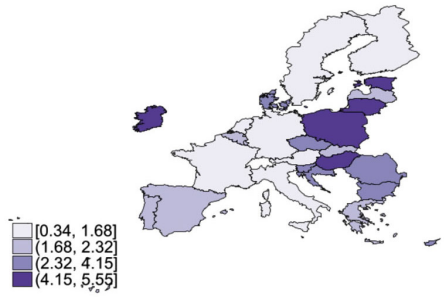
a) total entrepreneurial activity



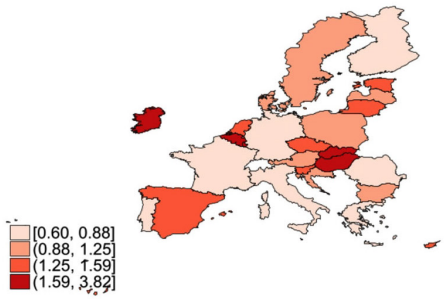
b) government expenditure



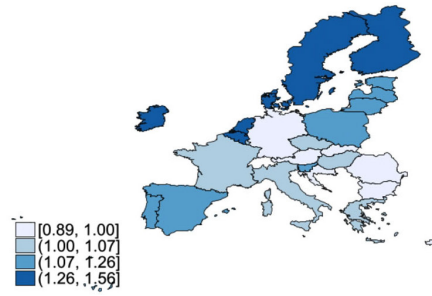
c) tax revenue



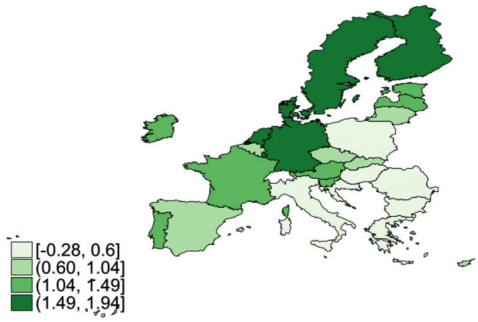
d) GDP growth rate



e) trade



f) education attainment



g) government effectiveness

Figure 1. a – Total entrepreneurial activity (EA); b – Government expenditure; c – Tax revenue; d – GDP growth rate; e – Trade; f – Education attainment; g – Government effectiveness levels in 2019, European Union (EU)-27 (source: own process in Stata 17)

On the other hand, the lowest values were found in Italy, Romania, Bulgaria, Greece, Poland, Croatia, and Hungary.

From the perspective of time and frequency domains, the annual data of Total entrepreneurial activity (EA), Government expenditure and Tax revenue from 2002 to 2019 are plotted in Figure 2. The variables present non-linear attributes, which provides the inspiration to employ the non-linear causality test method to investigate the relationship between fiscal policy and entrepreneurship activity.

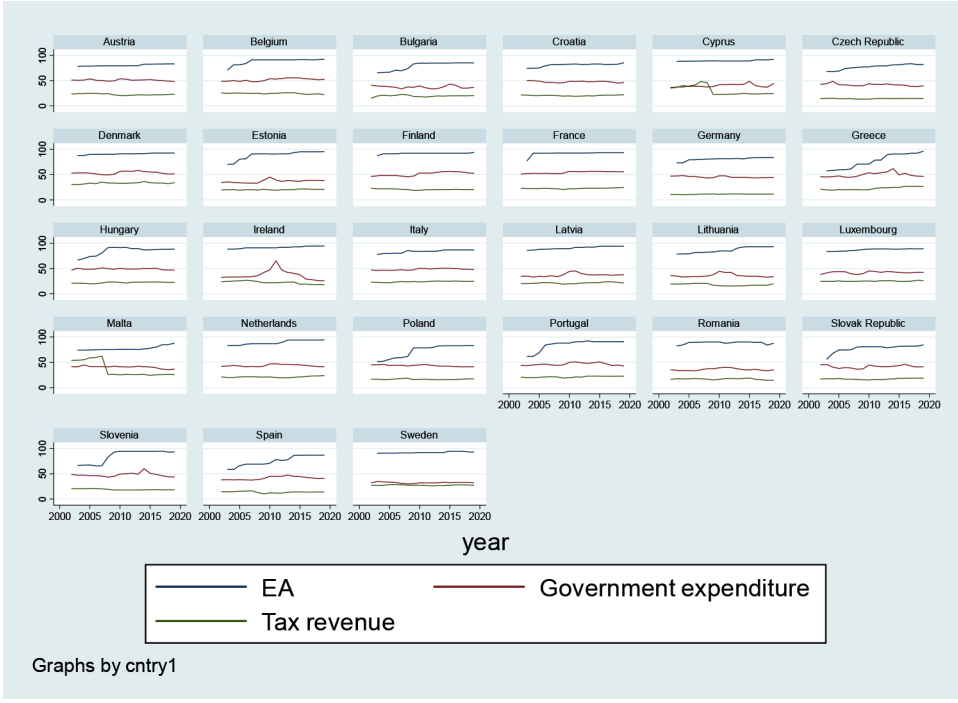


Figure 2. The trends of Total entrepreneurial activity (EA), Government expenditure and Tax revenue in the European Union (EU)-27 (source: own process in Stata 17)

In this framework, along with graphical representation, at the level of EU-27 member states, there is an urgent need to reinforce the existing level and connection between total entrepreneurial activity and fiscal policy, in general, and, in particular, its relation to education attainment, government effectiveness, GDP growth rate, and trade.

Table 2. Description of proxy variables employed in the analysis

Index	Description	Source
Entrepreneurial activity	The number of adults per 100 "who are either a nascent entrepreneur or owner-manager of a new business"	Global Entrepreneurship Monitor
Government expenditure	General government expenditure (% of GDP)	World Development Indicators
Tax revenue	Tax revenue (% of GDP)	
GDP growth rate	GDP growth (annual %)	

End of Table 2

Index	Description	Source
Trade	"The sum of exports and imports of goods and services, measured as a share of GDP" (% of GDP)	
Education attainment	School enrolment, referring to "number of students enrolled in secondary education regardless of age by the population of the age group which officially corresponds to secondary education" (% gross)	
Government effectiveness	The perceptions of the quality of public services	World Governance Indicators

Note: data sources are available on the websites: https://www.gemconsortium.org/, https://databank.worldbank.org/source/world-development-indicators, and https://databank.worldbank.org/source/worldwide-governance-indicators

The sample period ranges from 2002 to 2019, on an annual basis, and the indicators refer to the countries of the European Union. The data was collected from several independent sources, as described in Table 2.

2.2. Research methods

Because of the non-linear distribution characteristics of the variables, we consider the panel threshold regression method, applicable to capture the non-linear relationship between dependent and independent variables. Furthermore, combined with the theoretical analysis, the non-linear relationship between fiscal policy and entrepreneurial activity may lead to the insufficiency of asymptotic distribution. Therefore, it is reasonable to investigate if there is an optimal level of fiscal policy to promote entrepreneurship activity from 2002 to 2019 in the 27 European Union Member States, as the prior results were ambiguous.

The traditional least-squared estimation method was developed by Hansen's (1999) into the advanced panel threshold regression model. After determining the stationarity of the variables, we test if there is a threshold. If we are not able to reject the null hypothesis, it means that there is no threshold. The bootstrap method suggested by Hansen (1999) employs simulations that calculate the asymptotic distribution of the testing statistics, along with testing the significance of the threshold effect. To estimate the panel threshold model, we applied a two-stage ordinary least squares (OLS) method. Firstly, we separately computed the sum of the squared errors (SSE) for any given threshold. Secondly, by minimising the sum of the squares, we obtained the estimation of the threshold by using the figures calculated in the first stage. In the final stage, the estimated threshold value is employed to estimate the coefficients of each regime.

Our model was inspired by the one developed by Lobonț et al (2022), who evidenced the non-linear effect of public policy (through governance effectiveness) on the entrepreneurial environment, but it brings more insights into fiscal policy implications on entrepreneurship. Accordingly, the single threshold model was constructed as follows:

$$EA_{it} = \{\mu_i + \beta_1 FP_{it} + \alpha' x_{it} + \varepsilon_{it} \quad if\ FP_{it} \le \gamma\ \mu_i + \beta_2 FP_{it} + \alpha' x_{it} + \varepsilon_{it} \quad if\ FP_{it} > \gamma\ ; \qquad (1)$$

$$\alpha = \left(\alpha_1, \alpha_2, \alpha_3, \alpha_4\right)' \; x_{it} = \left(q_{it,} m_{it}, s_{it}, v_{it}\right);$$

$$\left\{EA_{it}, FP_{it}, x_{it} : 1 \le i \le n, 1 \le t \le T\right\},$$

where: EA_{it} denotes the total entrepreneurial activity; FP_{it} represents the level of fiscal policy, being the threshold variable of the model; γ designates the estimated threshold value; β_1 and β_2 represent the estimated threshold coefficients of different threshold values; x_{it} is the vector of 4×1, comprising the control variables q_{it}, m_{it}, s_{it} and v_{it}; α_1, α_2, α_3 and α_4 are the estimated coefficients corresponding to the control variables; q_{it}, m_{it}, s_{it} and v_{it} are the control variables (growth rate of the GDP, trade volume, educational attainment, and government effectiveness, respectively); μ_i is a fixed effect, employed to underline the countries' heterogeneity under different levels of trade dependency; ε_{it} is the white noise process or error term, which subjects to iid(0,σ^2); *i* is 1 ... 27 (representing each of the EU Member States); *t* represents the year, referring to the 2002–2019 period.

The advanced threshold regression can be rewritten as follows:

$$EA_{it} = \mu_i + \beta_1 FP_{it} \mathrm{I}\left(FP_{it} \le \gamma\right) + \beta_2 FP_{it} \mathrm{I}\left(FP_{it} > \gamma\right) + \alpha' x_{it} + \varepsilon_{it}. \quad (2)$$

This second equation represents a single threshold regression model, but the empirical analysis may result in numerous thresholds. Therefore, the formula of the double threshold regression model can be detailed as further:

$$EA_{i,t} = \{\mu_i + \beta_1' FP_{it}\left(\gamma\right) + \alpha_i' x_{it} + \varepsilon_{it} \; if \; FP_{it} \le \gamma_1 \; \mu_i + \beta_1' FP_{it}\left(\gamma\right) + \alpha_i' x_{it} + \varepsilon_{it},$$
$$if \; \gamma_1 \left\langle FP_{it} \le \gamma_2 \; \mu_i + \beta_1' FP_{it}\left(\gamma\right) + \alpha_i' x_{it} + \varepsilon_{it} \; if \; FP_{it} \right\rangle \gamma_2. \quad (3)$$

Equation (3) can also be simplified as follows:

$$EA_{it} = \mu_i + \beta_1' FP_{it} \mathrm{I}\left(FP_{it} \le \gamma_1\right) + \beta'_2 FP_{it} \mathrm{I}\left(\gamma_1 < FP_{it} \le \gamma_2\right) +$$
$$\beta'_3 FP_{it} \mathrm{I}\left(FP_{it} > \gamma_2\right) + \alpha' x_{it} + \varepsilon_{it}, \quad (4)$$

where the threshold value is $\gamma_1 < \gamma_2$. Accordingly, it may be extended into the multiple threshold model.

3. Results and discussion

3.1. Results

We consider a panel threshold regression model that allowed us to obtain new insights into the interaction relationship between fiscal policy and entrepreneurial activity. Moreover, a great deal of attention must be addressed to the need to include stationary variables that allow the avoidance of the spurious regression problem. Therefore, the first step is to proceed with unit root tests before the panel threshold regression model. Two panel unit root tests proposed by Levin et al. (2002) and Im et al. (2003) were employed to increase the reliability of the results. Table 3 reveals that the null hypothesis of unit roots is rejected, implying that all the variables in our analysis are stationary, proving the panel threshold regression premise.

Table 3. Results from the unit root tests adequate to panel data

Variables	Levin et al. (2002)		Im et al. (2003)	
	t-statistic	p-value	t-statistic	p-value
Total entrepreneurial activity	–6.891***	0.000	–3.783***	0.000
Government expenditure	–0.838	0.799	–1.598*	0.055
Tax revenue	–3.027***	0.001	–1.174	0.120
GDP growth rate	–5.542***	0.000	–4.291***	0.000
Trade	–2.450***	0.007	–1.886**	0.029
Education attainment	–5.279***	0.000	–3.808***	0.000
Government effectiveness	–5.118***	0.000	–2.932***	0.001

Note: 1. *, ** and *** indicates significance at the 10%, 5% and 1% levels, respectively.
2. All variables have been logarithmically processed.

The panel threshold regression between government expenditure and entrepreneurial activity in the EU countries are presented in Table 4, after repeating 10,000 times in bootstrapping of the sample. Results indicate a threshold effect (for the value 1.651) evidenced by the single threshold model (under the 5% significance level), but no significance for the double threshold effect is not significant. This proves that there are different effects from government expenditure on EA before and after the threshold value of 1.651. After also observing the results from Table 5, we confirm that when government expenditure is lower than 1.651, the coefficient $\hat{\beta}_1$ is 0.162. At this stage, government expenditure positively influences entrepreneurial activity. Once the government expenditure exceeds the threshold value, the coefficient $\hat{\beta}_2$ is –0.033. Accordingly, when government expenditure is more than 1.651, the effect of government expenditure on enterprise activities becomes negative.

Table 4. Threshold effects between government expenditure and entrepreneurship in EU countries

	Threshold value	*F*-statistics	*p*-value
Government expenditure			
Single Threshold Effect Test	1.651	11.235**	0.010
Double Threshold Effect Test	0.839	11.993	0.370
	1.651		

Note: 1. The critical values of the *F*-statistics for the single threshold effect are 5.813, 6.422, and 9.475 at the respective 10%, 5%, 1% levels; the critical values for the double threshold effect are 22.055, 26.854, and 43.397 at the respective 10%, 5%, 1% levels. 2. ** indicates significance at the 5% level.

Table 5. The coefficients estimated for government expenditure

	Estimated Value	OLS se	t_{OLS}	White se	t_{White}
$\widehat{\beta_1}$	0.162	0.060	2.700***	0.090	1.800*
$\widehat{\ \ 2}$	–0.033	0.026	–1.269	0.015	–2.200***

Note: 1. OLS se (White se) refers to homogeneous (heterogeneous) standard deviations.
2. $\widehat{\beta_1}$ $(\widehat{\beta_2})$ indicates that the coefficient estimates are smaller (larger) than the threshold value.
3. * and *** indicate significance at the 10% and 1% levels, respectively.

Table 6. The coefficients estimated for the selected control variables

	Estimated Value	OLS se	t_{OLS}	White se	t_{White}
$\widehat{\alpha_1}$	0.019	0.046	0.413	0.017	1.117
$\widehat{\alpha_2}$	–0.034	0.033	–1.030	0.012	–2.833***
$\widehat{\alpha_3}$	0.013	0.032	0.406	0.015	0.866
$\widehat{\alpha_4}$	0.056	0.046	1.217	0.034	1.647*

Note: * and *** indicate significance at the 10% and 1% levels, respectively.

As for control variables, based on the statistically significant coefficients from Table 6, we observe that trade has a negative effect on total entrepreneurial activity and government effectiveness has a positive effect on it.

Table 7 reports the panel threshold regression between tax revenue and entrepreneurial activity in the 27-EU member states. Once again, the statistical significance of the threshold effect is proven only for the single threshold model, and the double threshold effect is not significant. In this case, the single threshold value is 1.517, which means that the influence of tax revenue on EA before and after this value are opposite. Referring to Table 8 as well, we can state that when tax revenue is lower than 1.517, the coefficient $\hat{\beta}_1$ is 0.173. At this stage, tax revenue will promote total entrepreneurial activity (having a positive influence). When the tax revenue exceeds the threshold value, the coefficient $\hat{\beta}_2$ is –0.048, which means that tax revenue may hinder enterprise activities if tax revenue exceeds 1.517. Overall, we expect tax revenues to support entrepreneurship development in a country.

Table 7. Threshold effects between tax revenue and entrepreneurship in EU countries

	Threshold value	*F*-statistics	*p*-value
Tax revenue			
Single Threshold Effect Test	1.517	14.145**	0.020
Double Threshold Effect Test	1.517	13.469	0.310
	2.362		

Note: 1. The critical values of the *F*-statistics for the single threshold effect are 56.272, 7.240, and 15.203 at the respective 10%, 5%, 1% levels; the critical values for the double threshold effect are 21.349, 31.444, and 40.365 at the respective 10%, 5%, 1% levels. 2. ** indicates significance at the 5% level.

Table 8. The coefficients estimated for tax revenue

	Estimated Value	OLS se	t_{OLS}	White se	t_{White}
$\widehat{\beta_1}$	0.173	0.060	2.882***	0.088	1.966**
$\widehat{\beta_2}$	–0.048	0.027	–1.777*	0.017	–2.823***

Note: 1. OLS se (White se) refers to homogeneous (heterogeneous) standard deviations.

2. $\widehat{\beta_1}$ ($\widehat{\beta_2}$) indicates that the coefficient estimates are smaller (larger) than the threshold value.

3. * and *** indicate significance at the 10% and 1% levels, respectively.

Table 9. The coefficients estimated for the selected control variables

	Estimated Value	OLS se	t_{OLS}	White se	t_{White}
$\widehat{\alpha_1}$	0.023	0.046	0.500	0.018	1.277
$\widehat{\alpha_2}$	–0.035	0.033	1.061	0.013	2.692***
$\widehat{\alpha_3}$	0.009	0.032	0.281	0.015	0.600
$\widehat{\alpha_4}$	0.072	0.047	1.532	0.037	1.946*

Note: * and *** indicate significance at the 10% and 1% levels, respectively.

Once again, for the control variables presented in Table 9, we mention those with a statistically significant coefficient: trade negatively influences total entrepreneurial activity, while government effectiveness has a positive influence on it.

3.2. Discussion

Based on the first results of the threshold analysis, it was indicated that once the government expenditure exceeds the threshold value of 1.651, the effect of government expenditure on enterprise activities shifts toward a negative one. We mention that this threshold is an extreme value considering that government expenditures were evaluated as % of GDP. However, a negative influence of government expenditures on entrepreneurship might be explained through a higher burden of regulations, which increases government costs, or a non-productive expenditure (Islam, 2015; Kuncoro, 2014). Moreover, significant public costs would rise in social welfare and the level of government expenditures, especially for countries with high unemployment. And although public spending for welfare provides a safety net, it increases the opportunity costs for entrepreneurship, discouraging its development. These are several reasons for the negative impact of government spending on entrepreneurship. Still, they should be related to exceptional situations because, in general, government expenditures positively impact and support entrepreneurial activities. Islam (2015) examined the composition of government spending based on some different strands, including fiscal policy, by developing a conceptual model since an increase in public and social goods can stimulate entrepreneurial activity. The paper examined various empirical models and data from the existing literature, including the GEM database. The results confirmed the negative effect of government spending on entrepreneurship. Moreover, the authors noted that entrepreneurial activity could be stimulated by an increase in the share of government spending on both public and social goods. Furthermore, in the context of fiscal policy, according to Kneller and Mc Gowan (2011), entrepreneurship may be encouraged by decreasing government spending.

The threshold analysis for tax revenue and entrepreneurship also evidenced an extreme value for the change in the influence. If tax revenue goes beyond 1.517, their impact on EA would be negative. But considering that our database evaluates tax revenues as % of GDP, this threshold value is not attainable. Therefore, we can conclude that the level of tax revenue represents a significant and direct factor for entrepreneurship, sustaining its development. In addition, tax policies usually favour micro-enterprises or start-ups, compared to more

prominent companies, with a lower tax rate or tax allowances for business development and accrual of wealth within new businesses. This direct relationship between tax revenue and total entrepreneurial activity evidenced in the European Union case is consistent with previous research evidencing a positive influence of tax revenue and even tax rates on entrepreneurship (Bacher & Brulhart, 2013; Da Rin et al., 2011; Wennekers et al., 2008; Parker & Robson, 2004).

From the control variables employed in the entrepreneurship and government expenditures analysis, there were only two statistically significant, trade and government effectiveness. Trade carries a negative influence on entrepreneurial activity, while government effectiveness is positive. Considering that the trade variable is based on both imports and exports, big companies expect a high level of trade to be realised. Small enterprises and start-ups struggle to promote their new products and services and gain a small market share. Therefore, in countries where large companies lead the level of trade, entrepreneurship would not be stimulated because the effort of market penetration and business development is very high. However, government effectiveness is a vital factor in entrepreneurial activity. Previous research also evidenced that effective governance is linked to engaged entrepreneurship (Parker et al., 2012), and citizens seem to be more willing to take risks and become entrepreneurs when their perceptions of the quality of public services are high. Additionally, government policies can strongly influence the development of the entrepreneurial ecosystem, supporting entrepreneurship education, developing R&D and innovation activities, and supporting the development strategies of small firms.

Threshold models offer a simply interpretable way to model some instances of nonlinear relationships, where the predictors are associated with the outcome variables in a threshold-dependent way by introducing a parameter for the changing point. Our study evidenced some extreme changing issues, leading us to believe that fiscal policies have a significant favourable influence on entrepreneurial activity in the case of EU member states, supporting sustainable entrepreneurship development. Future research may consider an extended set of countries, and even a threshold analysis on sub-samples, to evidence differences between developed and emerging countries or differences depending on the fiscal pressure and its influence on the development of entrepreneurship.

Conclusions

The previous literature does not provide very recent evidence on the perspective of the development of entrepreneurial activity in terms of fiscal policies. Therefore, we chose to study the influence of fiscal policies on entrepreneurship in all the EU member countries. Considering the non-linear characteristics of the variables, the panel regression model is employed to investigate if there exists an optimal level of fiscal policy to promote entrepreneurial activity. The empirical results show that from 2002 to 2019, the single threshold effect is significant under the 5% significance level, which means that there are different effects from government expenditure on entrepreneurial activity before and after the threshold value. When government expenditure is under the threshold value, it positively influences total entrepreneurial activity. Once the government expenditure exceeds this threshold value, its effect on enterprise activities becomes negative. A similar result occurs when we select the tax revenue as

the proxy variable of the fiscal policy. In the first stage, when tax revenue is lower than the threshold value, tax revenue will promote total entrepreneurial activity. Once the tax revenue exceeds the threshold value, the tax revenue may hinder enterprise activities. These findings are consistent with the theoretical hypotheses setup after reviewing the literature.

Several indicators were included in the analysis of entrepreneurship, such as the GDP growth rate, education, trade, and government effectiveness. The trade and government effectiveness proved to be significant and influential factors for entrepreneurial activity in EU countries, while the statistical tests did not confirm the GDP growth and education's positive influence on entrepreneurial activity.

Based on our results, some policy implications can be inferred for policy-makers. Increasing government expenditure and tax is not always better and tends to hinder entrepreneurial activity after a point. The optimal level of fiscal policy is a key concern for policymakers attempting to stimulate entrepreneurial activity. Moderate fiscal policies have the power to increase entrepreneurship and reduce the costs involved with setting up a business, facilitating their setup through eased regulations. Governments can encourage entrepreneurial opportunities through a lighter regulatory burden and policies that foster competition, lower taxes, increase transparency and provide open access for all businesses. Public policies should also encourage savings to accumulate wealth, which may be turned into an investment. Entrepreneurs have limited access to external funds and must pitch their business idea, convincing investors to fund them if they do not have the necessary capital. Progressive taxes may be constraining new businesses, discouraging supplementary efforts and savings expected from entrepreneurs. On the contrary, higher income taxes can make self-employment more desirable. Therefore, lower taxes for micro-enterprises or tax advantages related to self-employment, setting up a start-up or investing in technological equipment are just a few of the fiscal policies to revive entrepreneurship in a country.

Furthermore, we link the development of entrepreneurial activity to sustainable development because it can help reduce the gaps and inequalities between countries. Moreover, tax benefits may offer protection of profits or other advantages to increase attractiveness for businesses with expansion and growth opportunities. Overall, our study proves the relevance of public policies for entrepreneurship development, as entrepreneurs feel more support in an economy characterised by good governance and effective government spending.

Following this extensive research on the comprehensive literature and based on the recent data and empirical results, several recommendations of interest to policymakers may be mentioned. First, removing regulatory barriers for entrepreneurs would simplify the licensing rules and increase support for establishing new businesses. A simpler tax code would remove some of the tax barriers, simplifying the compliance of contributors and the enforcement of the tax system. The main effects of taxation on entrepreneurship may be reflected in a three levelled framework based on the risks taken by entrepreneurs, their productivity and outputs, and the costs they must cover. Policymakers should consider the large impact of the tax code and amend the level of taxes required from the entrepreneurial community, which may be an engine to accelerate economic growth. Governments continue to subsidise the creation of businesses because there is a positive link between entrepreneurship and job creation, among other desirable economic phenomena. Increasing competitiveness in the markets allows an efficient allocation of resources in the economy. And these are just a few reasons for public

policies and strategies (including in the European Union) should focus on entrepreneurship and its support and development, having a unique contribution to economic growth and innovation.

Our research is not without limitations, acknowledging the relatively reduced sample of indicators, respectively a small number of control variables, alongside the number of observations included in our empirical analysis. Considering the restricted access to relevant data, another limitation is related to the analysis performed only for the 2002–2019 period. However, our research offers a general framework of analysis, focusing on the dimensions and associated coordinates of socio-economic drivers for entrepreneurial activity, with an emphasis on fiscal policy, with beneficial spillovers on the total entrepreneurial activities for the 27 EU Member States. Further development of the current research will overcome these limitations by focusing on entrepreneurial and fiscal policies that need to be strengthened and tailored to each of these member states according to their heterogeneity. Hence, we aim to expand the research by considering a larger panel regarding the time span and including other control variables that might also have a high statistical significance, providing additional robustness.

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Challenges on Radical Health Redesign to Reconfigure the Level of e-Health Adoption in EU Countries

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The recent worldwide COVID-19 pandemic has highlighted the importance of a performant public sector in terms of health. To achieve greater use and efficiency of health information and communication technology (ICT), the whole community of European states needs a model to develop a common strategy to support the implementation of e-health and reduce decision-making difficulties. Our research suggests such a model, starting from the level of adoption to the implementation of e-health and points out the existing disparities in the European countries regarding the difficulties of adopting e-health. We draw a composite index to assess the inequalities present in the quality of life, the public health system, and the adoption of e-health. Furthermore, to return to a hierarchy of European countries, the relative distance method (RDM) is applied by combining various classification criteria. The results identify the European countries with the highest levels of adoption (Denmark, Estonia, Spain, Sweden, Finland, and the United Kingdom), where e-health is routine, and the countries with the lowest levels of adoption (Greece, Lithuania, Luxembourg, Malta, Romania, and Slovakia), where e-health is not widespread. These results reveal critical implications in identifying solutions to reduce the gaps between countries, identifying public policies to support the adoption of e-health, and reducing difficulties in decision-making.

Keywords: e-health adoption, relative distances method, composite index, digitalization, EU

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INTRODUCTION

The government plays the primary role in ensuring the well-being of the people and also has the responsibility to ensure the health of the people. On the other hand, ministries of health must provide policies that contain the most effective and appropriate choice in creating and delivering a high-performance health system. However, the society of today is categorized as a knowledge society; hence, supremacy and authority no longer depend entirely and are no longer focused only on government. Informed citizens, the organizations involved, agencies, and expert bodies have an increasingly significant role to play in the society and whose opinions weigh heavily in decision-making. The health system can only meet all our needs if there is a common goal of government and society, for which there must be coherence between the decisions taken.

In the present crisis time caused by the COVID-19 pandemic, of fiscal and demographic crises, when economic growth is uncertain, it becomes apparent not many nations will be shaped by the health of their population. E-health plays a crucial role in achieving a European community that is predefined by the existence of a healthcare system characterized by the following key terms: quality, increased safety, and high efficiency. Within the e-health community, close communication is needed to form and clarify a precise path leading to fulfilling the common vision of the main actors: government, private industry leaders, and academia (1).

Although e-health is proven to improve healthcare quality, the adoption of e-health dimensions, such as electronic health record (EHR), health information exchange (HIE), telemedicine, and personal health record (PHR), is either low or unused in European countries. This is partly due to factors that affect the perceptions of citizens, the barriers and challenges that health professionals face, and how professionals come to accept this new system and then make it available to the infrastructure. Although the components, such as EHR, HIE, telemedicine, and PHR are the essential tools to improve the safety and quality of healthcare, the medical field still faces some shortcomings due to high costs and difficulties in their implementation, despite the clear benefits that it can bring in the integration of information and communication technology (ICT) in the health area. According to Sapirie (2), there is a large gap between planning the adoption of the new technology and in the sustainable implementation of such technology to obtain future strategic or expected benefits.

Good health technology management is a prerequisite for increasing the efficiency of health services. The need to do more with less is essential, as the health sector faces increasing demands while receiving static or declining resources.

The use of ICT in the medical field is of significant importance, especially in the contemporary society, facing a health crisis, the impact of the pandemic requiring transfer to the online environment, and the use of ICT. Thus, ICT brings important benefits in improving the quality and the delivery of medical services, reducing costs, increasing revenues, increasing patient safety, reducing waiting times, and creating greater patient engagement during its care (3).

In the recent years, e-health has significantly expanded in Europe. In our paper, we endorse the definition of e-health as the use of ICT in health services, products and processes combined and adapted to organizational changes in health systems, and new concepts to improve the health of the citizens, and at the same time, providing productivity in healthcare. Simultaneously, the health system will benefit from improvement in the economic area and its social value.

In the recent year, health has not only shaped the modern state and its social institutions in Europe in, but it has also fueled social movements, defined the rights of the citizens, and contributed to building the modern self-concept and aspirations (4).

Once again, the worldwide crisis (COVID-19 pandemic) generated an economic downturn and demographic change and highlighted the importance of the health system of a country. More precisely, the future of a country is related to the health of its population, and nowadays, the rapid development of the health system is crucial. The level of economic diversification in countries is also important as it might reduce the lag in the development of different sectors. As the health system currently needs a strong support, investments are necessary and a greater institutional quality might lead to an improvement in the determinants of growth process, reducing the lag and development differences across sectors (5).

Even though health is essential for the well-being of individuals and for the progress of the society, political discussions acknowledge it as the provision of health services. Many countries, especially those with low incomes, do not yet have an effective health system, while others face difficulties with the basic mechanisms of e-health governance, such as ensuring financial protection for users. Richer countries must also remain vigilant and also address e-health inequalities. These concerns are and will remain challenges to the public sector.

Result-oriented management and leadership and patient-centered care processes are two of the concepts related to e-health. Furthermore, the literature reveals that IT employment in the health systems will produce revolutionary results (6). Moreover, special attention is accorded to the IT impact on the doctor–patient relationship. If health systems are seen as ways to organize access to specialized knowledge, then it is essential to have an access to knowledge and in organizing it (7).

In this case, e-health can provide enormous health benefits and help in the management of health systems in the future. However, the benefits offered are not automatic but require governance on three issues: monetary cost, policy, and utility.

The general opinion is that the functions of an information system at a national level are broad. Thus, at the European level, the infrastructure, systems engineering tools, and associated techniques for the design, regulation, and improvement of health processes must expand and align with the 2004 "European e-Health Action Plan" (8).

Popovic et al. (9) stated that the rapid advances in ICT and the growing number of intelligent devices allow the transfer of health and healthcare resources by electronic means. E-health is linked to the Internet, which provides a new environment for disseminating healthcare and interaction and collaboration between institutions, health professionals, healthcare providers, and the public. In developing countries, e-health is particularly important due to shortage of doctors and nurses. Although most doctors in developing countries recognize the benefits of e-health, adoption is low.

Applications of e-health technology are essential tools that enhance healthcare provision quality in hospitals in developed and developing countries. Regardless of its benefits, the literature reveals that e-health adoption in developing countries is still reduced. Some of the reasons are due to barriers, such as the resilience of health professionals, poor infrastructure, and reduced technical expertise (10). It was found that performance expectation, effort expectation, social influence, and personal innovation significantly impacted the behavioral intention to use e-health, while facilitation conditions did not have any significant effect (11).

Murray et al. (12) explored the experiences from the perspective of the implementers—senior managers and other employees responsible for implementing e-health initiatives—and evaluating factors that promote or inhibit the

implementation, incorporation, and successful integration of e-health initiatives.

More recently, Devlin et al. (13) considered normalization process theory (NPT) to analyze data on the "Dallas" program in the United Kingdom. The results identified five key challenges: (i) the challenge of establishing and maintaining heterogeneous, large multi-agency partnerships to provide new healthcare models; (ii) resistance to barriers and continuous attention to changes in external environments; (iii) the inherent tension between innovative co-design and timely and scaled delivery; (iv) the effects of branding and marketing problems in consumer care environments; and (v) challenging interoperability and information governance when proprietary business models are dominant.

In 2004, the European Commission launched an initiative to adopt the first e-Health Action Plan. Thus, Lang and Mertes (14) analyzed the implementation of 12 e-health policies and explained the variation in e-health tools (applications) among 24 EU Member States.

Melchiorre et al. (15) analyzed 24 European countries based on the project, "ICARE4EU." The study highlights certain aspects, which are found to be benefits (integration/management) or barriers (cost-effectiveness and quality of care/life) for e-health adoption. Furthermore, the findings are subsequently linked to the "10 es" in e-health: "Efficiency, Enhancing, Evidence-based, Empowerment, Encouragement, Education, Enabling, Extending, Ethics, and Equity." Thus, the results can represent new support objectives for implementing e-health technologies in integrated care across Europe. Peek et al. (16) found that the use of technologies by the elderly was complex, dynamic, and personal. The results indicate that periods of both stability and change occur naturally. Moreover, the framework of Dynamics in Technology Use by Seniors (DITUS), followed in the Netherlands, can help understand the stability and instability of using technology and the development and implementation of sustainable technological solutions. Therefore, the results reveal that a core of six correlated factors was closely related to the frequency of technology use: emotional attachment, compatibility of needs, cues to use, the competence of use, resource inputs, and support. In addition, disruptive forces, such as social influences, competition with alternative means, and changes in personal needs, could induce changes by affecting these six factors.

Furthermore, the study conducted by Arena et al. (17) empirically examined Italian public hospitals and used a combined measure of innovation based on different e-health solutions. The results show that women managers encourage the implementation of innovative strategies and facilitate the adoption of e-health. The results also show that gender similarity increases the rivalry between the top management team and the line managers, thus limiting the adoption of e-health solutions. Johansson et al. (18) investigated the experience of digital primary health system (DPHS) using written dialogues in Sweden, highlighting that the examination of patient experiences can support decision-making in expanding the digital healthcare. The main results reveal that patients felt well-prepared and experienced in various aspects; some patients would recommend digital primary health care (DPHC) to others, and a notable reason for satisfaction was available. However, patients expressed some uncertainty about the ability of a doctor to assess the correct care needs. The results of the authors can be a knowledge base that will be useful for other areas and for countries that encourage implementing digital health services in primary healthcare systems.

Hantrais et al. (19) conducted a study through which they gathered evidence from different areas about the impact of COVID-19 in digital societies and identified policy responses in this context. The authors showed how the pandemic produced changes not only in data collection techniques and in the practices of disseminating official statistics, but also in the way in which the seemingly insurmountable obstacles to the implementation of health treatments managed to be largely overcome. The results obtained by the authors confirm that the ethics of emotional intelligence has become a significant concern for government legislation at the national and international levels.

Our study makes three contributions. First, it identifies the levers that could create the momentum for change in e-health adoption, setting out the preconditions and benefits for different groups of countries. Secondly, the inequalities present in the quality of life and the public health system, respectively, in the level of e-health adoption are assessed in a multicriteria manner, finally implying a hierarchy of countries. Third, this research also takes into account, the distinction of different research topics, which reveals that no significant progress has been made in the recent years. Finally, in the context of continued digitalization, this research concludes and affirms the need for public policies, structural and decision-making reforms, and joint action plans through which EU countries can reach a significant threshold on all matters, which essentially means adopting e-health. European Union countries need to consider common approaches in all aspects involved in the adoption and implementation of e-health, as evidenced by the uniform and interoperable approach to vaccination or to the development of effective applications for monitoring and warning of COVID-19 infection.

The rest of the paper is structured as follows: section Materials and Methods depicts the data and methodologies used in this paper, section Results reveals the obtained results, section Discussion discusses and presents robustness and empirical analysis, and section Conclusion provides the conclusion.

MATERIALS AND METHODS

Considering that public health is a prerequisite for continuous development, the need for sustainable improvement and constant investment in e-health adoption is stated, which would lead to a sustainable increase in the quality of life and in the efficiency of the public health system.

Thus, a wide range of methodologies have been applied, which are as follows:

- Statistical analysis focusing on disparities in individual health (measured by the quality of life), EU28. Statistical analysis by cluster technique uses KNIME software and the K-means clustering algorithm.

- Statistical analysis focused on disparities in the quality of the public health system, EU28;
- Statistical analysis focused on disparities in e-health adoption, based on the ranking of the country, EU28;
- Correlation econometric analysis— finding the intensity of possible links between e-health adoption level and country rank (depending on the public health system and quality of life)—the analysis used to identify a common policy orientation to be applied to all Member States of EU, which envisages the implementation of the information and communication technologies (ICT) on health, to increase the quality of life, the public health system, and significantly reduces the existing disparities among the EU Member States;
- Level of implementation and use of compound indices, such as EHR, HIE, telemedicine, and PHR—finding the level at which each country is and also highlight the subdimensions and functionalities that are already used or in use, in order to draw the defining lines which can lead to the adoption at a more significant level of these functionalities, respectively of the others.

To capture particularities, many variables were taken into account, made use of the relative distances method to combine different criteria, and to obtain the hierarchy.

We followed the methodology used by the report of the European Commission (20, 21) and the study by Lobont et al. (8), namely the calculation of composite indices. We used PCR to compute our indices, considering that this methodology allows us to transform our more extensive set of variables (some of them correlated) into an uncorrelated smaller set of variables that captures most of the variations from the original set. The RDM allows us to classify and rank countries, indicating the countries that managed to implement and successfully apply the specific e-health functionalities. This ranking analysis also allowed us to focus on disparities in the quality of the public health system and disparities in e-health adoption. In addition to other studies which only employed the RDM method [e.g., (22, 23)], we also included a regression analysis to emphasize the factors which mostly influence the quality of life (or a proxy for individual health), and on the efficiency of the public health system. Employing the KNIME software is also an advantage compared to previous studies (even to the latest, similar research undertaken by 8), allowing us to perform a cluster analysis which defined the groups based on the similarities observed among the countries.

The relative distance method helps in the transformation of the initial value into relative distance compared to the most performing value related to each criterion (24, 25). In this section, the RDM allows the observation of the relative distance of each country and that of the country with the highest level at the European level. The relative distance between the best-performing country [according to criterion (j)] and the rest of the countries is measured by the following ratio:

$$\frac{Xij}{Xmaxj}$$

Moreover, the relative distances of each classification criterion (j) are calculated. At the same time, as a simple geometric mean of the previous results, the average of the relative distances of each country [for all criteria (j)] is calculated:

$$Di = \sqrt[m]{\prod_{j=1}^{m} \frac{Xij}{Xmaxj}} \quad (1)$$

where, m = the number of criteria used.

Therefore, the country (i) can be classified according to the decreasing average relative distance (Di).

Only through a common basis, we can compare disparities in a country with those in other countries. In order to satisfy the method of relative distances, the average value at the European level will replace the performance recorded by the best country for criterion, j (Xmax j); therefore, the following formula for multi-criteria, provides the result for j, which is the average distance for each country:

$$Di = \sqrt[m]{\prod_{j=1}^{m} \frac{\mathrm{Xij}}{\overline{\mathrm{Xj}}}} \quad (2)$$

The approach taken is the way to reach a firm and the fixed place of each country compared to the European average, making possible comparisons at different levels (both at the European and national levels). For measuring the disparities, economic criteria are employed, which include synthetic indicators that we consider relevant to our analysis and comparable in space. Based on the objectives of this paper and the available databases, only the criteria were selected to reflect the individual health and the quality of the public health system. Also, Jeremic et al. (22) and Seke et al. (23) selected and used some of these indicators in their analysis. The data comes from the European Union databases, such as the WHO, Eurostat, the World Bank (WB), and Statista. To perform the classification of the quality of life (the individual health) in the European countries, we made use of the Physical Quality of Life Index (PQLI) (data source: Eurostat and WB; see **Supplementary Table 1**).

Considering the quality of the public health system and to classify the European countries, we use the Public Health criteria (data source: Eurostat, European Commission, and Statista; see **Supplementary Table 2**).

Regarding the adoption of e-health, Lupiáñez-Villanueva et al. (21) conducted a survey funded by the European Commission, a survey of general practitioners (GPs) from 31 countries (EU28 + Iceland, Norway, and Turkey) to measure and explain the levels of availability and the use (adoption) of e-health applications and services. A random sample of 9.196 family physicians was interviewed, and data were processed using sophisticated multivariate statistical techniques. The survey was conducted between January 2018 and June 2018. In the 28 EU countries analyzed, a final sample of 5,793 GPs was randomly selected, with an overall sampling error of ± 1.30%. Univariate and multivariate statistical analyzes were performed to analyze the survey data. Each composite indicator consists of two to five subdimensions, which group the functionalities into broader categories. The grouping of functionalities into subdimensions followed the same

approach used in the 2013 study by "Benchmarking Deployment of e-Health among General Practitioners" (20).

The EHR criteria is the system used by healthcare professionals (both physicians and nurses) to enter, store, view, and manage patient health and manage information and data (**Supplementary Table 3**).

The HIE is the process that includes the electronic transfer/sharing/allowing access to information and data on patient health (see **Supplementary Table 4**).

Telemedicine—TeleHealth—represents the use of technological platforms based on the broadband for the distribution of distant services, medical training, and health education (**Supplementary Table 5**).

Personal health record (PHR) reflects an electronic system that allows patients to have secure access and proper management of personal health information (**Supplementary Table 6**).

The analysis carried out in the report of the European Commission also includes the classification of EU Member States, based on the calculation of the composite index for each dimension and the global e-health adoption index for each European country using the Factor Analysis (FA) method. In our study, we considered comparing the global e-health adoption index developed using FA with the composite index that we constructed using the RDM. The coefficient of determination, R2 on the correlation analysis of the two composite indices reveals that the indices are practically interchangeable (a value of 0.9767).

The first part of the study proposes the classification of European countries according to the quality of life. Besides, many indicators have been taken into account to create the composite index of healthy living quality (Di), but only those such as life expectancy at birth, and healthy life years of women and healthy life years of men provide a different image in terms of the best performance of the indicators. Therefore, of all the indicators taken into account, the highest possible values indicate the best performance of the analyzed indicator of the country. The results obtained are presented in the section 3 and were used to classify the European countries according to the quality of life. The relationship applied to calculate the average of the relative distances is as follows:

$$Di = \sqrt[7]{\frac{Xisvn}{\bar{X}isvn} * \frac{Xifvs}{\bar{X}ifvs} * \frac{Xibvs}{\bar{X}ibvs} * \frac{\bar{X}ibps}{Xibps} * \frac{\bar{X}iamns}{Xiamns} * \frac{\bar{X}imir}{Ximir} * \frac{\bar{X}irm}{Xirm}} \quad (3)$$

where, Di = composite index of disparities (multicriteria distance compared to the EU28 average for the country "i");

Xi svn, Xifvs, Xi bvs, Xi bps, Xi amns, Xi mir, and Xi rm = the value corresponding to each country "i" for life expectancy at birth, healthy life years of women, healthy life years of men, people with long-term illness or health problems, unsatisfactory healthcare, and infant mortality

$\bar{X}$i svn, $\bar{X}$i fvs, $\bar{X}$i bvs, $\bar{X}$i bps, $\bar{X}$i amns, $\bar{X}$i mir, and $\bar{X}$i rm = European average value life expectancy at birth, healthy life years of women healthy life years of men, people with long-term illness or health problems, unsatisfactory health care, infant mortality rate in the country, and mortality rate per month.

RESULTS

A starting point in the econometrical analysis regards the values of disparities (both average and individual), and the fact that they can reflect two situations: a favorable one (when the values are above 1) and an unfavorable one (when the values are below 1). After the actual achievement of the composite index of disparities among individual health, the resulting values formed the basis for the order of the EU Member States. **Figure 1** presents the ranking of the EU Member States according to the values obtained.

Figure 1 highlights the ranking of countries in terms of individual health. Thus, countries such as Cyprus, Malta, and the Netherlands are among the countries considered to be the

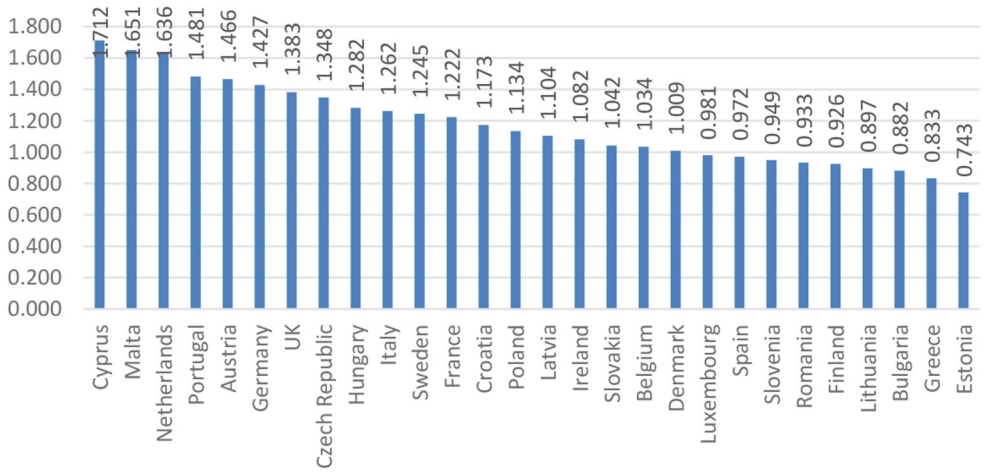

FIGURE 1 | Ranking of the EU countries based on the composite index of disparities of individual health.

"healthiest" as a result of initiatives taken to provide relevant information to support policy makers and analysts in the development of health systems, including implementation of healthcare reform programs.

Moreover, at the end of the ranking, Greece and Estonia record the lowest values among the countries analyzed. In the case of Greece, the values recorded are due to an aging population, which leads to an increase in long-term health care needs, while there are fewer working-age people to meet these needs. Therefore, the creation of an efficient network of primary care services is one of the most urgent priorities in Greece, in order to be able to respond effectively to the needs of the population. In Estonia, these values are justified by unmet health needs, which are among the highest in the EU, affecting people of all income groups. Other EU countries can provide a source of inspiration for strengthening primary care, but there is probably an issue called "no one fits everyone," and different models of primary care are likely to coexist and continue to evolve for each country.

The study also aims to regress the composite index of individual health, as a dependent variable, concerning the criteria of the quality of life, as an independent variable. In this sense, from the results obtained from the construction of regression function (linear model), the most significant criteria, such as life expectancy at birth (svn), unsatisfactory care (amns), infant mortality rate (mir), and mortality rate (rm) were selected based on the regression coefficients presented in **Table 1**.

The resulting coefficients indicate that the most significant variable in determining the quality of life is rm, followed amns, mir, and svn. According to the analyzed statistics, countries such as Cyprus, Malta, and the Netherlands have values reported as the lowest in terms of unsatisfactory healthcare, with a percentage of <0.05% in both the total population and mortality rate. Simultaneously, the recording of such values may be due to the success of the primary care reforms proposed by these countries, a success that probably depended on financial resources, support for innovative ways of efficient service delivery, and effective coordination of different primary care units.

On the other side of the ranking are the countries, such as Greece and Estonia with the highest values related to the variable mortality rate. The decrease in mortality can be mainly attributed to the reduction of important risk factors, such as smoking, especially in men, and to the improvement of the quality of healthcare. Another significant variable is unsatisfactory healthcare, with 9.10% (Greece) and 7.30% (Estonia). In Estonia, high levels of unmet needs can be caused by waiting times for specialist outpatient care, day surgery, and inpatient care. Greeks have difficulty in accessing doctors or a health center not only due to the cost and in the distance to the office of the doctor and waiting for a meeting, but also due to the consultation of a doctor.

Next, through the statistical technique of cluster analysis, it was possible to group and intuitively visualize the discrepancies among European countries. Cluster analysis aims to group the observations to reduce the distance between the observations within the group.

Thus, with the performance of the K-means algorithm, we categorized the data set into k-distinct predefined subgroups (clusters) which do not overlap, so that each data point belongs to a single cluster. This analysis was made possible through the analytical platform, KNIME, the software that offers the possibility to create scientific data. Intuitively and openly, it continuously integrates new developments. The KNIME makes it possible to understand data by designing workflows and reusable components accessible to all.

This model was implemented in the 28 countries considered in this study and taking into account, the four variables that were the most significant in the previous analysis (**Table 1**: rm, amns, mir, and svn). **Figure 2** presents the clusters obtained through the KNIME analytical platform, using the K-means clustering algorithm. The intuitive distance among countries and/or groups formed is highlighted in the diagram, using a scale from 0 to about 8.5. We can see that the relative distance among the clusters is greater as we move toward the Dendrogram's maximum scale (upwards). Also, the significant distance among the groups means a big difference between them.

Before moving on to the intuitive specification of the groups formed through the dendrogram, we proposed another way of establishing them, namely the design in the KNIME software with a flow that effectively leads us through several elements selected and connected to the grouping of countries depending on the same data taken into account when creating the dendrogram (**Table 1**: rm, amns, mir, and svn). Cluster analysis was applied to define groups and to observe the similarity among the countries within each group, to identify the similarities that characterize the different countries and with which they can be grouped in the same cluster. At the same time, **Figure 3** depicts the chosen elements, while **Figure 4** depicts the results obtained after their connection.

Each element has a decisive role in obtaining the final result, and the K-means algorithm plays an essential role in

TABLE 1 | Coefficients of determination between the composite index of individual health and the variables of quality of life.

Independent:	svn	fvs	bvs	bps	amns	mir	rm
Coefficients	0.049***	0.007	0.014	0.001	−0.075***	−0.068*	−0.639***
t-Stat	(3.097)	0.840	1.558	0.208	−3.896	−1.852	−3.803
R-Square	0.2695	0.0264	0.0854	0.0016	0.3687	0.1166	0.3575
F-test	9.596***	0.706	2.428	0.043	15.185***	3.432*	14.467***

***, **, * - *significant at 1%, 5%, respectively 10% level.*

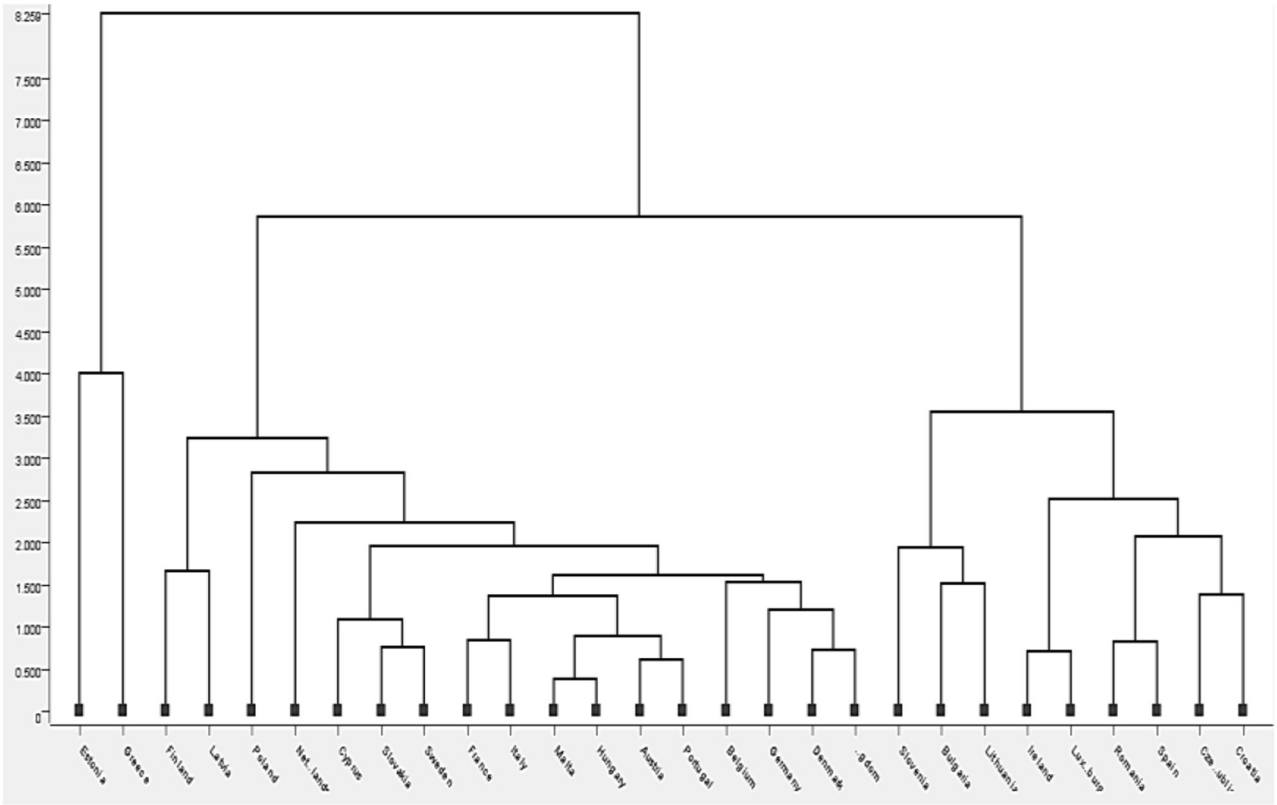

FIGURE 2 | K-means clustering Dendrogram.

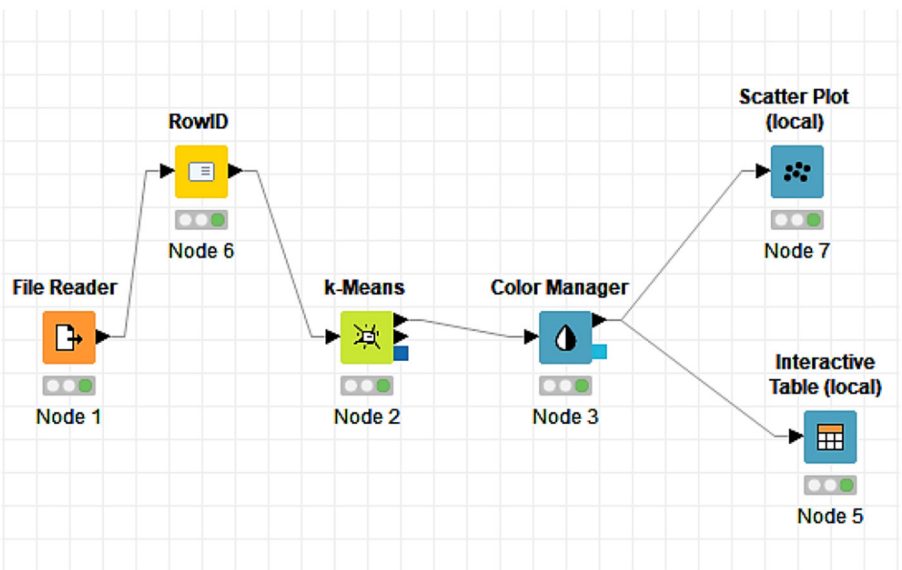

FIGURE 3 | KNIME elements.

Row ID	D svn	D amns	D mir	D rm	S Country	S Cluster
Austria	81.69	0.1	2.86	0.94	Austria	cluster_1
Belgium	81.6	1.6	3.69	0.96	Belgium	cluster_1
Bulgaria	74.96	2	5.8	1.56	Bulgaria	cluster_0
Czech Republic	78.07	0.1	3.72	1.3	Czech Republic	cluster_0
Cyprus	80.83	0.1	1.58	0.65	Cyprus	cluster_1
Croatia	79.03	0.5	2.85	1.06	Croatia	cluster_1
Denmark	80.95	0.7	4.05	0.95	Denmark	cluster_1
Estonia	78.24	7.3	2.33	1.19	Estonia	cluster_2
Finland	81.73	2.9	1.77	0.99	Finland	cluster_1
France	82.72	0.3	4.3	0.91	France	cluster_1
Germany	80.89	0.1	3.11	1.15	Germany	cluster_1
Greece	81.79	9.1	2.85	1.12	Greece	cluster_2
Ireland	76.07	0.5	3.34	1.34	Ireland	cluster_0
Italy	82.26	0.7	3.79	0.62	Italy	cluster_1
Latvia	83.35	2.9	2.12	1.06	Latvia	cluster_1
Lithuania	74.78	0.8	4.88	1.51	Lithuania	cluster_0
Luxemburg	75.68	1	3.04	1.42	Luxemburg	cluster_0
Malta	82.3	0.1	2.72	0.69	Malta	cluster_1
Poland	82.45	0.8	5.64	0.72	Poland	cluster_1
Portugal	81.81	0.1	3.46	0.88	Portugal	cluster_1
Romania	77.6	1.5	4.23	1.09	Romania	cluster_0
Slovakia	81.32	1.1	2.25	1.1	Slovakia	cluster_1
Slovenia	75.36	1.1	7.06	1.37	Slovenia	cluster_0
Spain	77.27	1.1	4.87	0.99	Spain	cluster_0
Sweden	81.38	0.4	1.96	0.98	Sweden	cluster_1
Netherlands	83.43	0.1	2.25	0.9	Netherlands	cluster_1
Hungary	82.56	0.3	2.69	0.89	Hungary	cluster_1
United Kingdom	81.26	0.1	4.32	0.92	United Kingd...	cluster_1

FIGURE 4 | Distributions of countries into groups.

our analysis. After connecting the elements, the interactive table allowed us to view the distribution of countries and the related groups (**Figure 4**).

The flow and the chosen elements lead the analysis toward the intuitive formation of three clusters of countries, as presented in **Table 2**.

The resulting groups are robust, with the countries that are part of them having approximate values in terms of all recorded values. After analyzing the resulting groups, we observed that life expectancy at birth (years) takes between 74.78 and 78.07 years for group 0 (green), then, Group 1 (blue) records values between 79.03 and 83 years, and for Group 2 (red), we maintained the interval of 78.24–81.79 years. Furthermore, unsatisfactory healthcare registers the highest value in Group 2 (red), with values of 7.3 and 9.1%, respectively. At the same time, the values registered by the other groups are between 0.1 and 2.9% for Group 1 (blue) and 0.1 and 2% for Group 0 (green), respectively. Furthermore, for the three groups, the infant mortality rate is identified as another variable. Group 0 (green) is the one in which the country with the highestvalue of this criterion is observed (Slovenia: 7.06 per 100,000 live births), and at the opposite pole is Cyprus (1.58 per 100,000 of live births) which is part of Group 1 (blue). In the mortality rate (% per month) registered by all groups (0, 1, and 2), the value of 1.56% per month, which is the maximum value was registered by Bulgaria (cluster 0-green) and the minimum value of 0.62% per month, was registered by Italy.

TABLE 2 | Countries grouped by cluster.

Cluster 0	Cluster 1		Cluster 2
Bulgaria	Austria	Latvia	Estonia
Czech Republic	Belgium	Malta	Greece
Ireland	Cyprus	Poland	
Lithuania	Croatia	Portugal	
Luxemburg	Denmark	Slovakia	
Romania	Finland	Sweden	
Slovenia	France	Netherlands	
Spain	Germany	Hungary	
	Italy	United Kingdom	

Given both the different priorities of each country on health and the fact that geographical barriers no longer condition the adoption of e-health in terms of technology, which are already overcome in most European countries, we can proceed to the second part of our analysis.

The next step of the analysis concerns the application of Formula (2) on the criteria that were chosen to assess the public health system and that were taken into account, the calculation of the composite index on the quality of the public health system of European states. Thus, based on the identification of the values of this indicator, European countries are classified as shown in **Figure 5**.

Figure 5 highlights the countries considered to be the best in terms of the quality of the public health system: Germany, Finland, and Belgium. They gained this position due to the involvement of the government in per capita health spending than other EU countries, offering a wide range of benefits, a high level of service delivery and reasonable access to care, and legislation focusing on long-term care. Instead, we find countries, such as Malta, Poland, and the Netherlands whose indicators of health spending and resources are low due to the main challenges of the health system, namely the long waiting time for services, medical conditions, poor working conditions, and low salaries for medical professionals. At the same time, limited access to health-education, reduced funding for healthcare, and the emigration of medical professionals, call into question, the long-term sustainability and quality of the health system.

Considering the causes underlying the ranking of countries in the top-ranking or at the end of it, we further propose a regression analysis of the composite index of the public health system, as a dependent variable, with the criteria of the public health system, as an independent variable. In this sense, in our models that contain variables related to the public health system, we find the effects of the following criteria: current health expenditure (ccs), health expenditure of the national public administration (csapn), number of dentists (nd), and number of pharmacists (nf), designated based on the R square regression coefficients highlighted in **Table 3**.

The results presented in **Table 3** indicate that the most significant criterion is represented by nf, immediately followed by number of hospital beds (nps) and by the criteria, ccs and csapn. Based on the study conducted by Lobont et al. (8), in which the results lead to the fact that the number of nurses has a significant role, our study makes a new contribution in the sense of introducing other variables and identifies new criteria,

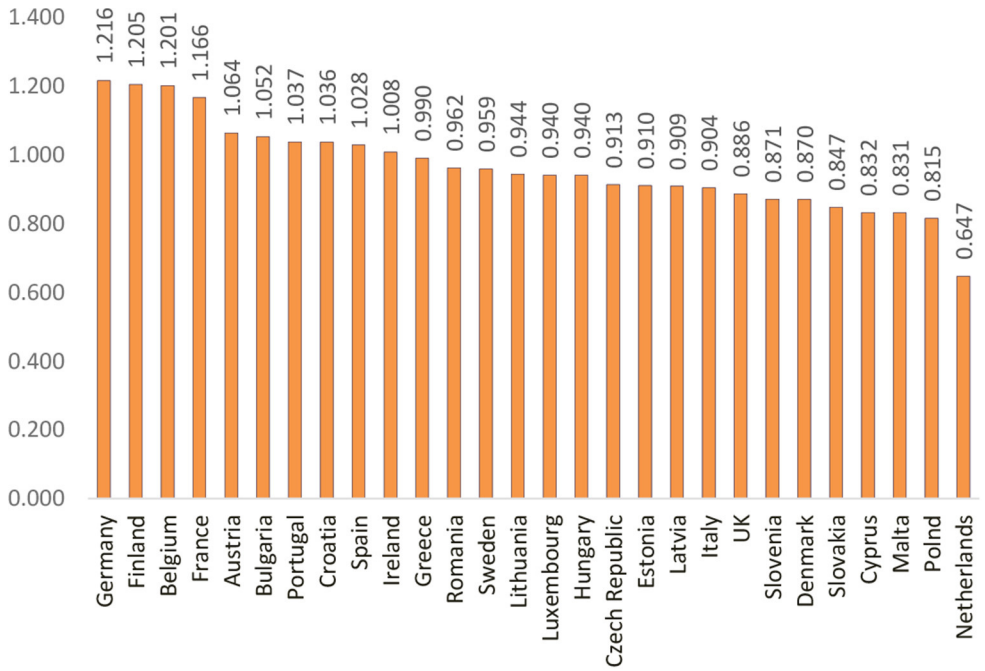

FIGURE 5 | Ranking of the EU countries based on the composite index of disparities in the quality of the public health system.

TABLE 3 | Coefficients of determination between the composite index public health system and the variables of the quality of the public health system.

Independent:	ccs	csapn	nps	nd	nf
Coefficients	0.027**	0.029**	0.0003***	0.002	0.002***
t-Stat	2.07	2.07	2.72	1.96	3.07
R-Square	0.1420	0.1414	0.2217	0.1292	0.2670
***F*-test**	4.30**	4.28**	7.40***	3.85	9.47***

***, ** - *significant at the level of 1 and 5% respectively.*

on which the quality of the public health system may depend, such as the number of dentists and pharmacists.

We further explain the problems regarding the quality of the public health system by exemplifying the first and the last ranking countries. Thus, the Netherlands (21.00 per 100,000 inhabitants) faces low values regarding criteria, such as the number of pharmacists or current health expenditure. Simultaneously, despite stable funding and resources, rising healthcare costs (especially long-term care), expensive new technologies, emerging labor shortages, and waiting lists can test the resilience of the health system. The government has addressed many of these issues through reforms and action plans. In contrast, Finland (192.70 per 100,000 inhabitants) has the most significant value in terms of the number of pharmacists due to an appropriate balance between theoretical studies and practical exercises.

Thus, starting from the basic idea that individual health is the result of the quality of the public health system, introducing and evaluating a classification system for the efficiency of the health system will be compared with the composite indices of individual health and the public health system. To carry out the proposed analysis, the relationship between the relative distance from the average related to individual health and the relative distance from the average of a public health system of a person was created.

The leaders highlighted in **Figure 6** are the Netherlands and Cyprus, closely followed by countries, such as Malta and the United Kingdom, which also have high public health indicators (higher than 1.56). In opposition, we find Bulgaria, Estonia, and Finland, which are at the end of the chart, holding the lowest values in the efficiency indicator of the public health system (<1.84).

The Netherlands records surprising values, being ranked in the first position on analyzing the quality of life index and last in the quality of the public health system. Contrary to these statements, on analyzing some criteria, we can see that the Netherlands has a very long life expectancy (83 years), even above the European average (80 years), which is the highest among the countries analyzed. Although the efficiency of the public health system is high, the Netherlands continues its efforts to support public health priorities and to increase the health promotion and disease prevention activities, i.e., the promotion of healthy lifestyles. At the same time, the position is justified by the measures taken in this country to improve the accountability and governance of the system and to identify the possible cost savings in the health sector administration. Malta is the country with a life expectancy of 82 years, very close to that of the Netherlands.

Moreover, healthcare assessed as unsatisfactory is deficient (both the Netherlands and Malta-0.1%), where both the countries have the lowest values, with a European average of 1.34%. Cyprus also integrates very well into this context, with a life expectancy of 80 years and an equally low reporting of unsatisfactory healthcare (0.1%). Despite the low share of economic resources devoted to healthcare and access problems for some groups of the population considered vulnerable, Cyprus generally enjoy good health than other high-income countries. Indeed, at the base of the specified indicators are some causes that can be considered specific: food, education, and lifestyle considered to be among the healthiest, namely the Mediterranean style, specific to these two countries (Cyprus and Malta). The results of our study are also supported by Jeremic et al. (22), which listed Cyprus as one of the countries with an efficient health system, not only in terms of public spending but also in other external factors, such as the adoption of a healthy Mediterranean diet and a balanced diet.

Bulgaria, Finland, and Estonia are among the countries with the most deficient public health systems, with the quality of life index reflecting low values. The causes could be the significant life expectancy rates (Bulgaria-74 years, Finland-81 years, and

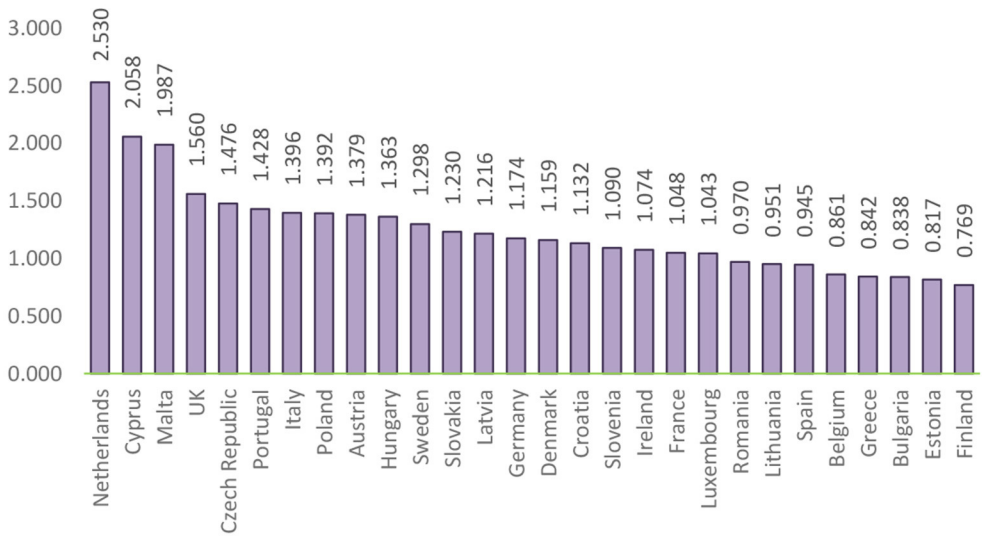

FIGURE 6 | Ranking of the EU countries based on the efficiency of the public health system.

Estonia-78 years) and the alarming mortality rate in Bulgaria-1.56% (which is well above the 1.04% average). In terms of the classification of the composite index of the public health system, Finland and Bulgaria occupy important positions at the top of the ranking, with Estonia somewhere in the middle (difference made by health and government expenditures which are lower than in the case of other countries). Although the health system in Finland and Bulgaria is approximately efficient in terms of several indicators, with a relatively high generic penetration of the number of dentists, even pharmacists, and high use of hospital beds, more indicators (expenditure on public health, those of the public administration) suggest the existence of a significant space that can be improved.

DISCUSSION

Our findings presented in section Results suggest that the efficiency of a public health system can be improved by revising the national health plan, which becomes less of a budgetary instrument and more of a means of planning activities, defining measurable objectives and empowering stakeholders.

In the following section, we discuss the evolution of the composite index of e-health adoption in European countries to observe the changes that took place in 2013–2018 (**Table 4**).

As pointed out in **Table 4**, the highest increase was found for Spain, namely, the composite index score increased by 1,198 points, from 1,167 in 2013 to 2,365 in 2018. Five Member States had comparable high increases of over 0.4 points: Estonia (an increase of 0.652), Finland (an increase of 0.557 points), Sweden (an increase of 0.512 points), Croatia (an increase of 0.496 points), and the United Kingdom (an increase of 0.446 points). All five Member States with increase of more than 0.4 points are either countries having National Health Service (NHS) or countries in transition.

In contrast, the composite index scores of other Member States increased by <0.2 points: Romania (an increase of 0.093 points), Austria (an increase of 0.146), Germany (an increase of 0.160 points), Luxembourg (an increase of 0.162 points), Malta (an increase of 0.164 points), France (an increase of 0.178 points), Hungary (an increase of 0.180 points), Greece (an increase of 0.180 points), and Slovenia (an increase of 0.188 points). Member States with increases of <0.2 points are a mix of NHS, transition, and social security countries. However, in general, we have

TABLE 4 | Changes in the e-health adoption index between 2013 and 2018.

Country	Composite index e-health adoption 2013	Composite index e-health adoption 2018	Changes 2013–2018 (+)
Spain	1.167	2.365	1.198
Estonia	2.133	2.785	0.652
Finland	2.087	2.644	0.557
Sweden	2.010	2.522	0.512
Croatia	1.684	2.180	0.496
UK	2.071	2.517	0.446
Denmark	2.490	2.862	0.372
Lithuania	1.346	1.695	0.349
Latvia	1.497	1.826	0.329
Belgium	1.752	2.067	0.315
Poland	1.540	1.837	0.297
Portugal	1.844	2.118	0.274
Cyprus	1.674	1.934	0.260
Ireland	1.851	2.103	0.252
Slovakia	1.517	1.756	0.239
Bulgaria	1.582	1.809	0.227
Italy	1.972	2.185	0.213
CzechRepublic	1.857	2.063	0.206
Slovenia	1.810	1.998	0.188
Greece	1.605	1.785	0.180
Hungary	1.848	2.028	0.180
France	1.876	2.054	0.178
Malta	1.531	1.695	0.164
Luxembourg	1.614	1.776	0.162
Germany	1.781	1.941	0.160
Austria	1.768	1.914	0.146
Romania	1.695	1.788	0.093

Own processing after "Benchmarking deployment of e-health among general practitioners" (2013) and "Benchmarking deployment of e-health among general practitioners" (2018).

seen higher increases among NHS and transition countries than countries with social security.

As robustness of our research, we performed in the following, a comparison between the composite indices for e-health adoption, taken in the first phase from the calculation of the European Commission [by the Factor Analysis (FA) method], and those calculated by the formula (2) (by the relative distances-RDM method), respectively based on the four dimensions that were proposed by the Benchmarking Deployment of eHealth among General Practitioners 2018—Final Report (21). **Figure 7** shows the results obtained.

Figure 7 depicts, on the one hand, the countries characterized by a high level of adoption (Denmark, Estonia, Spain, Sweden, Finland, and the United Kingdom), taking into account that e-health is considered routine. On the other hand, the countries with the lowest adoption level (Greece, Lithuania, Luxembourg, Malta, Romania, and Slovakia) suggest that e-health is not widespread.

Furthermore, we revealed the analysis of all the dimensions underlying the formation of the composite index of e-health adoption. Thus, the composite e-health adoption index was based on the four composite indicators described in the previous sections (EHR, HIE, Telemedicine, and PHR).

Figure 8 illustrates the countries that reach a high level in 2018 in terms of the presence and use of e-health adoption dimensions (Estonia, Denmark, UK, Ireland, and Spain), as well as countries with a low level (Lithuania, Greece, Latvia, Malta, and Slovenia). The composite index implies equal weights for each dimension.

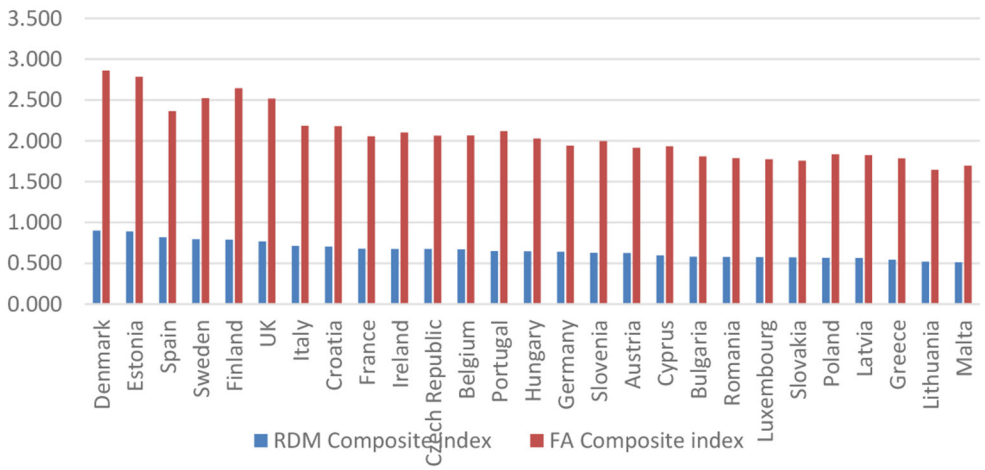

FIGURE 7 | Comparison between the values of RDM and FA composite index.

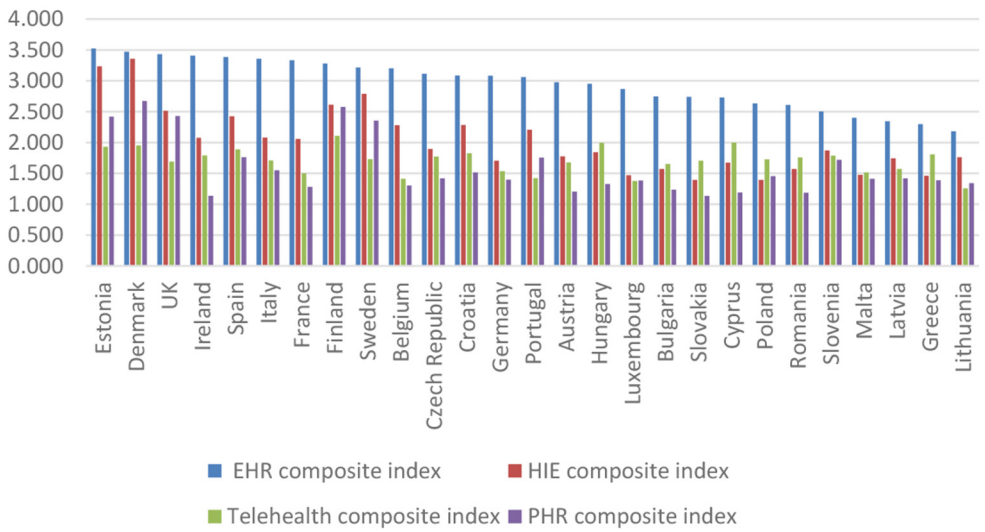

FIGURE 8 | Ranking of the EU countries based on the levels of the composite indicators of e-health adoption.

Therefore, it balances the high adoption of EHR and HIE with the low adoption of telehealth and PHR.

Electronic health record is currently available in all EU countries surveyed. In the majority of the countries, doctors use decision support features (the United Kingdom, Italy, Denmark, Estonia, Spain, Sweden, and Estonia) and administrative data of patients (Luxembourg, Denmark, France, Ireland, and Czech Republic). Adopting HIE is inferior to the adoption of the EHR. The degree of exchange between clinical, administrative, and management data is not yet very high in all the countries analyzed. For example, we observed a significant increase in patient data administration, namely the certification of sick leave and the transfer of prescriptions to pharmacists. An evolution of telehealth can be observed, but it is still characterized by low availability and use in the analyzed countries. Furthermore, training and education features are now available for half of the analyzed countries. The adoption of personal PHR presents a model similar to telehealth. The availability of functionalities regarding the request for appointments and prescriptions have increased, and the functionalities through which patients can view medical records and test results. It can easily be observed that there are some countries (Finland, Denmark, the United Kingdom, Estonia, and Sweden) where these features are more often available than in other countries (Slovenia, Ireland, and Belgium).

CONCLUSION

According to our research objective, which aims to identify disparities among the Member States at the European level in e-health adoption, the results reveal the need for significant support for the low level of adoption in countries, such as Malta, Lithuania, Greece, and Latvia. They are also among the countries with a lower quality of life (along with Bulgaria, Finland, and Romania) and a poorly functioning public health system (which can also be witnessed in countries, such as the Netherlands, Poland, Cyprus, and Slovenia). On the other hand, the adoption of e-health is successfully implemented in countries, such as Denmark, Estonia, Spain, Sweden, and Finland, which also have the best level of quality of life and public health system. According to Lobont et al. (8), who conducted a research study on the adoption of e-health, we can say that to a large extent, our results confirm the research hypotheses and are similar to those of this study. After a gap of 3 years, with updated data, no significant changes are observed; therefore, it is essential to adopt measures at the EU level, which should stimulate as much as possible, the implementation of technology in the field of health. Furthermore, the economic and health context that the world faces nowadays highlights the use of ICT in medicine and the importance of digitalization in this sector. The health of the citizens is strongly connected with their level of well-being, along with the performance of the governments in each country.

In 2012, Jeremic et al. analyzed the effectiveness of the public health system and classified the EU countries based on two types of indicators, concerned with the public health systems, and referring to general health. Our results are in contrast to those of this study, in which Greece was ranked first among the EU countries (followed by Belgium and Luxembourg, while Romania, Poland, and Cyprus were at the bottom of the ranking), as a country that invests the most in its health sector, providing the best health services. In terms of the efficiency of health system, the ranking established by Jeremic et al. (22) ranked Cyprus as the most efficient (in our study, Cyprus was placed the second), followed by Ireland, Poland, and Spain, while Latvia, Bulgaria, and Estonia were at the bottom of the health system efficiency ranking. Seke et al. (23) also rated EU countries based on the available data in 2010, in terms of sustainable development and public health. In their case, Norway, Iceland, and UK had a score of approximately 64, Greece was placed sixth (with 61.3), while Hungary, Romania, Lithuania, and Latvia ranked low, with levels lower than 33. Overall, the results obtained in our analysis indicate a significant change in the evolution and development of the public health sector in EU countries.

Looking at the RDM analysis, the countries that directly manage to implement and successfully apply specific e-health functionalities, such as EHR, HIE, telemedicine, and PHR, are Estonia, Denmark, the United Kingdom, Ireland, and Spain, which can be considered to have the highest level of e-health adoption in Europe. Simultaneously, limiting access to health education, low funding for healthcare, and the emigration of medical professionals call into question, the long-term sustainability and quality of the health system in European countries, like Lithuania, Greece, Latvia, Malta, and Slovenia. The countries mentioned above present a low level of implementation and the use of specific dimensions of e-health, such as HIE, Telemedicine, and PHR, which leads to the classification of these countries as the most underperforming countries in e-health adoption. As an alternative to aid, other EU countries (Denmark, Estonia, Finland, and the United Kingdom) can provide some inspiration for the adoption and strengthening of e-health adoption and in the successful implementation of specific dimensions in the medical field (EHR, HIE, Telemedicine, and PHR) in low-adoption countries (Lithuania, Greece, Latvia, Malta, and Slovenia). However, an issue titled "no one fits everyone" and different e-health models probably need to coexist and evolve for each country.

Our result reveals several directions toward which the governing mission of all Member States of the European Union can be directed. The mission of the government mission must be able to create joint visions, objectives, and strategies through which EU Member States can align and reach an agreement. In this case, the creation and existence of national plans must consider the coordination of the Member States toward a common approach that offers the possibility of recovering the economy and digitalization of a country, especially the adoption and implementation of e-health.

The national plans of all Member States must be designed so that they can generate new directions for other states, together creating a framework for the whole of the European Community to follow. The national plan of each Member State must ensure that the other Member States can follow it, essentially that its national plan can generate future benefits for any Member

State following it. The EU must provide strategic guidance so that complementarity can be ensured and coordination of these strategic plans is possible.

Another policy measure that is capable of increasing the adoption of e-health is to identify vital national priorities in terms of the health of the citizens. The main priority is to match country specificities in terms of citizens (culture, people education, aversion of people to ICT) with regard to the primary needs of the health system in order to increase the use of e-health dimensions (EHR, HIE, telehealth, and PHR), considering that they have a different degree of adoption and use in the EU Member States.

Taking into account not only the different and complex medical needs of citizens, but also the emergence of crises, as evidenced by the COVID-19 pandemic, each Member State requires the existence of common public health objectives that can regulate interoperability and e-health, more precisely the creation of e-consultation, patient monitoring, and remote care.

The policy measure also highlights the need for each Member State to promote the future benefits and make patients aware of the revolutionary role of technology in the medical system, standardize medical services, and spread the importance of implementing and using information systems, the pillars underpinning e-health adoption.

Moreover, the adoption of e-health in the EU depends on patients and professionals in the field, how to use it in patients, and making distant medical services available to healthcare professionals. As far as medical professionals are concerned, they can be supported by the government by providing funding for innovation, research, and development. New regulations can be developed to increase the adoption of e-health while increasing the level of opportunities and reducing the risks to which patients may be exposed.

Thus, in the context of continued digitization, we affirm the need for public policies, structural reforms, and joint action plans through which EU countries, which alone can reach a significant threshold for all that is essential for the adoption of e-health. Therefore, EU countries need to create common approaches, as evidenced by the uniform and interoperable approach to vaccination, or to develop compelling applications for monitoring and warning with regard to the infection by COVID-19. We note that to help Europe deal with future threats to public health, the EU has proposed a new enhanced EU4 Health program, which will improve support for the health systems of Member States. The EU4 Health aims to contribute to post-COVID-19 recovery, focusing on improving the resilience of health systems and promoting innovation in the health sector.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.728287/full#supplementary-material

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How Taxes Relate to Potential Welfare Gain and Appreciable Economic Growth

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Abstract: This paper investigates new insights into the effect taxation has on the welfare state, using Granger causality analysis, and focusing on both economic growth and human development as welfare components. Moreover, Granger causality allows us to determine whether or not there is a bidirectional causal relationship between taxes, growth, and human development. The analysis is based on a comparative study between part of the Central and Eastern Europe (CEE) countries and the richest European Countries, over the period 1995–2015. Taxes are illustrated by different types of tax revenues to GDP ratio, economic growth is defined by gross domestic product and gross national income, while the human development index (HDI) included in the analysis is a composite measure used to rank countries based on their social and economic development level. Results confirm the fact that taxes support economic growth, but their impact on human development is rather limited. However, in countries with higher HDI, an increase in tax revenues is expected, but over long-term. This study confirms that taxes are an important instrument for governments, and should be used in economic growth. In addition, taxes are closely related to well-being, as citizens from countries with large HDI values are more likely to pay higher taxes over time. Therefore, practical tax reforms should imply an equilibrium between equity and a decent standard of living that supports life expectancy, increased tax revenues, and efficiency.

Keywords: tax revenues; economic growth; Human Development Index; welfare; Granger causality

1. Introduction

Nowadays, the concept of the welfare state has become more popular, enclosing the protection role of the state by promoting equal opportunities and equitable distribution of public resources and responsibilities for its citizens. As long as taxation represents the most important means of gathering public resources, it is expected that an advanced welfare state would be associated with higher taxation. Accordingly, sustainable growth and development are based on taxation, and therefore tax policy may be an essential tool for governments. Over time, unpopular taxes caused various protests or riots and, in extreme cases, even regime changes. Taxes are often used in political campaigns, in order to increase popularity among voters. However, studies still search for the best tax system, in which the loss of economic welfare is minimized while the redistribution of wealth is most efficient. In order to ensure economic growth and human development, governments should effectively collect taxes and provide infrastructure, social welfare, healthcare benefits, and other essential public services.

Despite country differences in the tax structure, the majority of European countries gain most of their tax revenues through personal and corporate income taxes, consumption taxes, and social contributions. But, as opposed to the richest states in the European Union in terms of GDP, over time,

CEE countries seem to apply more flat tax rates, especially in terms of corporate and personal income. Regardless of the tax structure promoted, countries may consider changes in taxes in order to promote sustainable economic growth. For instance, if labor taxes such as personal income tax would be reduced, consumption and capital taxes should be simultaneously increased. This way, losses from one type of tax revenues are compensated by another type of taxes. Anyway, taxes tend to have both negative and positive effects on citizens and government. For example, low levels of tax on personal income represent for individuals an incentive for saving or even working more, while high personal income taxes demotivate citizens. On the other side, through higher taxes, governments dispose of higher revenues to sustain economic development. Essentially, taxes are means of transferring resources from private to public sector, in order to accomplish the development of the society, economically and socially.

As most previous studies focused on the economic factors affected by the level of taxation, and very few on the impact taxes have on human factors, the aim of this study is to underline the relationships between tax revenues and well-being, focusing on both economic growth and human development in different European countries. These two are the basic components of the dynamic social development, reflecting the economic and social policies of the society, and ensuring sustainability through welfare. In order to also discuss a series of policy implications, more details on the relationships will be obtained by analyzing the tax structure (different types of tax revenues) and its effect on welfare, in countries where taxation is one of the highest in Europe, and in some CEE countries where, although tax regimes faced important changes over time, they are still low, especially in terms of direct taxes.

By mixing taxation with the quantitative concept of economic growth and the qualitative concept of human development we will emphasize the impact taxes have beyond the economy, on citizens' well-being, supporting the idea of the welfare state. As this mix reflects the novelty of the paper, results will prove that citizens are willing to pay higher taxes for a better quality of life, providing more tax revenues which, spent correctly, will ensure better public services, the welfare of the society, and sustainable growth over the long term.

In order to achieve the objective of this study, the next section of the paper will present the main findings of the relevant literature, being followed by a description of the data and methodology used. Section 4 presents the empirical results and the last one concludes.

2. Literature Review

The literature studying the level of taxation associated with economic growth presented over time a series of contradictory opinions. Some researchers found that higher levels of economic growth are linked to low tax rates [1,2], while others stated that economic growth is supported by an increase in tax rates [3,4].

There is also evidence of a mixed impact on economic growth, depending on the type of tax. For example, in order to increase economic growth, tax rates related to consumption should be high, while income tax rates should be low. But findings reflecting a negative impact from direct taxes towards economic growth are also divided, depending on the type of tax analyzed. Some studies only confirmed a significant negative influence from the corporate tax side, but not from personal income tax [1]. However, the reduced significance of the results associated with personal income tax may also be due to an analysis of the immediate influence of taxes on economic growth. A better view may be observed by separating the dynamics of the relationships over the short and long term. This way, a statistically significant negative relationship between labor taxes and economic growth over the long run was evidenced [5].

The analysis of developing countries from different continents and OECD member countries suggested that developing countries, including those from OECD, face challenges related to poor tax administration, high variation in the average total tax to GDP ratio, limited understanding from taxpayers towards keeping accounts, and relatively small shares of wages in the national income. All of these are reflected into reduced tax sources, with reliance on the taxes from international trade and

limited income taxes. The researchers stated that personal income tax is, in general, a fiscal instrument for the government, revealing a commitment to social justice and to gathering political support [6].

Labor income tax also has an indirect effect on economic growth, as higher taxes imply higher shadow price of capital, which will eventually increase labor supply, but also lower consumption. Less consumption would have more economic implications, through a fall in tax revenues. In order to reduce this fall as much as possible, tax systems tend to rely on value-added tax (VAT) when it comes to consumption taxes, rarely implementing other sales tax, above VAT rate. In addition, a simple way to reduce distortion in consumption taxes is by broadening the tax base. In addition, using VAT as the main consumption tax is a fiscal measure that reduces evasion, as businesses apply it in every stage of the production, being liable only for the added value of their products.

In terms of general welfare in the society, a permanent combination between progressive taxation and government expenditures would ensure the transfer of income from richer to poorer. Therefore, tax progressivity would be one of the important instruments associating taxation to citizens' well-being [6–8]. Recent studies prove that countries promoting higher tax rates and more tax brackets present higher values of economic growth and development. But in countries with no tax progression, low tax rates are associated with higher values of growth and development index [9].

After studying how taxes influence welfare and economic growth in the United Kingdom, it was suggested that whenever countries support the welfare state idea, which considers an equal distribution of wealth, changes in the tax system would imply increasing labor and consumption taxes while reducing capital taxes [10]. These changes are risky especially when taxes are progressive, as citizens will face a reduction in wages or other types of income, which may actually induce an increase in unemployment. In addition, through the welfare state, the government offers support to citizens who do not provide for themselves, while cutting the public budget.

In terms of social contributions, in general, a good tax system is one that does not involve employers in labor taxes. Otherwise, the process may breach transparency and neutrality by separating the official incidence from the real one [11]. Moreover, sometimes taxes on employers raise the total costs of employing labor.

Taxes on wealth are different from the rest of the taxes as they breach the convenience principle. They are levied regardless of the fact that a taxpayer disposes of any source of income to pay them. In addition, these taxes create a distortion between savings and immediate consumption. As long as savings or investments are taxed separately, the process is discouraged in favor of consumption, which leads to a reduction in productivity [11]. Therefore, apart from stopping or delaying economic growth, these wealth taxes might have an important impact on the human development index, discouraging savings and investments, and affecting taxpayers with no income who need to cover their tax obligations.

In terms of human development, its relationship with taxes and economic growth is expected as long as governments may introduce fiscal policies that increase social and cultural investments to enhance citizens' well-being. The highest level of human development index is registered in Scandinavian countries and Switzerland, countries where government spendings on education and other public services are high. More specifically, Norway practices a dual income tax system, with progressive taxes for labor income and flat tax rates for capital income. Although focused on high revenues and income redistribution, economic development is not affected by these fiscal policies. Similarly, the Swedish government also focuses on the redistribution of income, providing top services for citizens in terms of education, healthcare, and retirement plans [12,13]. Sweden and Norway are the main examples for the modern welfare states, providing social and economic benefits for all its citizens, but heavily taxing high incomes in order to reduce income disparities.

Sustainable social welfare should be based on democracy and market economy in order to avoid an excessive capitalist system. Therefore, a welfare state should ensure the equal distribution of capital, progressive taxation of income and wealth, under conditions of full employment, integrating the

citizens with lower incomes in order to increase supply and demand. All of these would converge towards sustainable social development.

Facing these diverse and contradictory results and opinions, authors were motivated to analyze the relationship between the level of taxes, economic growth, and human development, in different European countries, focusing on developed and emerging countries, in order to identify whether or not taxation does represent one of the most important instruments that ensure growth and development.

As long as previous studies focusing on the relationships between taxes, growth and welfare analyzed large panels, comprising developed countries, as well as emerging or developing ones, we consider appropriate to analyze two distinct panels, one on developed countries (characterized by high tax revenues and large GDP per capita), and another one on emerging countries, more specifically the former communist countries from the Central and Eastern Europe. We expect to find differences between the panels in terms of the level of tax revenues, their potential impact on growth, as well as the influence on citizens' willingness to contribute to the economic development by paying taxes. Moreover, country differences in the tax structure would produce diverse effects on economic and social development. While the richest European countries gain the highest tax revenues from personal and corporate income taxes, using progressive taxation, the CEE countries apply flat tax rates, especially in terms of corporate and personal income. Our analysis will also reveal whether or not the welfare state specific to developed countries, where taxes are high, determines a sustainable human development along with significant economic growth.

3. Data and Methodology

The data used in this study refers to tax revenues to GDP ratio, economic growth and human development in different countries: the Central and Eastern Europe (CEE) countries database includes the Czech Republic, Estonia, Hungary, Latvia, Poland, Slovak Republic, and Slovenia, while the panel referring to rich European countries comprises Denmark, France, Germany, the Netherlands, Norway, Sweden, and the United Kingdom. Therefore, every panel includes seven countries, with annual data presented over the period 1995–2015.

All the data related to the taxes, measured as percentage level in GDP, was collected from the Organisation for Economic Co-operation and Development (OECD) website. More specifically, it refers to the % level in the GDP of tax revenues (TotTax), tax on income, profit and capital gains (TaxIPrC), social security contributions (SSC), tax on property (TaxProp), and tax on goods and services (TaxGS).

Data on Gross Domestic Product (GDP) and Gross National Income (GNI), both used to reflect economic growth, was collected from the World Bank website in the form of GDP per capita based on purchasing power parity (PPP), and GNI per capita, PPP (both in current international $), and used to compute their annual growth rates from one year to another. Finally, the human development index (HDI) was available through the United Nations Development Program website.

In order to understand the data and compare the level of taxation, economic growth and citizens' well-being in CEE countries and in some of the richest European countries, we will first focus on the descriptive statistics and the evolution of indicators over the period analyzed, also observing the extent to which the financial crisis affected the level of the variables.

As a second stage of the analysis, a general approach of the Granger non-causality tests will be applied to both panels, referring to cointegration techniques with error correction models. In order to apply this method, each panel dataset needs to be tested for the unit root.

The panel model applied in this study is based on Dumitrescu and Hurlin's [14] test for Granger non-causality test, considering the following linear model:

$$y_{i,\,t} = \alpha_i + \sum_{l=1}^{K} \gamma_i^{(k)} y_{i,\,t-l} + \sum_{l=1}^{K} \beta_i^{(k)} x_{i,t-l} + \varepsilon_{i,t}$$

where lag order l are identical for all cross-section units (countries), i refers to the number of panel cross sections ($i = 1, ..., 7$ countries for every panel), t is the time period ($t = 1, \ldots, 21$ years over the period 1995–2015), $\gamma_i^{(k)}$ represent the autoregressive parameters, and $\beta_i^{(k)}$ are the regression coefficient slopes. It is important to mention that this model allows the autoregressive parameters and the coefficient slopes to differ across the cross-sections. $x_{i,t}$ and $y_{i,t}$ are the observations of two stationary variables, α_i are the individual effects, and $\varepsilon_{i,t}$ represents the individual residuals. Considering that $y_{i,t}$ is a variable of economic growth or HDI, and $x_{i,t}$ is the % level of different categories of tax revenues in GDP, we analyze whether or not taxes are an important cause of growth and human development. Testing the opposite direction of the causality is also possible, by considering tax revenues as the dependent variable (tax variables become the $y_{i,t}$ in the model).

We will also investigate the cross-sectional dependence in the two sets of panel data. This is an important stage before Granger causality analysis because the existence of cross-sectional dependency among countries would indicate a high integration among the countries observed [15]. Due to this fact, a shock occurring to a country would be easily transmitted to others included in the panel. The existence of cross-sectional dependency points out the suitability of the bootstrap panel causality approach, which means that the analysis should be realized for each country rather than analyzing all of them in a panel. A command was developed in Stata in order to test for Granger causality in heterogeneous panel datasets, using the method developed by Dumitrescu and Hurlin [14]. Their method assumed less strong assumptions than the ones from previous models, which referred to the homogeneity of cross-section units. Therefore, Dumitrescu and Hurlin's model is appropriate for heterogenous panels, accounting for fixed coefficients model with fixed individual effects. However, in order to decide on whether or not to employ the bootstrap panel causality analysis, we test the cross-sectional dependence.

If results do not indicate a cross-sectional dependency between the countries, we choose to apply the granger cause analysis on the panels, in order to observe if the level of taxation in developing countries has different effects or a more powerful impact on economic growth and citizens' well-being. We expect stronger causal relationships within the panel of CEE countries, but it is important to also observe which type of taxes has more impact on citizens and economy.

4. Results and Discussions

4.1. Descriptive Statistics

Table 1 includes the descriptive statistics for all the variables included in this analysis: the tax revenues in GDP ratios, the GDP and GNI growth, and the HDI. On average, the level of tax revenues in GDP is below 34% in CEE Countries, while tax revenues in developed countries are 40% in GDP. In CEE countries the social security contributions and taxes on goods and services represent more than 12% of the GDP each, being followed by taxes on income, profits and capital gains, around 7.5% of the GDP, and taxes on property, which are less than 1% of GDP. The panel consisting of developed countries indicates differences in this hierarchy of different tax revenue categories: the highest are taxes on income, profits, and capital gains, with an average of 15% of GDP, followed by taxes on goods and services (11.8% in GDP) and social security contributions (10% in GDP); taxes on property are almost 2% in GDP.

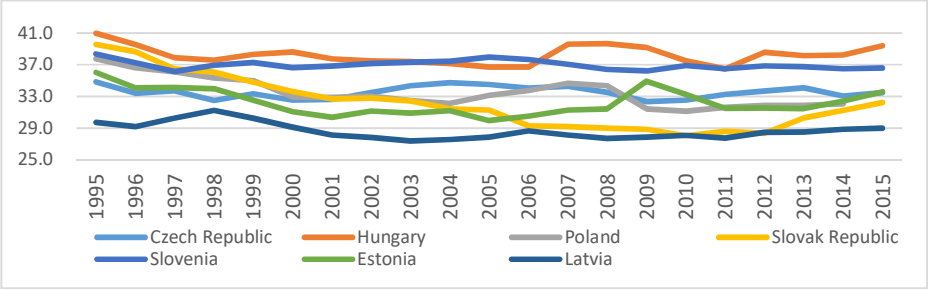
The economic growth indicators highlight an increased level for CEE countries. The annual growth in GDP and GNI are 6.3% and 3.5%, compared to 4% and respectively 1.5%, in the case of developed countries. The standard deviation of the economic growth variables is very high for both databases, emphasizing that the values are spread out over a wide range. CEE countries have a much wider range in the case of GNI annual growth rate, indicating a higher variation relative to the mean.

Table 1. Descriptive statistics.

Variable	CEE Countries				Developed Countries			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
TotTax	33.622	3.426	27.4	41	40.031	5.210	29.7	49.6
TaxIPrCap	7.556	1.194	5.3	10.9	15.129	6.501	6.8	32.2
SSC	12.403	1.973	7.9	16.4	10.141	5.212	0.1	18
TaxProp	0.733	0.373	0.2	1.7	1.966	1.057	0.8	4.1
TaxGS	12.555	1.737	9.9	17.2	11.83	1.878	9.2	16.3
GDP	6.273	4.316	−13.087	16.668	3.981	3.571	−10.079	20.856
GNI	3.548	3.763	−12.406	12.380	1.511	2.177	−7.330	6.655
HDI	0.809	0.045	0.674	0.89	0.889	0.029	0.825	0.949

The average HDI for the developed countries is 0.89, while the CEE countries indicate an average index of 0.81, confirming that there is a higher standard of living in the European richest countries, and the population here has a longer and healthier life, with more years of schooling. Through the United Nations Development Program the summary measure of human development was computed for 188 worldwide countries. From the overall HDI database, the countries analyzed in this paper are ranked in the first quarter. Furthermore, the seven richest countries included in this analysis indicate some of the highest HDI values, being classified in the top 10%.

The evolution of the total tax revenues over the period analyzed is observed in Figure 1, as a comparison between the two panels. From all the countries included in the analysis, Sweden and Denmark present the highest tax revenues. Although before 2000, Sweden had the highest level of tax revenues in GDP (49%), it decreased to 43% by the end of the period analyzed, being overtaken by Denmark and France. The United Kingdom is, on the contrary, indicating the lowest level of tax revenues (up to 33% over the period analyzed). Between the CEE countries, Hungary has the highest tax revenues, followed by Slovenia (tax revenues above 37% in GDP), while Latvia has the lowest tax revenues (less than 30% of the GDP).



(**a**)

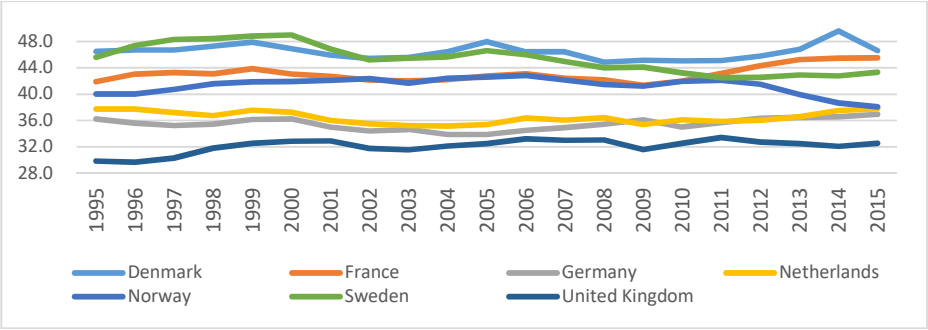


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Figure 1. The evolution of tax revenues over the period 1995–2015. (**a**) panel of CEE countries; (**b**) panel of developed countries.

We focused on the main ideas on the evolution of different tax revenues to GDP ratios, in the two sets of countries, without including graphs on every type of tax revenues. Taxes on income, profits and capital gains are highest in Denmark (approximately 30% of GDP), followed by Norway and Sweden (with 15% at the end of the period analyzed). Compared to the CEE countries, the richest European states do not have high fluctuations in the level of taxes from income, profits and capital gains over time. However, Poland and Estonia had the highest level of taxes on income, profits, and capital gains (11% in GDP in 1995) which decreased to 6.5% and 8%, respectively, in 2015.

In terms of social security contributions (SSC), developed countries did not register important fluctuations over the period analyzed. France has the highest SSC levels, between 16% and 18% of the GDP, followed by the Netherlands and Germany, with 14% in 2015. Tax revenues from social contributions change more over time in CEE countries: Slovenia and the Czech Republic have the highest levels (approximately 15% in GDP), while Latvia and Estonia indicate the lowest (8% and respectively 11% in GDP).

The highest levels of taxes on the property are registered by France and the United Kingdom, increasing over time from 3% up to 4% in GDP. Other developed countries have a level of 1–2% in GDP, as Germany presents the lowest taxes on the property. From CEE countries, Poland has the highest level (1.4%, with its peak in 2001 when it reached 1.7% in GDP), Hungary registers above 1% in GDP (with a significant increase over time), and Estonia has, on the other side, the lowest levels of taxes on property (0.2–0.3% in GDP since the crisis started).

The highest levels of taxes on goods and services are registered by Hungary and Denmark. If in the case of Denmark, since the crisis started, the level of indirect taxes decreased from 16.2% to 15% in GDP, Hungary indicated an opposite evolution, increasing from 14% to 17.2% in GDP, since 2006. Norway had the most dramatic decrease over the period analyzed, from 15.4% to 11.6% in GDP. For the CEE countries, fluctuations were more obvious than for the other set of countries, decreasing between 1995 to 2006, and increasing after the crisis. Slovakia and the Czech Republic have the lowest tax revenues from goods and services (approximately 11%).

The evolution of GDP and GNI over the decades analyzed are reflected in the following figures (Figures 2 and 3). Estonia and Latvia indicate the highest levels of GDP and GNI growth during the first decade analyzed, with an average increase of 10% and 7%, respectively. Although the richest European countries do not present such high GNI growth rates, France, Denmark and Germany have an annual average increase of 1.5–2%, while the rest of the developed countries indicated an average increase of 2.5%; Sweden had the biggest increase (3.4%).

From all the countries analyzed, the increase in Norway's GDP was the highest (in 2000 it reached 20% from 0 in 1998). This is the richest country with the most important fluctuations over the period analyzed, as it will also be described based on the other indicators. Over the crisis period, Estonia and Latvia faced the most dramatic decrease in GDP and GNI, while Sweden and Norway were two of the rich countries with the highest dropout in GNI (−7%) and GDP (−10%) in 2009. In 2008–2009 all the countries analyzed (except Poland) faced a decrease up to 13% in GDP or GNI. The growth indicators slowly recovered and registered increases from 1% to 5% in 2014 and 2015. For these final years, the CEE countries registered the highest GNI growth rates, while Sweden and Norway are the only richest countries that registered more than 3% increase in this rate.

For the human development index, the evolution is reflected in Figure 4. This measurement of life quality constantly increased over the period analyzed, but to a larger extent for the CEE countries. From these, Latvia, which had the lowest HDI value in 1995, managed to catch up with the other CEE countries, to 0.83. Slovenia and Estonia had the highest level of HDI over the period, increasing from 0.78 to 0.89. Related to the developed countries, the highest HDI was registered by Norway, increasing from 0.88 in 1995 to 0.95 in 2015. Besides, this is the country ranked on the first position in the HDI database realized by the United Nations Development Program. On the other side, from the richest countries considered, France has lower levels of HDI, up to 0.897 in 2015.

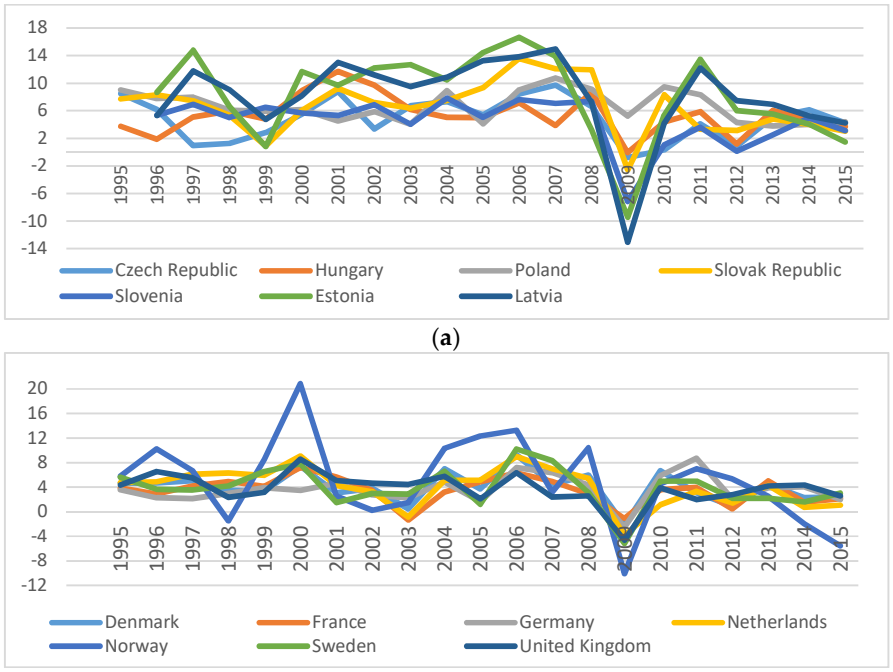


Figure 2. The evolution of Gross Domestic Product (GDP) over the period 1995–2015. (**a**) panel of CEE countries; (**b**) panel of developed countries.

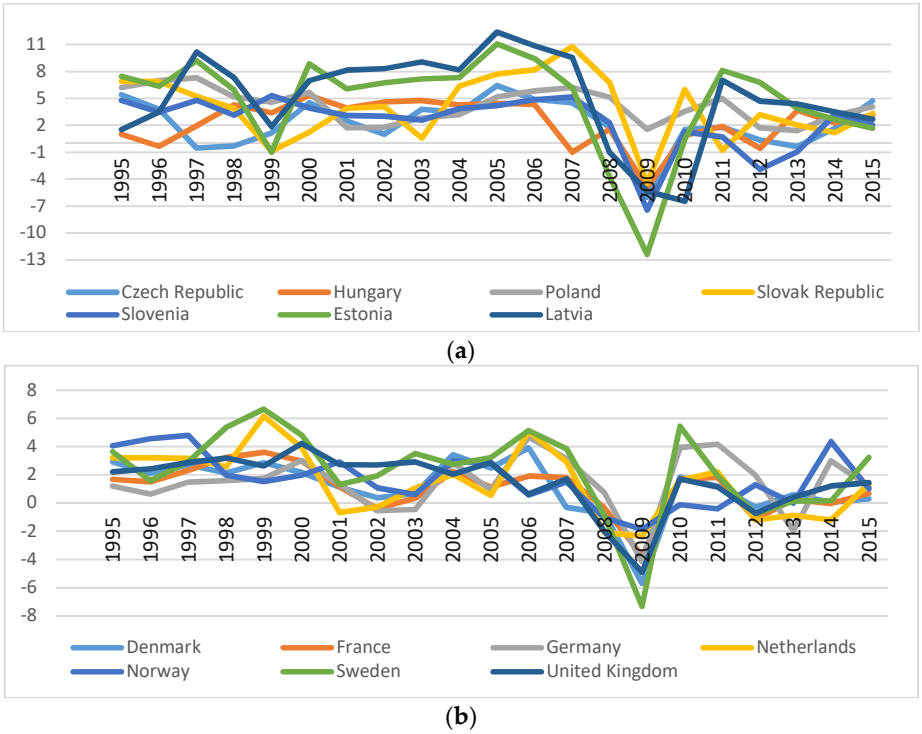
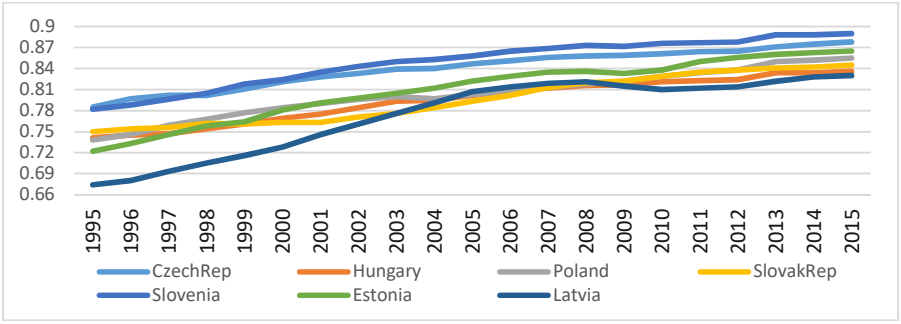


Figure 3. The evolution of Gross National Income (GNI) over the period 1995–2015. (**a**) panel of CEE countries; (**b**) panel of developed countries.



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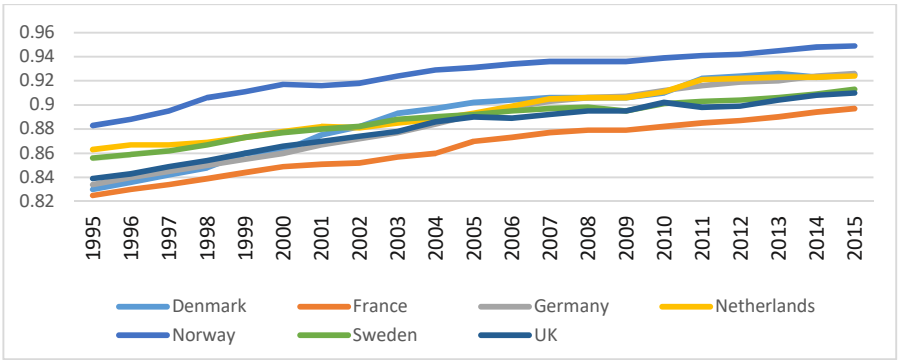

(**b**)

Figure 4. The evolution of HDI over the period 1995–2015. (**a**) panel of CEE countries; (**b**) panel of developed countries.

4.2. Granger Causality Statistics

The results for the Im Pesaran and Shin test for panel unit root indicate that some of the variables reflecting the level of taxes in GDP, for developed countries, contain unit roots. In order to ensure data consistency and to maintain a unitary level, the first difference of the tax variables was computed for both panels. After applying the Im Pesaran and Shin test again, results proved us that all variables are stationary, satisfying the first condition necessary before testing for non-causality.

As outlined in the data and methodology section, testing for cross-sectional dependency in both panels is very important in order to ensure the appropriate estimators. The results are presented in Table 2, and were computed based on the group estimator developed by Pesaran, because this test is applicable to a wide range of panel data, including homogeneous or heterogeneous ones, regardless of the sample size (in this case we have a small N—seven countries for every panel, and larger T—20 years).

Results from the cross-sectional dependence tests demonstrate, with very few exceptions, that there is no cross-sectional dependence in the two panels. This means that the Granger causality analysis may be realized on the overall panel, not on individual cross-sections (countries).

The Granger non-causality tests indicate different causes for growth and development in CEE countries and in the richest states in Europe. We will first refer to the results obtained with a default lag of one, included in Table 3. Over the short term, the level of taxes in GDP is not necessarily the most important cause of growth or human development. For the CEE countries included in this study, tax on income, profits and capital gains, as well as tax on properties (with a *p*-value below the statistical significance, at 88% level) granger cause the level of annual GDP growth. Moreover, this growth indicator granger causes an increase in the level of tax on income, profits and capital gains, and tax on properties, as the bidirectional causal relationship is also direct. Fewer results were statistically significant in the richest countries case. For this panel, only the GDP granger causes taxes on property or taxes on goods and services, and it also seems to be statistically significant in terms of granger causing taxes on property.

Table 2. Results of cross-sectional dependence tests.

Variables Considered	CEE Countries			Developed Countries		
	GDP	**GNI**	**HDI**	**GDP**	**GNI**	**HDI**
TotTax	3.21 (0.0731)	2.19 (0.1385)	0.35 (0.5517)	5.58 ** (0.0181)	1.36 (0.2444)	0.16 (0.6883)
TaxIPrCap	0.27 (0.6049)	1.18 (0.2766)	0.09 (0.7682)	3.10 (0.0781)	0.11 (0.7423)	0.48 (0.4901)
SSC	7.87 *** (0.005)	0.06 (0.8044)	2.65 (0.1036)	3.13 (0.0767)	2.82 (0.0933)	0.01 (0.9043)
TaxProp	2.26 (0.1326)	0.70 (0.4031)	0.44 (0.5062)	1.61 (0.2049)	0.91 (0.3396)	1.19 (0.2759)
TaxGS	0.06 (0.8104)	0.23 (0.6326)	5.89 *** (0.0152)	6.67 *** (0.0098)	0.05 (0.8219)	0.06 (0.8008)

***, ** indicate statistically significant at the 0.01, and 0.05 level respectively.

Table 3. Granger causality between tax revenues and GDP, GNI, and HDI. (in CEE and developed countries).

	Lag 1	TotTax→GDP	TaxIPrCap→GDP	SSC→GDP	TaxProp→GDP	TaxGS→GDP
CEE	Wald stat.	0.991	5.134	1.294	2.178	1.095
	Z-bar	−0.213	**5.954** ***	0.239	1.554	−0.058
Dev	Wald stat.	1.055	0.968	0.888	1.278	1.414
	Z-bar	−0.117	−0.246	−0.365	0.216	0.418
	Lag 1	GDP→TotTax	GDP→TaxIPrCap	GDP→SSC	GDP→TaxProp	GDP→TaxGS
CEE	Wald stat.	0.596	2.545	1.158	3.048	0.912
	Z-bar	−0.7998	**2.101** **	0.037	**2.849** ***	−0.329
Dev	Wald stat.	1.841	0.885	0.49	2.167	47.338
	Z-bar	1.054	−0.369	−0.957	1.538	**11.093** ***
	Lag 1	TotTax→GNI	TaxIPrCap→GNI	SSC→GNI	TaxProp→GNI	TaxGS→GNI
CEE	Wald stat.	0.719	2.393	2.264	1.624	0.582
	Z-bar	−0.617	**1.874** *	**1.683** *	0.73	−0.819
Dev	Wald stat.	1.371	1.166	0.416	2.788	1.349
	Z-bar	0.353	0.048	−1.067	**2.463** ***	0.321
	Lag 1	GNI→TotTax	GNI→TaxIPrCap	GNI→SSC	GNI→TaxProp	GNI→TaxGS
CEE	Wald stat.	0.904	3.592	0.912	3.888	1.735
	Z-bar	−0.342	**3.658** ***	−0.329	**4.099** ***	0.896
Dev	Wald stat.	1.281	0.675	0.659	1.415	2.168
	Z-bar	0.22	−0.683	−0.706	0.419	1.539
	Lag 1	TotTax→HDI	TaxIPrCap→HDI	SSC→HDI	TaxProp→HDI	TaxGS→HDI
CEE	Wald stat.	2.116	1.263	3.241	1.547	0.889
	Z-bar	1.463	0.192	**3.136** ***	0.615	−0.363
Dev	Wald stat.	1.438	2.089	1.303	0.479	1.872
	Z-bar	0.453	1.422	0.253	−0.973	1.099

Table 3. *Cont.*

	Lag 1	HDI→TotTax	HDI→TaxIPrCap	HDI→SSC	HDI→TaxProp	HDI→TaxGS
CEE	Wald stat.	2.326	1.542	1.709	0.809	1.347
	Z-bar	**1.775** *	0.609	0.856	−0.418	0.318
Dev	Wald stat.	3.652	1.439	1.643	2.158	1.321
	Z-bar	**3.747** ***	0.456	0.758	1.524	0.279
	Lag 1	TotTax→GDP	TaxIPrCap→GDP	SSC→GDP	TaxProp→GDP	TaxGS→GDP
CEE	Wald stat.	0.991	5.134	1.294	2.178	1.095
	Z-bar	−0.213	**5.954** ***	0.239	1.554	−0.058
Dev	Wald stat.	1.055	0.968	0.888	1.278	1.414
	Z-bar	−0.117	−0.246	−0.365	0.216	0.418
	Lag 1	GDP→TotTax	GDP→TaxIPrCap	GDP→SSC	GDP→TaxProp	GDP→TaxGS
CEE	Wald stat.	0.596	2.545	1.158	3.048	0.912
	Z-bar	−0.7998	**2.101** **	0.037	**2.849** ***	−0.329
Dev	Wald stat.	1.841	0.885	0.49	2.167	47.338
	Z-bar	1.054	−0.369	−0.957	1.538	**11.093** ***
	Lag 1	TotTax→GNI	TaxIPrCap→GNI	SSC→GNI	TaxProp→GNI	TaxGS→GNI
CEE	Wald stat.	0.719	2.393	2.264	1.624	0.582
	Z-bar	−0.617	**1.874** *	**1.683** *	0.73	−0.819
Dev	Wald stat.	1.371	1.166	0.416	2.788	1.349
	Z-bar	0.353	0.048	−1.067	**2.463** ***	0.321
	Lag 1	GNI→TotTax	GNI→TaxIPrCap	GNI→SSC	GNI→TaxProp	GNI→TaxGS
CEE	Wald stat.	0.904	3.592	0.912	3.888	1.735
	Z-bar	−0.342	**3.658** ***	−0.329	**4.099** ***	0.896
Dev	Wald stat.	1.281	0.675	0.659	1.415	2.168
	Z-bar	0.22	−0.683	−0.706	0.419	1.539
	Lag 1	TotTax→HDI	TaxIPrCap→HDI	SSC→HDI	TaxProp→HDI	TaxGS→HDI
CEE	Wald stat.	2.116	1.263	3.241	1.547	0.889
	Z-bar	1.463	0.192	**3.136** ***	0.615	−0.363
Dev	Wald stat.	1.438	2.089	1.303	0.479	1.872
	Z-bar	0.453	1.422	0.253	−0.973	1.099
	Lag 1	HDI→TotTax	HDI→TaxIPrCap	HDI→SSC	HDI→TaxProp	HDI→TaxGS
CEE	Wald stat.	2.326	1.542	1.709	0.809	1.347
	Z-bar	**1.775** *	0.609	0.856	−0.418	0.318
Dev	Wald stat.	3.652	1.439	1.643	2.158	1.321
	Z−bar	**3.747** ***	0.456	0.758	1.524	0.279

***, **, and * indicate statistically significant at the 0.01, 0.05, and 0.1 level respectively.

At first glance, results prove that tax systems produce different effects on economic and social development in CEE and richest countries. The most obvious results prove that, in CEE countries, higher levels of taxes on income, profits and capital gains immediately cause an increase in economic growth. Negative coefficients would indicate that total tax revenues should be reduced in order to

register higher GDP or GNI values. However, this assumption was not proven as coefficients are not statistically significant.

The level of income, profit, and capital gains taxes are a granger cause for GNI as well as the annual growth in GNI represents a granger cause for these types of taxes. These effects happen over a very short time. The social security contributions proved to be a granger cause for GNI as well. For developed countries, the only category of taxes to granger cause GNI was tax on property. Considering the opposite causal relationship, this growth indicator was revealed as a granger cause for tax on property for CEE countries, but it was not statistically significant as an influential factor on taxes from the richest European countries.

The fiscal revenues that granger cause human development index are the social security contributions, in the case of CEE countries, while in developed ones it seems that tax on income, profit and capital gains are a cause. In addition, regardless of the panel analyzed, the human development index is a granger cause of the level of total tax revenues, proving that the happier and healthier citizens are, the higher their tax payments will be.

The causality models applied to panel data indicate whether or not the results request different lag orders in order to minimize the Akaike, Bayesian, or Hannan-Quinn information criteria. Therefore, we extend the model by applying a set of regressions containing lag orders above 1. Moreover, Stata offers options which rely on a series of estimations for the maximal number of observations available and re-runs with the optimal number of lags. A new set of results is presented in Table 4, being selected in an optimal way. With few exceptions, where results are the same as the previous ones (where optimal lag was considered to be 1), the rest of the models are optimal for lag 6. Considering that more results were statistically significant with the use of lag 6, it demonstrates that in terms of taxation, economic growth and human development, causality is produced over the long-term, and not immediately.

Coefficients obtained through all models are positive, indicating that there is a direct influence between the three categories of variables (taxes, economic growth, HDI). Except for the granger cause between taxes and HDI, all the other coefficients are statistically significant at 1% level.

A growth in tax revenues granger causes an increase in GDP growth. For the developed countries the impact of total taxes seems to be higher, according to the Z-bar value. From all the taxes, tax on income, profits and capital has the most impact on GDP growth in CEE countries. For the richest countries in Europe, results indicate that social contributions have the strongest impact on growth. The inverse relationships are also confirmed between GDP and tax categories. The highest coefficient values highlight the fact that GDP variations in CEE countries have the most influence on taxes on property and on taxes on income, profit, and capital. In developed countries, a growth in GDP would cause the highest increase in taxes on property, social security contributions, and taxes levied for income, profit, and capital.

An increase in tax revenues would also granger causes a rise in GNI, the impact being higher in CEE countries. Granger coefficients are lower than in the relationships between taxes and GDP, but, in CEE countries, we observe once again that the highest impact comes from taxes on income, profit, and capital gain. Even a higher impact is observed for the opposite granger cause: results indicate that, from all the taxes, those on income, profit, and capital gain represent the strongest granger cause on GNI.

In terms of the human development index, the only taxes with statistically significant influence on HDI are social security contributions. However, in the opposite direction, results indicate that HDI is a granger cause for taxes in all countries. More specifically, in CEE countries, whenever HDI value increases we can expect an increase in future tax revenues; most influence is on consumption taxes and social contributions. Trends are different in the richest European countries, where HDI seems to have the highest impact on social contributions and taxes on income, profit, and capital.

Table 4. Granger causality between tax revenues and GDP, GNI, and HDI with multiple lags (in CEE and developed countries).

	Lag 6	TotTax→GDP	TaxIPrCap→GDP	SSC→GDP	TaxProp→GDP	TaxGS→GDP
CEE	Wald stat.	1220.34	23200	377.04	418.406	732.26
	Z-bar	**345.28** ***	**6595.45** ***	**105.03** ***	**116.81** ***	**206.23** ***
Dev	Wald stat.	43400	20.939	7731.77	80.899	47.338
	Z-bar	**12,400** ***	**3.572** ***	**2200.40** ***	**20.65** ***	**11.093** ***
	Lag 6	GDP→TotTax	GDP→TaxIPrCap	GDP→SSC	GDP→TaxProp	GDP→TaxGS
CEE	Wald stat.	77.37	2376.11	48.71	4318.09	252.66
	Z-bar	**19.65** ***	**674.56** ***	**11.485** ***	**1227.84** ***	**69.58** ***
Dev	Wald stat.	90.958	916.22	3633.32	4094.31	204.696
	Z-bar	**23.52** ***	**258.64** ***	**1032.75** ***	**1164.08** ***	**55.93** ***
	Lag 6	TotTax→GNI	TaxIPrCap→GNI	SSC→GNI	TaxProp→GNI	TaxGS→GNI
CEE	Wald stat.	2176.87	2636.83	91.289	118.204	198.91
	Z-bar	**617.8** ***	**748.84** ***	**23.62** ***	**31.28** ***	**54.277** ***
Dev	Wald stat.	142.21	244.705	221.21	127.41	42.203
	Z-bar	**38.13** ***	**67.324** ***	**60.63** ***	**33.906** ***	**9.63** ***
	Lag 6	GNI→TotTax	GNI→TaxIPrCap	GNI→SSC	GNI→TaxProp	GNI→TaxGS
CEE	Wald stat.	18100	1420000	222.95	743.82	2202.82
	Z−bar	**5155.99** ***	**406,000** ***	**61.13** ***	**209.52** ***	**625.19** ***
Dev	Wald stat.	284.25	154000	147.97	113.35	122.16
	Z-bar	**78.59** ***	**43,700** ***	**39.76** ***	**29.902** ***	**32.41** ***
	Lag 6	TotTax→HDI	TaxIPrCap→HDI	SSC→HDI	TaxProp→HDI	TaxGS→HDI
CEE	Wald stat.	2.116	1.265	575.59	1.547	0.889
	Z-bar	1.463	0.192	**161.59** ***	0.615	−0.363
Dev	Wald stat.	1.438	2.089	1.303	0.479	1.872
	Z-bar	0.453	1.422	0.253	−0.973	1.099
	Lag 6	HDI→TotTax	HDI→TaxIPrCap	HDI→SSC	HDI→TaxProp	HDI→TaxGS
CEE	Wald stat.	1390.83	658.95	1559.92	165.86	2505.12
	Z-bar	**393.86** ***	**185.34** ***	**442.03** ***	**44.86** ***	**711.32** ***
Dev	Wald stat.	1116.07	2655.98	30400	540.07	1008.57
	Z-bar	**315.57** ***	**754.3** ***	**8644.57** ***	**151.47** ***	**284.95** ***

*** indicates statistically significant at the 0.01 level.

The main results observed with the granger cause analysis with lag 1 prove that the statistical significance of the relationships between taxes, economic growth, and human development is reduced over the short term. According to the statistics analyzed, higher tax revenues are collected in developed countries, with highest shares from taxes on income, profit and capital (15% of GDP compared to 7.5% of GDP in CEE countries). CEE countries tend to depend on taxes on good and services and on social contributions. Regardless of these important tax differences between countries, our results indicate that taxes on income, profit and capital have more impact on immediately increasing the economic growth of CEE countries. The opposite causal relationship evidenced that developing countries with higher GDP and GNI would collect a larger share of their national output in taxes on income, profit, and capital and in taxes on property. This proves that by relying more on direct taxation, economic

growth and development is ensured. For CEE countries results also indicated that a larger share of social security contributions would positively influence the GNI and HDI, inducing an increase in both measures over the short term. Modern countries should develop social security systems with a major role in the welfare state. Our results prove that, especially in developing countries, higher social security contributions are associated with happier and wealthier people. This means that in CEE countries the national social security systems tend to focus more on ensuring the social protection for their citizens over the short-term, providing the financial assistance for contingencies such as retirement, childbirth, unemployment or disabilities.

For the granger cause analysis with lag 6 almost all results prove statistically significant causal relationships in all the countries analyzed. First of all, results indicated that over the long term, higher taxes (regardless of their category) induce an increase in economic growth. More specifically, for developed countries, the most influence on GDP comes from total tax revenues and social security contributions, while GNI would be mostly increased based on higher taxes on income profits and capital and social security contributions. In CEE countries, the most influential for GDP and GNI growth would be taxes on income, profits, and capital and total tax revenues. Once again, results prove that economic development is sustained over the long term by an increase in tax revenues. Although in developed countries the total taxes and the taxes on income, profit and capital levied have a higher share in GDP, their role in country development is as important in developing countries such as the CEE countries overviewed in this study. The citizens wealth in developed countries is strongly impacted by social contributions, but the effect is over the long term (opposite to the short term relevant in CEE countries). Evidencing a cycle, the results proved for both country samples that an increase in GDP and GNI per capita would also induce an increase in the level of taxes collected. All these confirm that direct taxation is the most relevant type of tax in sustainable economic growth, as long as the tax competition does not interfere [16]. This competition is specific to taxes on income, profit and capital, and refers for example to a decrease in profit tax which should not generate inequitable effects on employees, by increasing taxes on income or capital. This way, the tax system would provide equity for businesses and citizens.

Over the short term, happier citizens are associated only with higher levels of tax revenues collected (HDI granger causes total tax revenues). But over the long term, our study evidenced that, regardless of the country analyzed, happier citizens would pay higher taxes of any kind, with most impact on social contributions and consumption taxes. As happiness may be related to internal feelings of empathy and various states of satisfaction, citizens are willing to pay more taxes and ensure the income redistribution across the society. Moreover, in rich countries the social security systems are viewed as a productive component in economic development, as social contributions were the taxes with highest impact on GDP and GNI growth. This way, a larger human development index could reflect a society with a more effective social security system, providing benefits from social insurance and other government assistance programs, and continuing the cycle by increasing economic growth.

5. Conclusions

Empirical studies, including this one, prove that taxation has significant influences on economies and citizens well-being. Although an immediate effect of tax revenues fluctuation is rather limited, over medium to long-term effects on GDP growth are obvious. Referring to the impact of taxes on human development, only social security contributions seem to have an immediate effect on HDI in CEE countries, but, regardless of the country analyzed, healthier, educated citizens with a decent standard of living will pay more taxes in the future. The novelty of this study is that it applies the mixed concept of quantitative and qualitative growth and development (through economic growth and HDI, respectively), emphasizing the impact taxes have beyond the economy, on the citizens, reflecting the welfare state.

This study proves that there are differences between the countries analyzed, especially over the short-term. From all tax revenues, those from income, profit and capital influence the most the GDP

and GNI in CEE countries. In the same countries, an increase in economic growth would also induce a rise in the level of taxes levied from income, profit, capital, and property. The immediate granger cause of direct taxes on economic growth is neglectable in developed countries, except for taxes on property, which seem to have a direct influence on GNI. For the opposite direction of the granger cause analyzed, an increase in GDP in the richest countries will bring an increase in revenues from consumption taxes.

These results point out that economic growth may be based on tax policies. However, policymakers should consider that increasing taxes has an effect over long-term, and must be sustained by citizens well-being. Taxpayers who are healthier, more educated and have an average or above average standard of living are willing to pay more taxes. This proves that sustainable growth and development are, as predicted, based on taxation, and that welfare states do practice a more sustainable tax policy by levying higher taxes but also registering larger values of economic growth and human development. These results are similar to those which found that higher values of economic growth and development may be realized by promoting higher tax rates and even higher tax progresivity [6–9]. Moreover, in CEE countries, social contributions paid seem to boost HDI values because social security and economic stability are essential factors for the quality of life. This comes in contrast with other studies on developing countries suggesting that a good tax system is one that does not involve employers in labor taxes [11].

From all types of taxes, the least distortive ones, regardless of the countries studied, are taxes related to wealth, especially those on immovable property. Besides, results indicate that economic growth has an immediate and direct effect on revenues from the tax on property in CEE countries. This demonstrates that in times of economic growth, citizens are willing to invest their money. Nowadays, there seems to be a gap in wealth taxation, which could be reduced by increasing property tax rates and raising substantial revenues to public budgets. Generally, taxes on returns on housing are smaller compared to taxes on returns on other assets, which may be appealing to citizens with savings.

Some conclusions based on the literature review and the different results obtained for developed versus emerging countries, will refer to changes in taxation, which should always be realized in complementary manners. For example, developed countries could shift from direct taxation towards consumption taxation. First of all, indirect taxes are less progressive than personal income taxes. Moreover, by transferring the tax burden from corporations to consumers (based on consumption taxation), an increase in share prices would be induced, as the net profits and firm after-tax values would grow, but there would also be an increase in wealth inequality generated by lower capital income taxation. In terms of direct taxation, relying more on personal income tax than on corporate income tax could be efficient in terms of economic growth, with results obtained over a shorter period of time. However, when tax systems regulate a lower corporate tax rate than personal income tax rate, individuals may be tempted to invest their savings in corporations in order to avoid taxes. Flattening personal income taxes may be one measure against a potential decrease in GDP per capita, reflecting in both, economic growth and citizens well-being.

Other matters that may be considered in terms of the positive relationship between human development and taxes are associated to longer life expectancy and more years of education (reflected by countries with high levels of HDI), which are both related to higher government spendings, better welfare systems and therefore increased levels of taxation. However, citizens are willing to pay higher taxes for a better quality of life. The main conclusion of this study is that as long as tax policies implementing high tax rates are practiced by Governments that invest more in education and health systems, better services will be provided to citizens, ensuring the welfare of the society and sustainable growth over the long term.

One study limitation refers to the period analyzed, which includes the financial crisis. Over the second decade, the growth variables (GDP and GNI) registered a sudden drop in 2009, then recovered in 2010 and 2011, then steady decreased over the rest of the period. These shocks in data could influence the results and therefore future research could consider Granger causality in the presence of structural breaks. For this panel data the period analyzed could be divided but the sub-samples

obtained would only consider a decade, allowing Granger causality analysis with few lags due to the limited time. Therefore, an extended period would be more appropriate for considering the structural break during the financial crisis, in order to reveal a reliable causal relationship over the long-term, which was evidenced over this 21-year analysis.

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RESEARCH ARTICLE

Addressing oil price changes through business profitability in oil and gas industry in the United Kingdom

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Data Availability Statement: Data are owned by a third party and therefore the authors cannot make the data publicly available. The data were obtained from Amadeus (www.bvdinfo.com) and Investing.com. As Amadeus is restricted under a subscription model, and the authors' subscriptions were provided by a colleague, interested researchers will need to pay the subscription fee to access the data. The Amadeus search engine for data used in this analysis was based on the following options: All active companies and companies with unknown situation; NACE Rev. 2 (Primary codes only): 06 - Extraction of crude

Abstract

In this paper, we investigate how crude oil price and volume traded affected the profitability of oil and gas companies in the United Kingdom (UK) since the financial crisis started in 2008. The study benefit from insights of the financial statements, to develop a model that focuses on how changes in oil price impact corporate performance. In order to observe the financial indicators that influence the performance, as well as the effects that changes in oil prices and demand of crude oil have on the profitability of oil and gas companies, we apply comparative regression analysis, including the generalised method of moments estimation technique for panel data set. The sample is consisting of 31 oil and gas companies in the UK, and the period analysed is 2006–2014. Results show that profitable oil and gas companies managed to face the drop in oil price and recover, characterized by significant cash flows and stock turnover, efficient use of assets, and high solvency rates. Although the oil price and volume traded do not significantly affect profitability and other financial ratios, if the oil price continues to decrease, it would permanently alter both the UK economy and oil and gas companies. In order to survive, companies make drastic cuts and defer essential investments, often at the long-term expense of asset performance. This study is important in a world where the energy consumption steadily grew over time. However, the renewable energy is cheaper and more environmentally friendly, and thus, countries where oil and gas industry is one of the most popular sectors face an economic decline. These results could be useful for investors, managers or decision makers, reclaiming strategic decisions in the current uncertain and volatile environment.

Introduction

This paper intends to investigate the relationship between oil price and corporate performance in a European country where the energy industry is one of the essential components of the economy. The UK offshore oil and gas industry used to contribute to 2.5% of GDP before

petroleum and natural gas. All other relevant data are found within the paper.

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2010, but in 2015 it only counted for 0.8%. Fiscal revenues declined from approximately £7 billion before 2010 to 2 billion in 2015 and to almost zero in 2016. Also, jobs continue to be made redundant, leaving a high unemployment rate. Although it is intuitive for the performance of oil and gas companies to be strongly related to oil prices, there are few papers to study this relationship, while many focused on the impact of oil price shocks on a macroeconomic level. This paper aims to observe to what extent were the oil and gas companies affected after the financial crisis began, and since the oil price dropped, to review corporate performance in times of high volatility and increased financial risks.

The world is dependent on energy, and thus consumption steadily grew over the last decades. Large economies such as the United States and China became the most significant oil consumers. China doubled its energy consumption over the first decade of the 21st century and accounted for approximately 60% of the world's growth in oil consumption over the last decade. The European Union is situated between the US and China in the list of countries by oil consumption, relying on net imports for 89% of the oil products consumed. The major producer of crude oil in the EU is the United Kingdom, followed by Denmark, Italy, and Romania (the last three countries produced less than half of the UK primary production of crude oil in 2015). The financial markets developed over the oil-related funds all over the world and thus many investors pay great attention to oil price fluctuations, while oil and gas companies increased the number of mutual and exchange-traded funds.

Nowadays, even the most profitable and stable companies suffer from the crisis threatening the oil and gas industry. After an extended period of high oil prices, the industry is now facing an extended period of low prices, amplified by a decrease in the operational efficiency of oil and gas companies due to higher extraction costs. On the contrary, economical fossil fuels allow higher standards of living for the population and thus, economic growth on this side, but significant costs regarding pollution or oil spills.

The oil and gas industry was always volatile, facing boom-and-boost cycles. Thereby, companies tend to invest in assets and raise employees number in order to grow during prosperous periods, while making drastic cuts and dropping profitable projects, to minimize costs during downturns.

Economic factors also put pressure on this industry, while digital technologies offer new tools that simplify operational processes and increase production. However, these are costly and require intelligent investing. Therefore, oil and gas companies are forced to create strategies for sustainable change, bringing stability, improving the primary performance metrics and operational excellence through booms and busts.

The main contribution of this paper comes from the analysis perspective, including besides the financial information, data reflecting the dynamics of the oil industry to observe the corporate performance, which is not only critical to companies operating in this field, but also to oil-dependent countries such as the UK. This research was undertaken to analyse the profitability of oil and gas companies in the UK, where unemployment rate and losses steadily grew over the last years due to the decrease in oil price, affecting the economy at different levels. The profitability is analysed based on assets efficiency, liquidity, and solvency, concerning crude oil prices. As the literature was primarily focused on the relationship between oil prices and stock markets, our study analyses the performance of oil and gas companies over the financial crisis and the periods of falling oil prices, reviewing their operational activity, and their ability to generate profits. Therefore, we seek to fill the gap in the present literature, developing the research into adjacent points of interest that have not been debated recently. In addition, the study is generalised to the corporate performance in the oil and gas industry, in the UK, while previous studies focused on the effects that oil prices have on individual companies.

The following section reviews the literature related to oil and gas industry performance over time. The third section presents the data used and the methodology. Section 4 describes the empirical results obtained through different stages of analysis. Firstly, correlations between all variables are discussed, followed by a presentation of the baseline regression results. Secondly, a non-linear analysis has been employed in order to capture the structural breaks in oil and gas companies performance, financial ratios, and crude oil prices. These various stages of the study were also intended to test the results robustness. Section 5 concludes.

Literature review

The financial crisis represented a turning point for some major national oil companies around the world. For example, although the competition for resources increased, in China, it was discovered that some of the world's biggest oil companies became the most efficient regarding production, mostly based on investment opportunities, expansions, and international cooperation agreements. National Chinese oil companies were also an advantage because of the production scale, and due to domestic macroeconomic regulations focused on protecting the monopolistic organisations and based on the gradual increase in the domestic oil demand. However, it was admitted that there is an unobserved heterogeneity with parameters related to the centrally planned economy or institutional environment, which may influence the analysis and cause unbiased results in oil companies efficiency on the subject of production [1]. These make the oil industry in China react differently to the financial crisis compared to other market economies. Other researchers agreed on the fact that unobserved heterogeneity among oil industry may produce biased efficiency in results, and factors related to market reforms and government policies, economic development or social environment may induce different strategies and operational activities among oil companies from different countries [2].

Studies also proved that corporate governance has an essential impact on oil companies' profitability and performance. Besides, ownership concentration also has a strong influence on firm performance, showing a nonlinear relationship. Studies prove the fact that, on a risk-adjusted basis, companies with strong shareholders rights outperform, proving that good governance has a positive impact on corporate performance [3,4]. Furthermore, it seems that companies with private ownership are more efficient than state ownership ones [5]. Previous studies focused on the relationship between oil prices and the share prices of oil and gas companies. For example, in the US, it was showed that returns are strongly affected by the shocks in the oil market and the economic policy uncertainty, while the shocks on demand have a positive effect on returns [6]. Although in this case results are more evident over the long run (after a period of 60 months), other researchers found through an unrestricted VAR model a significant positive impact of oil price shocks on stock returns, over the short-run [7]. For the oil and gas companies in the UK, the oil price shocks seem to have both, negative and positive effects on stock prices [8]. More specifically, the study shows through wavelet analysis that over the short term risks and oil price have weak effects on oil and gas industry investors, who can still diversify their portfolios', but risks become more important for long-term investors. Actually, for them, previous oil price information can be very useful to improve the forecasting quality of future stock prices.

The fact that changes in oil price have a positive effect on stock returns, and an increase in oil prices does not depress the demand of oil to a large extent, shows that oil and gas companies easily pass oil price increases on to customers. Depending on the corporate culture, managers and shareholders are focused on maximising companies' operational efficiency over long-term through constant returns and gradual growth. Oil companies should also have an increased level of control and transparency in order to safeguard investor's interests and bank

officials offering resources for new investments [9]. Moreover, a campaign requiring transparency in company payments, government revenues and expenditures, and licensing procedures, was launched in 2002 in order to strengthen corporate governance in extractive sectors [10]. This campaign was entitled the "Extractive Industries Transparency Initiative"—EITI and was established by the UK prime minister, and implemented in 39 countries through a government-driven process. It was shown that the countries implementing EITI do not outperform others, due to corruption, stakeholders' ignorance to implications, especially in the case of state-owned companies, and strong dependence on civil society [11].

The liberalization of capital flows increased the competition in globalized markets, although the EU members tried to reduce the disparities between the integrated European areas. In the recent context, companies reach competitiveness through innovation and research, focusing on increasing productivity, but also supporting sustainable economic growth and citizens' quality of life [12]. Research on the recent financial crisis indicated that oil prices affect stock prices in all stock markets, although the supply and demand have not been affected to that extent. Therefore, oil companies were blamed for price gauging, as studies showed that commodity prices mainly drive their performance. Firms claim that their profits have been reduced due to crude oil price volatility, after investing billions of dollars and paying high taxes. Results are different, depending on the periods and countries analysed, showing that oil prices may have a weak impact on non-commodity based stock markets (like in the UK or Japan). For example, in North America, crude oil prices have a positive impact on oil and gas sector profitability but, through the recent financial crisis, the relationship became an indirect one, with a negative influence from oil prices to corporate performance. However, other crisis such as the Asian one or the 9/11 did not influence firm performance significantly [13]. From a comparison between risk factors in developed and developing countries, it was shown that oil and gas industry responds more strongly to the volatility in oil prices in developed countries. Moreover, the returns in this industry tend to be asymmetric, as increases in oil price have a more significant impact than price drops [14].

In developed countries, oil and gas companies have robust command-and-control regulations, while the lack of control, corruption and weak enforcement of legislation penalise returns and productivity in developing economies. This is a strong reason for companies to use their know-how and resources to change the situation in developing countries and in economically disadvantaged communities, where selling off natural resources causes poverty and low wages [15,16]. Although companies need intelligent investing that is costly, this ensures a continuous generation of cash and higher operating profits. For a reduced bankruptcy risk, shareholders should agree on increasing equity, or even changing debt into shared capital [17]. Moreover, oil and gas companies are now required to take into consideration environmental friendly strategies, as this is one the crucial competitive advantages proved to have a positive influence on firm performance and profitability [18].

The aim of this study contributes significantly to this field of research as it focuses on the question related to what extent the oil price may drop until it would permanently affect oil and gas companies performance and the UK economy. Considering that the relationship between the stock prices and oil price was analysed over time, our study will focus more on companies' financial performance rather than on shareholders' returns, reviewing their operational activity as well as the level of the taxes paid, based on oil consumption and its prices. The period analysed is suitable to reveal if there is an effect over the short or long-term period, and the sample is adequate to consider the results specific to the oil and gas industry in the UK. Therefore, the study is more general than previous works that considered influences on individual companies, and thus a limited number of companies.

Data and methodology

Data and variables

This study evaluates the profitability of oil and gas companies in the UK, based on different financial indicators, but also trying to capture to what extent profitability was affected by the changes in crude oil prices. To obtain more information on the profitability of oil and gas companies, the analysis will include besides the evidence on oil prices and corporate performance, financial information related to the companies, such as assets efficiency, liquidity, solvency or the level of taxes paid. Considering the recent steady period of low oil prices, and the switch towards renewable energies, it is expected for oil and gas companies profitability to drop. Therefore, it is essential to overview how efficiently they operate and the financial risks undertaken.

The analysis is based on annual data, over the period 2006–2014. The following financial indicators and ratios used in this study were collected from Amadeus database, which offers financial information on companies across Europe: return on equity (ROE), cash flow over operating revenue (CF/OpRev), current ratio (CurrRat), Asset turnover (AssTn), solvency ratio (SolvRat), stock turnover (StockTn), and finally, taxation, computed as the natural logarithm of the value paid by companies every year as taxes (lTax). The data related to the oil industry (crude oil price, as $/barrel; the volume of oil traded every month, in millions of barrels) was obtained from the website Investing UK. It was then used to compute three control variables, with identical annual values regardless of the company considered: OilPrice, as the annual average of the crude oil price, OilVolume, as the annual average amount of oil traded, and a dummy variable (dummyOilPrice) which takes the value 1 when the annual average oil price drops compared to the previous year's average, or 0 if it increases.

In order to obtain robust results, we collected data for a limited sample of 31 oil and gas companies, due to the fact that many companies in this industry had missing data from their balance sheets, profit and loss accounts, and global ratios over the period considered. The data collected were analysed with STATA, a statistical software package commonly used in the economics field, to observe statistical analysis, graphics and regressions. All the results further presented and those from the "Results and analysis" section represent authors' computations in STATA.

Table 1 below presents the descriptive statistics of the variables considered in this research.

Return on equity is on average 27.67%, which indicates high profitability of oil and gas companies in relation to the book value of shareholders' equity. The cash flow over operating revenue ratio also proves that oil and gas companies are profitable, showing investors and shareholders that most oil and gas companies can generate consistent cash from their sales.

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
ROE (%)	279	27.6777	38.2054	-119.53	310.7
CF/OpRev	279	35.5832	22.1877	-30.88	97.81
CurrRat	279	2.4939	3.6119	0.08	37.59
AssTn	279	1.4560	2.2535	0.07	17.84
SolvRat	279	46.6986	21.6390	8.56	92.86
StockTn	279	44.7989	66.3885	2.12	724.5
lTax	250	11.8915	1.9748	6.5356	16.7504
OilPrice ($/barrel)	279	84.9207	12.9505	63.9233	98.5833
OilVolume (barrel)	279	5.1808	1.1365	2.5033	6.6125

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With an average current ratio of 2.5, companies analysed can pay off their short-term liabilities based on their current assets, which is another proof that they are financially stable. Based on the average asset turnover of 1.45, the oil and gas companies are efficient regarding their assets, as they are generating sufficient sales revenue. The average solvency ratio of 46.7, the companies observed also prove that they can meet their long-term obligations, sustaining their operations indefinitely. The stock turnover is very high, approximately 45, showing that the oil and gas companies' inventory is used or sold quickly.

Tax variable shows an average of approximately $150 million (lTax value of 11.89) paid annually by the oil and gas companies in the UK. For this variable, some data is missing as companies rarely registered negative values on Taxation, and therefore these values could not be computed based on the logarithm.

Over the period analysed, from 2006 to 2014, the average price of the crude oil was $84.92, while the volume of the oil traded was of approximately 5 barrels/month, increasing very much from the first year until the last ones.

Profitability will be considered as a function of multiple indicators, some internal and other exogenous to the companies, as presented in the following equation:

$$Profitability = f\left(\frac{cash\ flow}{operating\ revenue}, current\ ratio, asset\ turnover, solvency\ ratio, stock\ turnover, taxation\right) \quad (1)$$

In order to test the results robustness, another model will be tested, based on the previous equation where the three control variables, related to the oil price and volume traded, are added:

$$Profitability = f\left(\begin{array}{c}\frac{cash\ flow}{operating\ revenue}, current\ ratio, asset\ turnover, solvency\ ratio, stock\ turnover,\\ taxation, crude\ oil\ price, crude\ oil\ volume\ traded, dummy\ oil\ price\ decrease\end{array}\right) \quad (2)$$

The linear model of the profitability function can be expressed by the following two equations:

$$ROE_{it} = \alpha_i + \beta_1\frac{CF}{OpRev_{it}} + \beta_2 CurrRat_{it} + \beta_3 AssTn_{it} + \beta_4 SolvRat_{it} + \beta_5 StockTn_{it} + \beta_6 lTax_{it} + \varepsilon_{it}, \quad (3)$$

$$ROE_{it} = \alpha_i + \beta_1\frac{CF}{OpRev_{it}} + \beta_2 CurrRat_{it} + \beta_3 AssTn_{it} + \beta_4 SolvRat_{it} + \beta_5 StockTn_{it} + \beta_6 lTax_{it} + \beta_7 OilPrice_t + \beta_8 OilVolume_{it} + \beta_9 dummyOilPrice_t + \varepsilon_{it,} \quad (4)$$

where α_i represents the unknown intercept of each of the 31 companies included in the sample (i = 1. . .31), t is the year analysed (t = 2006. . .2014), the coefficients associated to each explanatory variable are the βs, and the error term is ε_{it}.

Methodology

The relationship between oil price and returns was mostly studied through vector autoregressive—VAR or structural vector autoregressive models—SVAR [6,7]. Within VAR models, the business cycle is defined by output movements associated with shocks. These shocks are assumed to be without long-run effects on output, but previous studies, as well as this one, show that there is a significant lag between the changes in oil prices and their impact on company returns. In addition, in these models, the exogenous oil price changes do not make a distinction between oil and demand shocks. Moreover, it is very difficult to find totally

exogenous variable especially in micro-economic models, where all the indicators are interdependent, and thus endogenous to some extent. Contrary to the previous studies based on VAR or SVAR results, which referred to individual oil and gas companies, we aim to observe the overall oil and gas industry, based on a sample of 31 companies. We will use both, static and dynamic models, developing the analysis through multiple regression models. The final step in our analysis will be estimating an instrumental variable panel VAR, which offers the responses of the variables used to an exogenous shock, after controlling for time-invariant characteristics of individual companies. As long as results from previous research seem robust for sub-periods [7], we expect a nonlinear relationship between oil price and corporate performance, and thus, will use nonlinear regression models as well.

First of all, this analysis reveals, through descriptive statistics, the dynamics of the variables observed, capturing their primary influences over profitability. In order to test whether or not the explanatory variables have a significant impact on return on equity, a comparison between different regression models will be realised: the first one considered is Pooled Ordinary Least Square (OLS) model, followed by Fixed Effect (FE) and Random Effect (RE) models. All will be regressed on the overall panel of oil and gas companies, for the nine-year period. One of the advantages of panel data analysis is accounting for individual heterogeneity while controlling for unobserved differences in corporate practices through time. The Hausman Test will be used to reflect the accuracy of fixed effect and random effect models. Therefore, if there are specific companies characteristics which would influence other variables, the fixed effect model is more appropriate. On the contrary, the random effect model is useful for samples in which variation across entities are random and uncorrelated with explanatory variables.

The sample is subject to the inverse causality of the explanatory variables towards the dependent one. Under these conditions, methods such as OLS, FE, and RE may return inaccurate estimates, using linear regression techniques. The generalised method of moments (GMM), or instrumental variable panel VAR, may be used to resolve issues such as simultaneity bias, reverse causality or omitted variables. Therefore, GMM is employed as a final stage in the comparative regression analysis, being a dynamic model, which uses a series of instrumental variables, generated from lagged dependent variables.

After testing the linear relationships between variables, revealing the most influential factors for profitability, a new stage of the analysis will be employed, using quadratic regression analysis. The stage actually means that the regression models previously used will be retested adding for every explanatory variable its quadratic form. This will indicate if there is a non-linear effect on the performance of oil and gas companies rather than a straight influence from the variables used to explain changes in ROE.

Analysis and results

Correlations between variables

The matrix presented in Table 2 includes the Pearson correlation coefficients between every pair of variables analysed, with the corresponding p-value reflecting whether or not the correlation is statistically significant. The significant correlations (with p-value$<$0.05) were highlighted in bold in the table.

It seems that the cash flow over operating revenue ratio, the asset turnover, and stock turnover positively influence the profitability indicator. Moreover, the solvency ratio and oil price also appear to be statistically significant factors, with a negative influence on ROE. The other variables, current ratio, the level of taxation and the volume of oil traded also restrict the return on equity, but their correlation coefficients are small and are not statistically significant, indicating very low to no impact.

Table 2. Correlations between ROE and indicators with potential impact on profitability.

	ROE	CF/OpRev	CurrRat	AssTn	SolvRat	StockTn	lTax	OilPrice	OilVolume
ROE	1								
CF/OpRev	**0.2548**	1							
p-value	0								
CurrRat	-0.0626	**0.1281**	1						
p-value	0.2973	0.0324							
AssTn	**0.1362**	**-0.4957**	**-0.126**	1					
p-value	0.0229	0	0.0354						
SolvRat	**-0.2265**	**0.2535**	**0.3466**	**-0.1469**	1				
p-value	0.0001	0	0	0.014					
StockTn	**0.148**	-0.0077	**0.2944**	0.0724	-0.0021	1			
p-value	0.0133	0.8976	0	0.2278	0.9715				
lTax	-0.0308	**-0.2089**	**-0.1855**	0.0095	**-0.1854**	0.0052	1		
p-value	0.6283	0.0009	0.0032	0.8811	0.0033	0.9349			
OilPrice	**-0.1267**	-0.0296	-0.016	0.0029	0.0303	-0.0763	0.0375	1	
p-value	0.0344	0.6222	0.7905	0.9617	0.6139	0.2039	0.555		
OilVolume	-0.0631	0.0953	0.0652	0.0302	0.0405	-0.0678	-0.0028	**0.3893**	1
p-value	0.2935	0.1124	0.2778	0.615	0.5002	0.2587	0.9651	0	

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The rest of the variables present various significant correlations between each other, but they do not present substantial coefficients, which means that they can be included in the same regression model without implying autocorrelation issues related to independent variables.

Overall, the cash flow over operating revenue ratio is in a direct relationship with the current and solvency ratios, and in a negative relationship with the asset turnover and the level of taxes paid. Moreover, the ability to pay off short-term liabilities with current assets should increase along with the solvency ratio and stock turnover, being affected, by great asset turnover and substantial levels of taxes paid. Results also reveal an indirect relationship between asset turnover and solvency ratio, indicating reduced asset efficiency when oil and gas companies have high debt ratios. Lower taxes are associated with higher solvency ratios, based on lower profits and interest deductibility. Finally, the volume of the oil traded seems to be dependent only on the oil price, following the same trend.

Linear regression analysis

The comparative regression models were computed, and the main results were included in Table 3. They are robust in term of the coefficient signs and significance, regardless of the static or dynamic models used, showing that the regression model proposed to determine the variance in ROE is correct when we consider the oil and gas companies in the UK.

From all the explanatory variables, results show that asset turnover and cash flow over operating revenue have the highest regression coefficients. Based on their values, a unit change in the asset turnover ratio will bring more than five units change in the same direction of the ROE, while one unit change in the cash-flow ratio induces a similar change in ROE. Although the asset turnover coefficient is the highest, the impact on ROE is at a lower level because the average value of the asset turnover (1.45) is 20 times lower than the average ROE (22.67). Along with these two variables, stock turnover also has a significant direct impact on ROE. Based on these positive coefficients, statistically significant, we can say that the profitability of oil and gas companies increases with the level of cash generated and the efficient usage of assets, as well as based on the number of times the inventory is sold or used over a year.

Table 3. Comparative linear regression analysis.

	OLS	FE	RE	FE (corr.)	GMM
L.ROE					0.224***
					(23.91)
L2.ROE					0.146***
					(37.26)
L3.ROE					0.095***
					(18.3)
CF/OpRev	0.953***	0.983***	1.003***	0.957***	1.207***
	(8.36)	(8.40)	(9.07)	(5.01)	(70.43)
CurrRat	-0.162	-0.743	-0.691	-0.551	-0.418
	(-0.26)	(-1.19)	(4.89)	(-0.90)	(-1.12)
AssTn	5.552***	8.826***	7.146***	8.342*	6.148***
	(5.29)	(4.36)	(4.89)	(1.80)	(3.80)
SolvRat	-0.635***	-0.911***	-0.765***	-0.866***	-0.320***
	(-5.82)	(-5.50)	(-5.49)	(-2.85)	(-5.46)
StockTn	0.074**	0.086***	0.087***	0.071**	0.062***
	(2.28)	(3.04)	(3.14)	(3.15)	(3.30)
lTax	0.186	7.645***	3.427*	6.908***	0.418
	(0.17)	(2.98)	1.94	(2.72)	(0.56)
cons	13.259	-67.562**	0.011	-46.962	
	(0.82)	(-2.26)	-0.24	(-1.60)	
R-Squared	0.31	0.38	0.37	0.69	
F / Wald Test	17.82***	22.12***	128.94***	5.64***	91599.84***
Hausman (chi-squared test)			11.35*		
Time fixed effects (F test)		1.86*			
Heteroskedasticity(chi-squared test)		9712.79***			
Sargan (prob.)					21.29 (0.8128)
Arr-Bond test (prob.)					-1.533 (0.13)
					0.757 (0.45)

*p< 0.1,

**p< 0.05,

***p< 0.01;

t statistics are reported in parenthesis; L.ROE, L2.ROE, L3.ROE represents the regression coefficients between the dependent variable, and lagged dependent variable from one, two, and three previous years respectively.

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Solvency ratio is also an influential variable, having a negative influence on ROE. This indicates that oil and gas companies in the UK perform better when they dispose of more liabilities (registering a higher degree of solvency). Also, the current ratio also has an indirect impact on profitability, but this is not statistically significant in any of the regression models used. This might also be related to the level of short-term debt, which may affect the general profitability when it increases.

The level of taxation also has a positive effect on ROE, with statistically significant coefficients in all the models besides OLS and GMM. Considering that the taxation variable includes logarithm values of the taxes paid annually by the oil and gas companies, having an average of 11.89 (compared to 27.67 for average ROE), based on the statistically significant regression

coefficients of approximately 7, we can can assume that a high level of taxes paid does not affect the oil and gas companies profitability, as they do not face high tax burdens.

The Pooled OLS model applied on return on equity, shows that 31% of the variation in ROE is explained by the independent variables used. The fixed effects (FE), followed by random effects (RE) models, return higher R squared values, indicating that these are better models for the profitability indicator studied. The Hausman test suggests that there are specific characteristics in oil and gas companies, which influence the relationships between variables. There is enough reason for computing a corrected fixed-effect model (denoted "FE (corr.)"), adjusting for time fixed effects and heteroskedasticity to return reliable results.

The final model employed was the Generalized Method of Moments using the lagged dependent variable. It is more performant regarding simultaneity bias, reverse causality, and omitted variables, and thus its results should be the most reliable in this type of analysis. They are also robust, due to the fact that they are similar to the results returned by the static models used. In addition, the profitability variable indicates a dependence on the previous years ROE levels. The Sargan test validates the over-identifying restrictions, with a substantial probability of 81%, while the Arrelano Bond test for serial correlation in the first-differenced errors also validates the GMM models results.

In order to test the robustness again, we include in the model the three control variables related to oil price and volume traded over the period analysed. The comparative regressions results are included in Table 4.

Slight changes appear only in term of the coefficient values, which are a little higher for most variables. However, the statistically significant regression coefficients have the same signs and indicate the same independent variables with a positive influence on ROE regardless of the model used, cash flow/operating revenue, asset turnover, stock turnover, and negative influence from the solvency ratio. The taxation variable returns a significant direct impact only from the fixed and random effect models.

Regarding the control variables, all regression coefficients show a negative impact on ROE. While the results show that oil and gas companies tend to be more profitable when oil price and the volume of the oil traded decrease, this would not be the logic effect. However, we can assume that in the first part of the period analysed, when the crude oil price and volume traded were reduced, the oil and gas companies from the UK were more profitable. As long as the regression coefficients of the control variables are not statistically significant, it means that this assumption cannot be confirmed. However, the GMM results indicate a negative relationship between the dummy and ROE. As the dummy was computed in order to capture the oil price drop (0 for an increase in price, 1 for the decrease in price), this coefficient suggests that over the nine years period, a decrease in oil prices did affect the profitability of oil and gas companies.

The goodness of fit indicator for these models show again a 32% of the variation in ROE explained through the Pooled Ordinary Least Square regression model, and 40% of the variation explained by the fixed effects and random effects models. The Hausman test suggests that in this case, random effects are more appropriate for the oil and gas companies database, indicating that the specific company characteristics do not affect the results. Therefore, a new random effect model corrected for heteroskedasticity was tested. The GMM model shows similar results, including the fact that profitability is directly dependent on the previous years levels, with a Sargan test which validates the over-identifying restrictions with a probability of 89%. The Arellano Bond test for serial correlation in the first-differenced errors also confirms the GMM models results.

Table 4. Comparative linear regression analysis (control variables included in the model).

	OLS	FE	RE	RE (corr.)	GMM
L.ROE					0.201***
					(14.01)
L2.ROE					0.116***
					(5.37)
L3.ROE					0.112***
					(8.70)
CF/OpRev	0.978***	1.003***	1.033***	1.033***	1.078***
	(8.42)	(8.44)	(9.20)	(5.42)	(13.98)
CurrRat	-0.054	-0.596	-0.547	-0.547	-0.665
	(-0.09)	(-0.96)	(-0.91)	(-1.40)	(-2.62)
AssTn	5.764***	9.532***	7.717***	7.717	6.170***
	(5.44)	(4.75)	(5.21)	(1.39)	(4.34)
SolvRat	-0.634***	-0.874***	-0.751***	-0.751***	-0.264***
	(-5.82)	(-5.35)	(-5.39)	(-2.82)	(-3.78)
StockTn	0.066**	0.075***	0.077***	0.077***	0.038***
	(2.04)	(2.67)	(2.79)	(2.60)	(3.21)
lTax	0.298	8.09***	3.942**	3.942*	-0.515
	(0.27)	(3.18)	2.20	1.85	(-0.35)
OilPrice	-0.087	-0.154	-0.131	-0.131	-0.068
	(-0.41)	(-0.98)	(-0.83)	(-1.12)	(-1.12)
OilVolume	-3.186	-2.829*	-2.982**	-2.981	0.155
	(-1.58)	(-1.89)	(-1.99)	(-1.57)	(0.11)
dummyOilPrice	-0.738	-1.073	-0.386	-0.386	-1.702*
	(-0.13)	(-0.26)	(-0.09)	(-0.14)	(-1.66)
cons	34.819	-48.129**	-5.569	-5.569	-12.179
	(1.62)	(-1.56)	(-0.23)	(-0.18)	(-1.23)
R-Squared	0.32	0.41	0.4	0.4	
F / Wald Test	12.46***	16.27***	142.12***	44.53***	146945.8***
Hausman (chi-squared test)			11.43		
Heteroskedasticity (chi-squared test)		13255.25***			
LM Test (chi-squared test)			170.59***		
Sargan (prob.)					19.19 (0.8920)
Arr-Bond test (prob.)					-1.516 (0.13)
					1.004 (0.32)

*p< 0.1,

**p< 0.05,

***p< 0.01;

t statistics are reported in parenthesis; L.ROE, L2.ROE, L3.ROE represents the regression coefficients between the dependent variable, and lagged dependent variable from one, two, and three previous years respectively.

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Descriptive analysis

The cash flow over operating revenue ratio is a complex indicator as it refers to more than company sales of goods and services. This ratio offers an overview of the financial health of the company, the sales effectiveness, its liquidity and cash management. Therefore, higher ratios

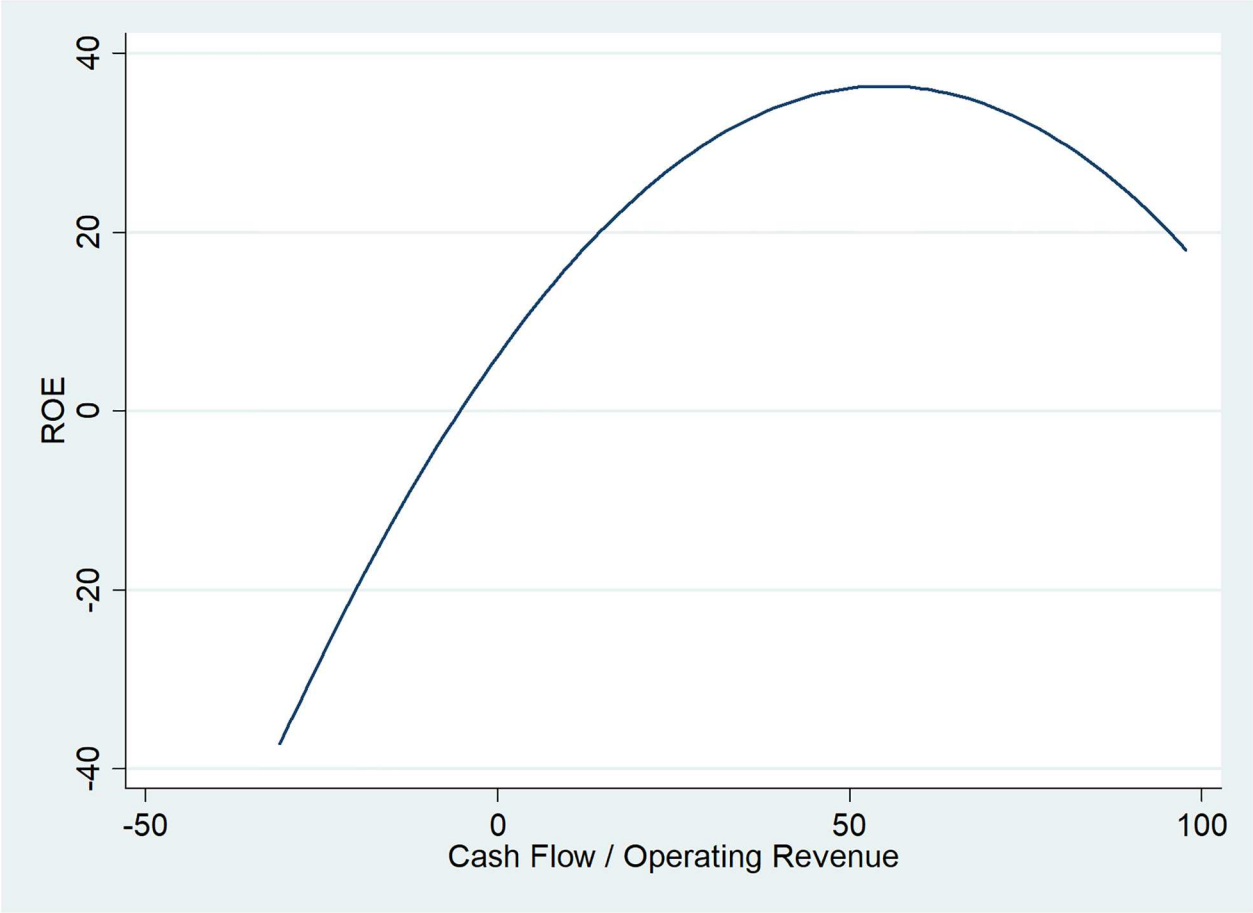

Fig 1. Two-way quadratic prediction plot between ROE and cash flow over operating revenue ratio.

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reflect companies' ability to generate cash from its sales. For the oil and gas companies in the UK, it appears that the return on equity increases along with the cash flows from operating activities, but for a ratio up to 50%. The figure below (Fig 1) indicates that non-profitable companies register negative cash flows. However, this is just a singular case for eight of the companies included in the database, managing to recover the following year.

For the companies analysed, there are minor differences between the current ratio and liquidity ratio. Therefore we chose the first, used to measure the firm's ability to pay off its short-term liabilities with its current assets. As observed in Fig 2, increased profitability is associated with low current ratios, declining along with an increase in the level of current ratio, of up to 20. For current ratios higher than 20, ROE is positively influenced, increasing as well. However, this is an exception, as in 95% of the data analysed the current ratio is of maximum 7.

As seen in Fig 3, there is a direct relationship between ROE and asset turnover, indicating that profitable companies efficiently use their assets in generating sales and other types of revenues. It is the ideal nexus between the two indicators, as oil and gas companies have fixed assets of high values as long as significant short-term items such as inventory, indicating that they benefit from economies of scale but also maintain their equipment and machinery in order to minimise downtime. For asset turnover ratios higher than 7, companies tend to become less profitable, this being the case in only 3% of the data analysed.

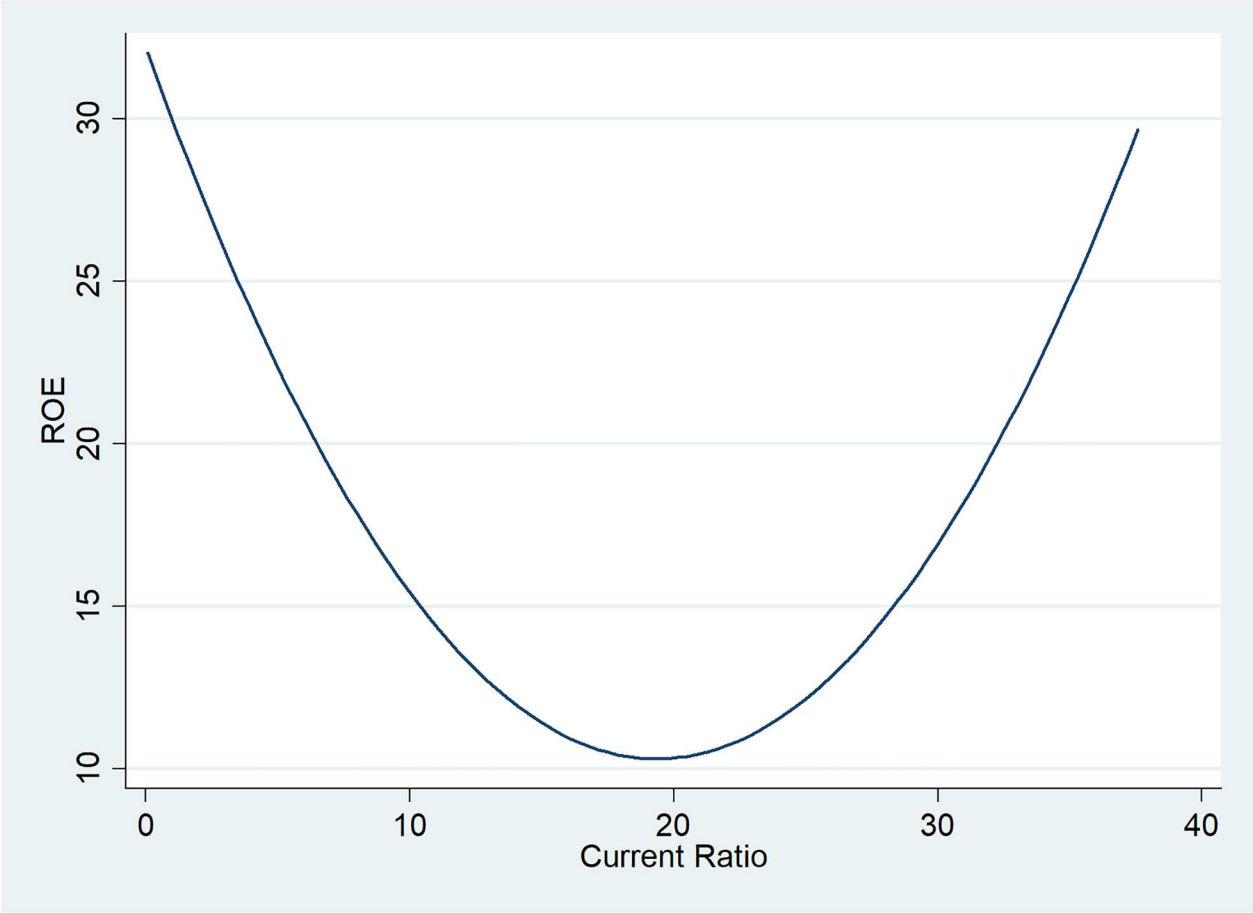

Fig 2. Two-way quadratic prediction plot between ROE and current ratio.

https://doi.org/10.1371/journal.pone.0199100.g002

Fig 4 indicates a solely indirect relationship between ROE and solvency ratio, showing that oil and gas companies in the UK are more profitable when they register lower solvency ratios, although these would generally be associated with a higher probability for companies to face default on their debt obligations. The companies analysed record high profit margins, and thus when they dispose of more borrowed funds they can increase their net profits.

The stock turnover, reflecting the number of times the inventory is sold or used over a period of one year, is very high for the UK oil and gas companies, indicating operational efficiency in the asset management department. Fig 5 suggests a direct relationship between profitability and stock turnover, up to a peak stock turnover of 400, which was found only in two cases in the overall data, showing the exceptional character of the negative impact of stock turnover on ROE.

For the oil and gas companies analysed, more than 50% pay taxes higher than 100 million Euros per year. Fig 6 illustrates the relationship between profitability and taxation, showing a structural break at a level of taxation of approximately 160 millions of Euros (value 12 on the x-axis). From that level onward, companies tend to be more profitable when they pay higher taxes.

Over the period analysed, the oil price had an average price ranging from 64 $/barrel to a little below 100 $/barrel. The first part of the period indicated lower prices, with the peak in 2008 (98.58 $/barrel), while from 2011 the price oscillated above 90 $/barrel. Considering this

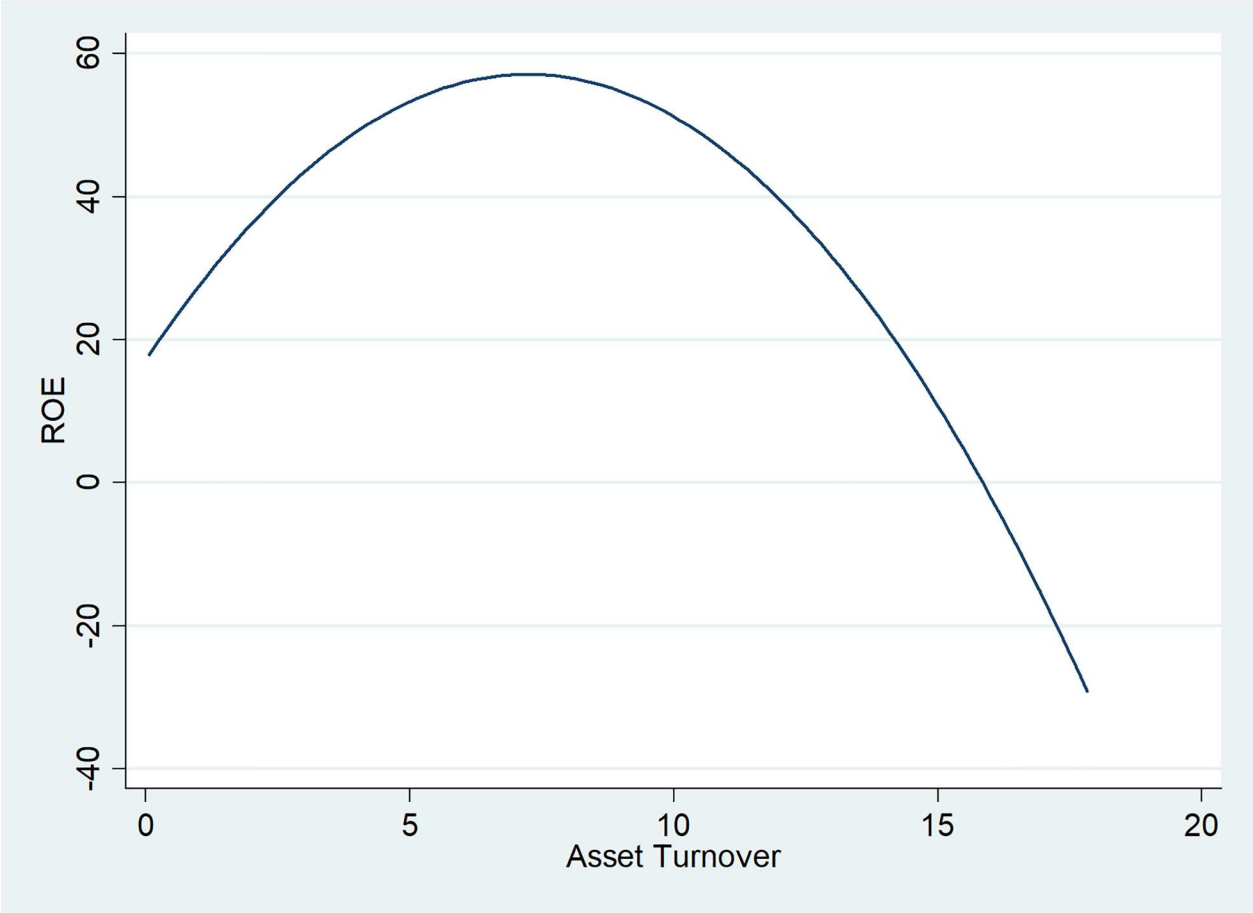

Fig 3. Two-way quadratic prediction plot between ROE and asset turnover.

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information, it can be presumed from the graph illustrated in Fig 7 that the UK oil and gas companies were the most profitable in the first part of the period analysed, before the settlement and deepening of the financial crisis, indicating larger values of ROE in spite of lower oil prices. The average oil volume traded monthly over the period analysed ranged from 2.5 to 6.6 millions of barrels. Although the smallest volume traded was registered in 2006, the oil and gas companies in the UK were the most profitable in term of shareholders' equity. It confirms the assumptions mentioned based on the dynamics of oil prices. After 2011, the volume traded decreased from an average of 6.5 millions of barrels to approximately 5 million, affecting the profitability of oil and gas companies, as shown in the second graph from Fig 7, illustrating the relationship between ROE and volume of oil traded in the UK.

Quadratic regression analysis

Observing from the descriptive analysis that the independent variables, except the solvency ratio, have a non-linear relationship with companies profitability, we decided to retest the regression model, including quadratic variables as well. We assume that the relationships discovered through linear regression analysis are the main ones, and the different influences occur in exceptional cases, associated with the squared variables. Results are presented in the following table (Table 5).

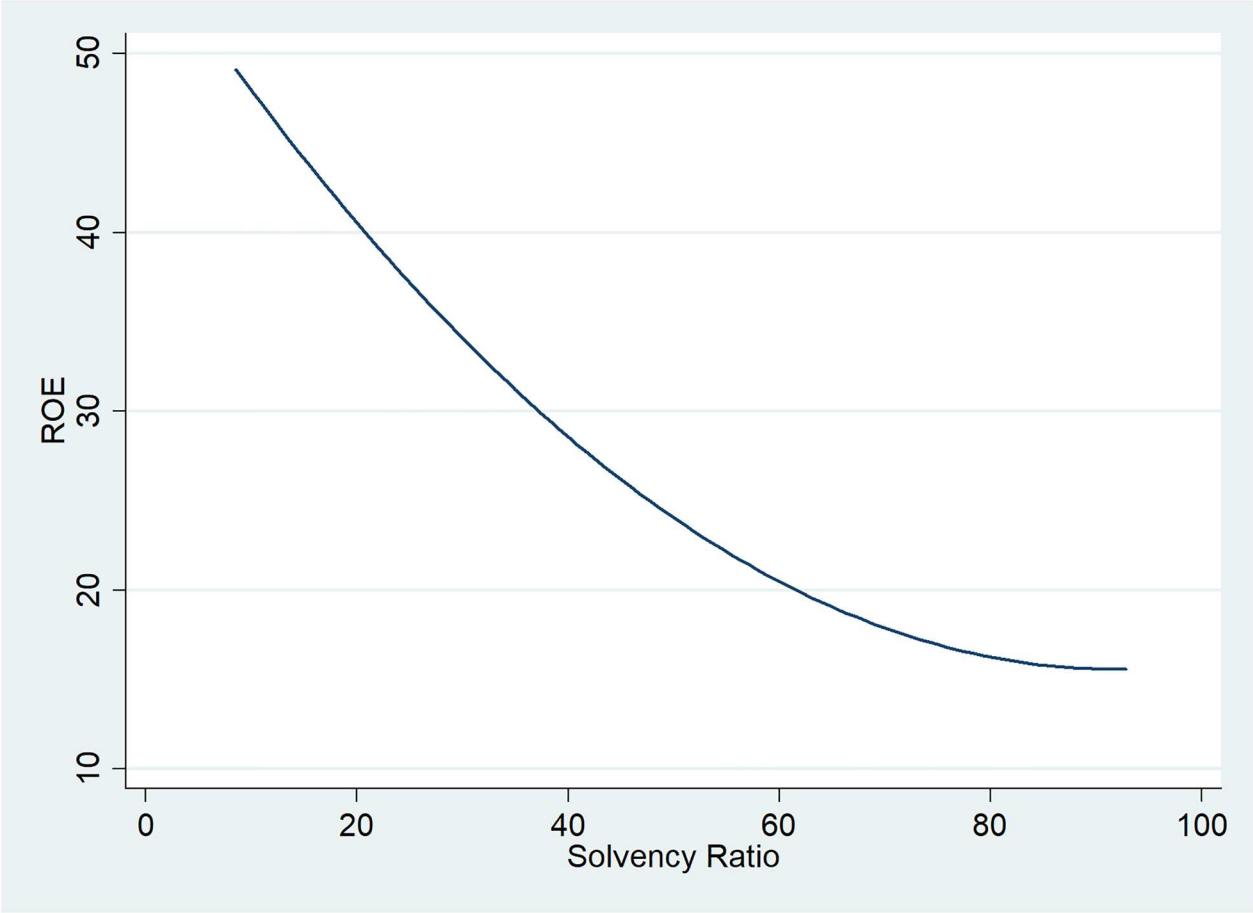

Fig 4. Two-way quadratic prediction plot between ROE and solvency ratio.

https://doi.org/10.1371/journal.pone.0199100.g004

Results show that cash flow over operating revenue has a positive influence on ROE, but from a certain point (from a ratio of 50 as suggested in Fig 1), it affects profitability to a very small extent. It is consistent with the results offered by the linear regressions.

The current ratio indicates a positive influence and a negative one from the squared ratio. The graph presented in Fig 2 indicated a U-shape, suggesting a negative relationship followed by a direct one for current ratios higher than 20. The current ratio regression coefficients cannot be considered a relevant ROE factor, as they are statistically significant only in the GMM model.

Asset turnover coefficients follow the trend reflected in Fig 3: this indicator has a strong direct influence on ROE (with large values of regression coefficient), but for asset turnover ratios higher than seven they start to affect the companies' profitability (as shown by the squared variable coefficient).

Solvency ratio only has a statistically significant indirect impact on ROE, as shown in Fig 4, confirming the fact that oil and gas companies with significant levels of liabilities tend to be more profitable. The squared variable has a positive influence, but a low impact on ROE, as suggested by the almost null regression coefficient.

The stock turnover confirms the inverted U-shape presented in Fig 5. Efficient companies regarding the asset management department tend to be more profitable, but up to a point,

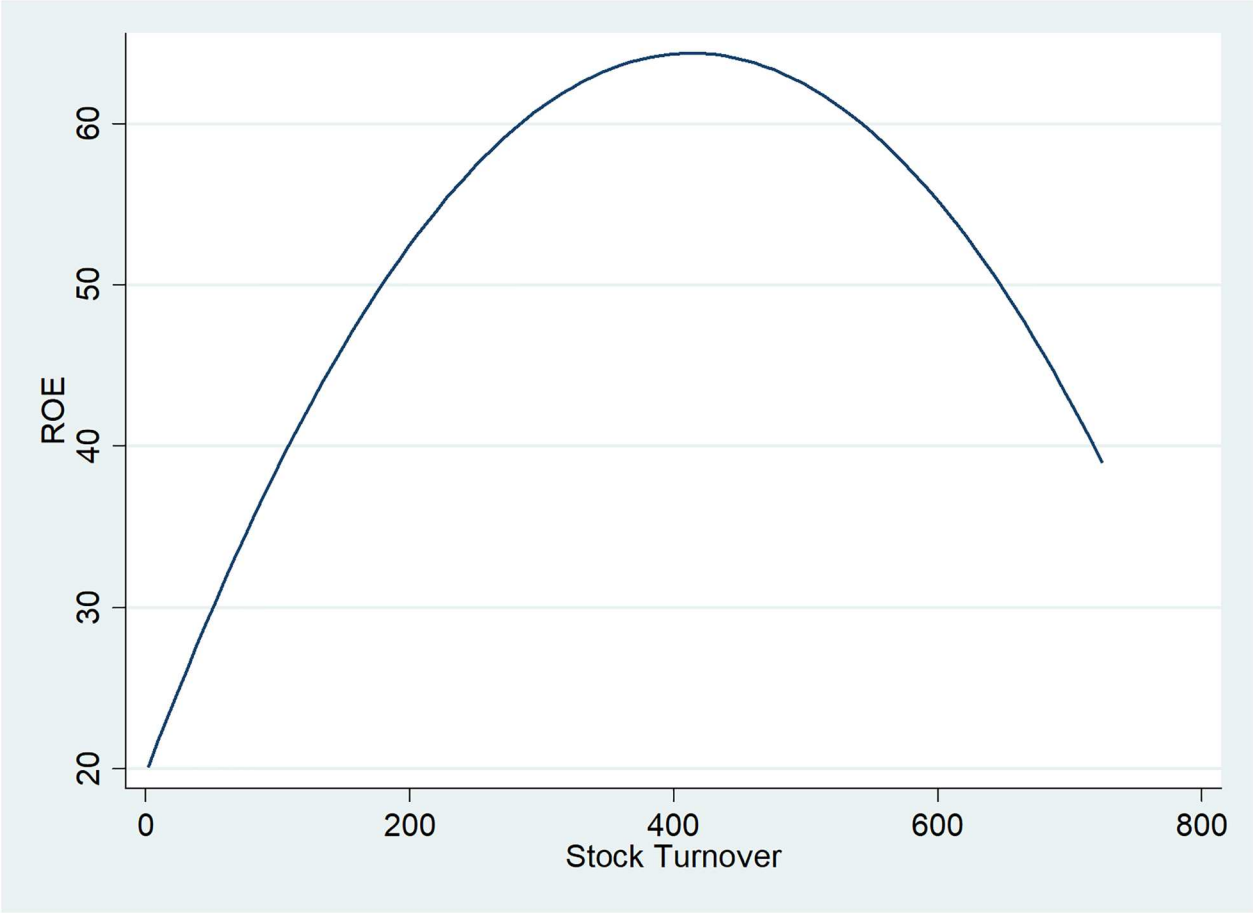

Fig 5. Two-way quadratic prediction plot between ROE and stock turnover.

https://doi.org/10.1371/journal.pone.0199100.g005

where significant stock turnover tends to affect the companies return on equity. The negative coefficient is very low, being attributed to exceptional cases of high stock turnover.

Taxation variables also follow the trend presented in the descriptive analysis: for taxes up to 160 millions of Euros (see comments on Fig 6), companies profitability is affected by the tremendous level of expenses on taxes; but for companies registering even higher tax payments, the returns on equity is no longer concerned, as tax burdens do not raise based on the increase in revenues. However, tax variables coefficients are statistically significant only in the OLS and GMM models.

This quadratic regression model indicates higher goodness of fit indicators. The Pooled Ordinary Least Square regression model surprises 52% of the variation in ROE, increasing to 55% of the variation explained through the fixed effects model. The Hausman test suggests that this is more appropriate for the oil and gas companies' database, as specific company characteristics affect the results. The GMM model is the best employed so far, with a Sargan test validating the over-identifying restrictions with a probability of 99%, and the serial correlation in the first-differenced errors confirming the GMM results.

Considering that the oil price and oil volume variables also revealed a non-linear relationship with ROE, we retested the quadratic regression model, including the three control variables, even with the squared variables of oil price and oil volume. There are no significant

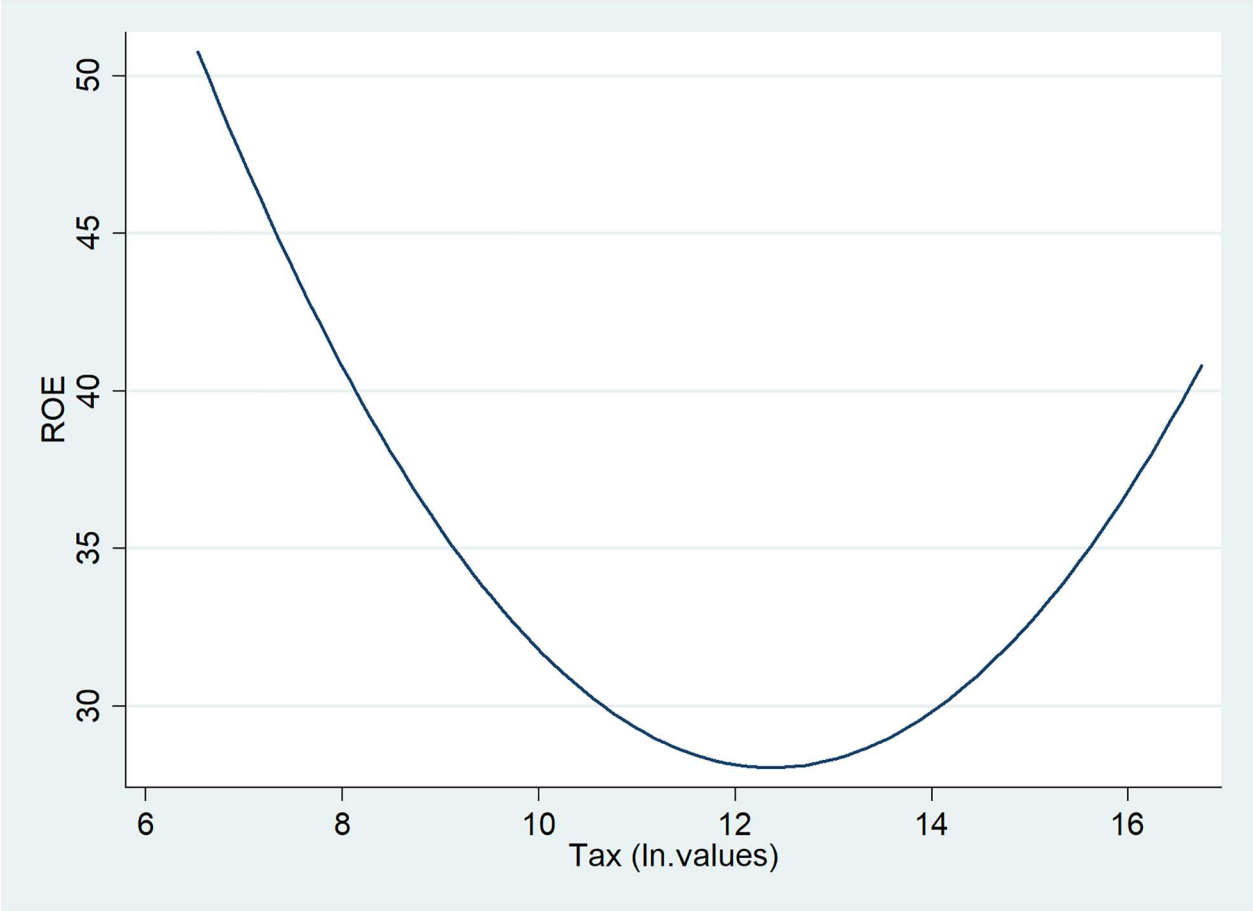

Fig 6. Two-way quadratic prediction plot between ROE and tax.

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changes in the results (Table 6), proving their robustness: the cash flow over operating revenue, current ratio, asset turnover, and stock turnover have a positive and then negative influence on ROE, while the tax and solvency ratio indicates a negative impact followed by a positive one. From all independent variables, current ratio shows statistically significant coefficients

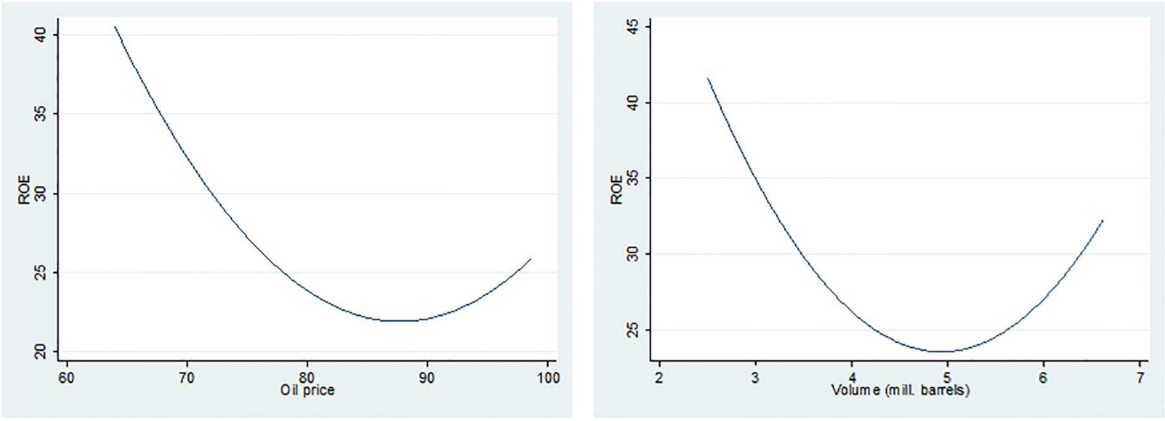

Fig 7. Two-way quadratic prediction plot between ROE and oil price, and volume of oil.

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Table 5. Comparative quadratic regression analysis.

	OLS	FE	RE	FE (corr.)	GMM
L.ROE					0.107***
					(4.92)
L2.ROE					0.085***
					(4.94)
L3.ROE					0.053**
					(2.38)
CF/OpRev	1.783***	0.976***	1.371***	0.976**	2.074***
	(8.20)	(4.78)	(6.55)	(2.40)	(27.56)
CF/OpRev sq.	-0.009***	-0.0004	-0.004	-0.0004	-0.012***
	(-2.94)	(-0.17)	(-1.3)	(-0.14)	(-15.64)
CurrRat	1.029	1.593	0.819	1.593	2.964***
	(0.87)	(1.23)	(0.66)	(1.27)	(6.32)
CurrRat sq.	-0.032	-0.051	-0.033	-0.051*	-0.073***
	(-0.86)	(-1.44)	(-0.93)	(-1.97)	(-6.60)
AssTn	22.82***	33.247***	22.038***	33.247***	31.65***
	(10.39)	(8.88)	(8.97)	(3.18)	(7.97)
AssTn sq.	-1.288***	-1.443***	-1.154***	-1.443***	-1.595***
	(-8.3)	(-7.74)	(-7.15)	(-3.44)	(-8.48)
SolvRat	-1.453***	-1.629***	-1.603***	-1.629*	-0.982**
	(-3.57)	(-3.62)	(-3.74)	(-1.88)	(-2.47)
SolvRat sq.	0.008**	0.007	0.009**	0.007	0.001
	(2.04)	(1.41)	(2.06)	(0.85)	(0.23)
StockTn	0.155**	0.137**	0.185***	0.137**	0.048
	(2.56)	(2.08)	(2.93)	(2.30)	(1.04)
StockTn sq.	-0.0002**	-0.0001	-0.0002**	-0.0001**	-0.0001**
	(-2.25)	(-1.29)	(-2.25)	(-2.06)	(-1.96)
lTax	-21.883***	-15.103	-17.293*	-15.103	-11.906*
	(-2.76)	(-1.13)	(-1.74)	(-1.26)	(-1.71)
lTax sq.	0.937***	0.879	0.794*	0.879	0.674**
	(2.82)	(1.47)	(1.89)	(1.44)	(2.21)
cons	13.259	58.392	97.162	58.392	19.415
	(0.82)	(0.76)	(1.63)	(0.93)	(0.49)
R-Squared	0.52	0.55	0.48	0.55	
F / Wald Test	21.23***	20.77***	220.76***	25.91***	121082.04***
Hausman (chi-squared test)			58.19***		
Time fixed effects (F test)		0.92			
Heteroskedasticity (chi-squared test)		6421.69***			
Sargan (prob.)					13.53 (0.9902)
Arr-Bond test (prob.)					-1.803 (0.07)
					-0.214 (0.83)

*p< 0.1,

**p< 0.05,

***p< 0.01;

t statistics are reported in parenthesis; L.ROE, L2.ROE, L3.ROE represents the regression coefficients between the dependent variable, and lagged dependent variable from one, two, and three previous years respectively.

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Table 6. Comparative quadratic regression analysis (control variables included in the model).

	OLS	FE	RE	FE (corr.)	GMM
L.ROE					0.108**
					(2.08)
CF/OpRev	1.824***	1.016***	1.379***	1.016**	1.896***
	(8.30)	(4.93)	(6.57)	(2.58)	(12.36)
CF/OpRev sq.	-0.009***	0.0005	-0.004	0.00005	-0.010***
	(-3.01)	(0.02)	(-1.28)	(0.02)	(-9.66)
CurrRat	1.044	1.664	0.846	1.664	3.833**
	(0.87)	(1.27)	(0.68)	(1.26)	(2.01)
CurrRat sq.	-0.029	-0.05	-0.032	-0.05*	-0.099**
	(-0.78)	(-1.39)	(-0.87)	(-1.76)	(-2.13)
AssTn	22.84***	33.382***	22.139***	33.382***	36.249***
	(10.29)	(8.83)	(8.75)	(3.15)	(6.50)
AssTn sq.	-1.280***	-1.415***	-1.129***	-1.415***	-1.476***
	(-8.18)	(-7.53)	(-6.91)	(-3.35)	(-6.44)
SolvRat	-1.417***	-1.589***	-1.564***	-1.589*	-1.185**
	(-3.47)	(-3.52)	(-3.62)	(-1.87)	(-2.17)
SolvRat sq.	0.008*	0.007	0.009**	0.007	0.005
	(1.94)	(1.40)	(1.98)	(0.84)	(0.95)
StockTn	0.135**	0.102	0.157**	0.102	0.081*
	(2.20)	(1.49)	(2.42)	(1.51)	(1.83)
StockTn sq.	-0.0002**	-0.0001	-0.0002**	-0.0001	-0.00005
	(-1.97)	(-0.80)	(-1.82)	(-1.146)	(-1.35)
lTax	-21.292***	-12.101	-15.043	-12.1	2.989
	(-2.68)	(-0.88)	(-1.46)	(-1.01)	(0.14)
lTax sq.	0.914***	0.761	0.709*	0.762	0.067
	(2.74)	(1.24)	(1.69)	(1.25)	(0.06)
OilPrice	-1.313	-0.362	-1.43	-0.362	-1.906*
	(-0.46)	(-0.16)	(-0.59)	(-0.19)	(-1.69)
OilPrice sq.	0.008	0.002	0.008	0.002	0.011
	(0.44)	(0.13)	(0.56)	(0.16)	(1.56)
OilVolume	-10.774	-3.095	-10.163	-3.095	12.466
	(-1.01)	(-0.37)	(-1.13)	(-0.5)	(0.38)
OilVolume sq.	0.919	0.099	0.879	0.099	-1.102
	(0.80)	(0.11)	(0.90)	(0.17)	(-0.37)
dummyOilPrice	3.405	-1.029	2.471	-1.03	-1.675
	(0.67)	(-0.26)	(0.58)	(-0.31)	(-1.16)
cons	200.118	69.269	169.439	69.269	
	(1.57)	(0.57)	(1.44)	(0.65)	
R-Squared	0.53	0.56	0.499	0.56	
F / Wald Test	15.18***	15.04***	226.11***	29.59***	48995.35***
Hausman (chi-squared test)			43.48***		
Time fixed effects (F test)		0.46			
Heteroskedasticity (chi-squared test)		6421.69***			

(*Continued*)

Table 6. (Continued)

	OLS	FE	RE	FE (corr.)	GMM
Sargan (prob.)					13.18 (0.9995)
Arr-Bond test (prob.)					-2.545 (0.01)
					-0.59 (0.55)

*p< 0.1,
**p< 0.05,
***p< 0.01;
t statistics are reported in parenthesis; L.ROE represents the regression coefficient between the dependent variable, and lagged dependent variable from the previous year.

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only from GMM, taxation variables are significant in OLS and GMM, and solvency ratio appears to have only a statistically significant negative influence on profitability.

The control variables do not reveal statistically significant regression coefficients, except in the GMM case, where the basic variables of the oil price have a negative influence on ROE, showing that lower prices of crude oil are associated to higher profitability over the period analysed.

The goodness of fit indicators for this updated quadratic regression model are slightly higher than the rest, showing that the Pooled Ordinary Least Square regression model surprises 53% of the variation in ROE, increasing to 56% of the variation explained through the fixed effects model. The Hausman test suggests again that company characteristics affect the results and the fixed effects model is more appropriate. In addition, Sargan test attributed to the GMM validates the over-identifying restrictions with a probability of 99.95%.

According to the homogeneous values of the data analysed, the profitability of oil and gas companies increases with the level of cash generated and the efficient usage of assets, as well as based on the number of times the inventory is sold or used over a year. These show a productive operational activity for oil and gas companies in the UK. Correspondingly, these tend to perform better when they dispose of more liabilities. While the oil price changes and oil volume traded does not seem to have a substantial impact on the analysed companies, results suggest that a decrease in oil prices affects their profitability. Although it seems that companies easily pass the oil price increases on to customers, if the oil price continues to drop, it would permanently affect both the oil and gas companies and the economy, as long as oil and gas industry is still an important pillar for the UK economy, bringing significant tax revenues.

Conclusions

As national strategic resources, the North Sea oil and gas is essential to the economy and development of the United Kingdom. With large energy companies operating, two of the six supermajor oil and gas companies have their headquarters in the UK: BP and Royal Dutch Shell. However, since the financial crisis started, due to the oil price volatility, the employment in the UK offshore oil and gas industry was reduced with 25% over the last five years, while oil and gas companies reduced their activity.

Although lately, they faced the challenges of a volatile environment with a reduction in production, oil and gas companies managed to recover and continue to register large profit margins and returns. The high-performance organisation is obtainable through operational efficiency in the asset management department, efficiently use of assets in generating sales, and ability to permanently generate cash from sales. Oil and gas companies seem to be

performant in the use of liabilities, with significant levels of solvency, and the higher the amount of taxes paid are, the more profitable regarding shareholders' equity they tend to be. It also shows that the oil and gas industry continues to be an essential pillar in the UK economy, providing substantial fiscal revenues based on profitable oil and gas companies.

The latest dropout in oil price and volume traded affected the return on equity, as oil and gas companies indicated higher profitability at the beginning of the period analysed when, although the oil price and volume traded were at their minimum over the nine years observed, the companies registered the highest returns and profit margins. If the oil price reduction continues, this will continue to affect oil and gas companies performance, along with the UK economy, through increased unemployment and reduced taxes paid to the government, towards a permanent decrease in GDP.

Problems related to various impacts of the global financial crisis permanently challenge the oil and gas companies, to cope with the decrease in oil price and the changes in production and revenues. Therefore, the influence of unobserved heterogeneity in the parameters used in this paper, and the ways to conduct quantitative analysis to observe these influential factors were exemplified in different stages of the analysis. On the one hand, results indicate that there is unobserved heterogeneity in the sample consisting of 31 oil companies, and therefore, estimation techniques employed may produce biased efficiency estimates. On the other hand, results demonstrated their robustness through different regression models and techniques, proving the consistency of this research.

Nowadays, the largest oil and gas companies seem to take the climate commitment very seriously and pledge to reduce the net carbon emission in the following decades. The latest requirements demand that companies disclose the climate change risks on their business, so the shareholders understand the implications of company activities. Although their shareholders, as well as consumers, approve the change from fossil fuels, oil and gas companies seem to undertake small investments in renewable energy compared to their overall revenues. Overall, considering the importance of renewable energy stocks in the future, we realise that increased oil prices and high prices for other types of fossil fuels will just increase the demand for clean energy products. Even though oil and gas companies seem to have steady profits and returns, over the long-term, the only solution for them to keep their high-performance is switching towards eco-friendly policies.

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Writing – original draft: Sorana Vătavu, Oana-Ramona Lobonţ.

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CORPORATE FINANCING DECISIONS AND PERFORMANCE IN TIMES OF CRISIS: THREAT OR CHALLENGE?

Abstract. *The objective of this study is to provide empirical evidence regarding the impact of financial crisis on companies' financing preference and economic performance. In order to highlight this objective the data was organized in two different panels consisting of performance determinants in 79 different-sized companies (large and SMEs), listed on the Bucharest Stock Exchange over the period 2003-2014. Both panels were also divided in two sub-periods, before and after 2007, when the crisis was triggered in Romania. The main results obtained in the comparative regression analysis indicate that large companies register higher returns when they operate with limited borrowings, while small companies tend to perform better when they have higher debt ratios in the capital structure. The financial crisis affected the corporate performance and companies had to change their financing activity in order to minimize financial risks, avoiding borrowed funds.*

Keywords: *performance, capital structure, financial crisis, large companies, SMEs.*
JEL Classification: G32, L25

1. Introduction

Although financial markets were always influenced by economic cycle phases, the global financial crisis led to a global reconfiguration of investors' behavior. In order to identify the best investment opportunities, investors tend to focus on short-term gains, most showing a risk-averse attitude. Some investors

base their decisions on technical analysis while less educated ones are not able to perceive market signals and may imitate others' actions. This generates a herding behavior which is more common in developing financial markets, such as the Romanian one. Besides, companies operating in developing countries rarely use share issuance when they are in need of resources, preferring to raise debt.

From its perspective, this study tries to answer multiple questions. The first is referred to the identification of relevant economic and financial indicators influencing corporate performance, and the second tries to reveal how the financial crisis affected the companies listed on Bucharest Stock Exchange since it was installed in Romania, causing a significant reduction of corporate performance and resizing the capital mix by diminishing access to borrowed resources. Many studies from the corporate finance literature focused on the relationship between financing decisions and performance, but little of them involved the analysis of individual performance of companies listed on Romania, during the crisis.

Financial crises may have different stages, but all reflect economic downturn, reduced productivity, asset price reduction, capital markets downsizing, financial institutions collapses and bankruptcies or high unemployment rate. Past crises, such as Great Depression in 1929 or Asian Crisis in 1997, developed over time inducing profound recessions with slow economic revival. Their causes were different: the Great Depression came as an effect of inefficient monetary policies and overinvestment, while the Asian Crisis was sudden and due to major investments with short-term maturities that caused instability. The global financial crisis developed in 2007-2008, over the breaking of speculative bubbles after a lack of transparency in the banking sector and high risks gathered. Companies operating in Romania reduced the number of employees and their activities facing significant declines in their returns.

Studies on Romanian companies focused primarily on determinants of capital structure, but the impact of financing decisions on performance was less analyzed and to our knowledge, did not consider a pre- and during crisis overview. Therefore, the theoretical perspective of this analysis is to frame the corporate performance during the crisis, based on financing behavior, asset composition, sales, earnings volatility and economic factors such as fiscal pressure and inflation.

The rest of the paper is organized as follows: Section 2 addresses some relevant literature regarding capital structure theories and their impact on corporate performance, considering economic conditions; Section 3 describes the research methodology; Section 4 discusses the descriptive analysis and Section 5 presents the empirical findings; Section 6 concludes.

2. Literature review

The global financial crisis affected the performance of listed companies around the world, especially those operating in developing countries. Managers were constrained to look for survival solutions, sustainable over unstable economic periods with restrictive conditions. Decrease in profits, high risks and constant deterioration of results and performance reflect negative signals on the financial markets, so risk-averse investors sell their shares to protect against future company

degradation. Moreover, during the financial crisis, potential investors tend to be more skeptical in terms of the companies development opportunities avoiding large investments unless they provide certain profitability.

Over time, major implications of investment and financing decisions on corporate performance and through various capital structure theories, namely the irrelevance theory, trade-off theory, agency theory, pecking order theory and market timing theory. However, in order to explain the contemporary financing decisions, the capital structure literature focuses on two competing models, Trade-off and Pecking Order Theory. The first assumes a positive relationship between leverage and performance, while companies obtain the optimal leverage levelby balancing its costs and benefits. Some studies showed debt has a positive influence on assets performance, in relation to the company market value (Zeitun and Tian, 2007; Pirtea et al., 2015).Pecking Order Theory occurs when issuance costs of risky securities (transaction costs, costs related to information asymmetry etc.) outweigh the costs and benefits obtained by borrowing these funds. In such case, firms undertake new investments with various resources in the following order: retained profits, debt implying allow level of risk, debt with higher risks involved and only if they are able to face more financial pressure, companies resort to equity resource (Fama and French, 2004).In comparative studies of pecking order and trade-off theories, greater support was demonstrated for the first, mainly because it is based on empirical factsand identifies corporate behavior (Shyam-Sunder and Myers, 1999; Pirtea et al, 2014).Considering the main theories, our study has anew insight to approach both concurrently, opening the way to an analysis that tries to demonstrate the preference for various financing resources but also observe the impact of taxation on financing decisions and company performance in companies operating in Romania.

Baker and Wurgler (2002) examined new ways of defining financing decisions, disregarding the traditional theories of capital structure. They concluded that low-leverage companies raised funds when their valuations were high, and high-leverage companies were those that raised funds during low valuation. Deviations and fluctuations in market valuations have a large persistent impact on capital structure, over a decade long. Relating to Baker and Wurgler's study, we considered relevant the introduction of profitability variation in performance analysis, as a measure of financial risk.

Corporate policies are usually modeled on the conflict of interests between key stakeholders: managers, the majority of shareholders and external investors. As underlined by La Porta et al. (1998), one of the most important remedies for this problem is the legal protection consisting of laws and their executive quality. Depending on the country degree of development, legal protection of foreign investors has a significant variance. Legal systems based on common law rights offer foreign investors greater protection than systems based on civil law. Therefore, it is expected for common law countries to use more long-term debt and equity resources.

The degree of legal enforcement is determined by the efficiency and integrity of the legal system, its power and impartiality. When the legal system displays a lack of integrity debt should be used in greater proportion than shareholders equity. It also makes greater use of short-term debt than long-term loans. Given the opportunistic environment offered by raising equity, the contract structure of debt is limited to the potential expropriation of investors' rights. When the legal system is poor in terms of integrity, companies are expected to choose short-term debt more often, since limited maturity period reduces creditors' expropriation possibility (Fan et al., 2012). Considering that the Romanian legal system has some of the characteristics mentioned, this study is expected to find that companies depend on internal resources and raise debt with short maturity when in need of external resources.

The economic conditions imposed by the capital market play a decisive role in corporate financing decisions. Developed financial markets ensure the applicability of the legal framework and protection of creditors and debtors. Besides the financial markets that have a direct impact on capital, other economic and political factors have a direct influence on the capital structure. Previous studies referring to comparative analysis of different countries (Rajan and Zingales, 1995; Booth et al., 2001) showed that gross domestic product and means of creditors' rights protection are economic factors with great influence on funding decisions. In countries with strict laws and stable economies, companies benefit of numerous investment opportunities, easily accessing borrowed funds.

Altogether, the capital structure-corporate performance relationship has been debated and studied over the decades without identifying a general theory applying to all companies, regardless of economic conditions or industries in which they operate. Although equity was always considered the most secured type of resource, involving reduced risks, studies discovered that debt does not necessarily affect performance indicators such as market valuation, share price evaluation or return on equity. Appreciation of share prices and increase in earnings are often independent of each other without exhibiting a systematic change of capital structure in order to increase shares value. However, the system is too complex to be identified and managed with a simple relationship between debt or equity ratios and performance, and thus this study comprises asset composition, sales, risk and economic factors such as fiscal pressure and inflation, means by which the relationship can be justified in detail.

3. Data and methodology

3.1 Samples and variables used

Two samples gathered were classified based on the number of employees every company has. All the companies were listed on the Bucharest Stock Exchange (BSE) between 2003 and 2014. Indicators were computed annually, over the whole period, using the financial information from the summarized balance sheets. In order to obtain balanced panels, all the companies selected had their

financial data available every year, from 2003 until 2014.To ensure the results reliability, the following categories of companies were excluded from the samples:

- delisted companies, those in dissolution stage or those registering negative equity values, in order to reduce the number of outliers;
- companies operating in the financial sector, as they have different regulations and specific requirements.

The financial performance should indicate the overall financial health of a company or how well companies use their assets in order to generate profits. Therefore, we consider return on assets, one of the most common profitability indicators. This performance proxy is the ratio of net income over total assets:

$$ROA = \frac{NetIncome}{TotalAssets} \quad (1)$$

The capital structure will be expressed through shareholders equity ratio. Equity, along with debt, is the main component of the capital structure. It is defined by summing up the common and preferred stocks with the retained earnings. This type of capital represents a permanent type of funding used to support companies' investments and growth. Therefore, it refers to the capitalization of companies, and especially for the analysis of Romanian companies, it can be considered as one of the most suitable proxies of capital structure, as long as these companies prefer either equity or short-term debt for their financing. In addition, data for computing the shareholders equity ratio was collected from the balance sheets, and used in the following formula:

$$Equity = \frac{ShareholdersEquity}{TotalAssets} \quad (2)$$

Considering previous studies, the level of fixed assets in total assets, referred to as tangibility, has two conflicting influences on company performance. On one hand, studies focusing on developing countries with rather young capital markets, revealed a negative relationship between tangibility and profitability (Zeitun and Tian, 2007; Nunes et al., 2009).Accordingly, companies with large values of fixed assets tend to be less profitable. On the other hand, earlier studies such as Himmelberg et al. (1999) indicated a positive effect. In this case, fixed assets played the role of collateral ensuring a better control while they are closely monitored by their creditors. Moreover, higher values of fixed assets tend to reduce agency conflict between creditors, managers and shareholders. In order to test the impact of tangibility on the performance of Romanian companies, the ratio (tang) is the fixed assets value over total assets:

$$tang = \frac{FixedAssets}{TotalAsets} \quad (3)$$

Studies focusing on this performance topic often use assets or sales in order to reflect the companies' dimension (Rajan and Zingales, 1995; Pirtea et al., 2014). In this context, the analysis already refers to different sized companies, in term of their employees, but this supplementary size variable will be calculated as logarithm of sales turnover. The logarithm procedure is computed in order to level up the values of the sales turnover to the rest of the ratios used as dependent and explanatory variables.

$$size = \log(SalesTurnover) \quad (4)$$

Liquidity ratios have an essential role in determining profitability. Some consider them performance indicators as they are measure of income sources, reflecting how safe the operating activities are and how long is the process of converting current assets, such as inventories and accounts receivables, into cash. However, high liquidity ratios do not always indicate a risk-aversion; sometimes they are a sign of poor management of current assets, especially when it comes tothe current assets previously mentioned. Deloof (2003) argued that companies with higher levels of liquidity have more investment opportunities over the long term especially when they focus on innovation and research and development. This way, they compensate for their reduced values of fixed assets. The explanatory variable used in this study is the current ratio:

$$liquid = \frac{CurrentAssets}{Short-termdebt} \quad (5)$$

Business risk is measured by the standard deviation of the profitability divided by its average, which is actually the coefficient of variation for profitability. Although risky companies are expected to generate higher returns, well-capitalized companies are usually less risky but register lower profits. According to the trade-off theory, companies operating in hazardous environments have a higher probability of experiencing financial difficulties, facing greater financial and business risks. Referring to pre and during crises periods, the analysis also focuses on how earnings volatility and higher risks reflect on performance.

$$risk = \frac{stdev\left(\frac{Earningsbeforeinterestandtax}{TotalAssets}\right)}{average\left(\frac{Earningsbeforeinterestandtax}{TotalAssets}\right)} \quad (6)$$

Related to state specific factors, taxation will also be included in the analysis. Given the fiscal savings, achieved through interest payments, it is important that companies understand the benefits of using borrowed capital especially when tax rate of corporate income and profits are increasing. This would not necessarily be the case for Romanian companies which avoid long-term debt in order to reduce their financial risks. Moreover, in Romania the standard corporate income tax rate is 16%, while micro-companies are required to pay a 3% tax on revenue and foreign companies that have representative offices operating in Romania pay an annual fixed tax of 4,000 Euros, regardless of their profits. In this study, the tax variable is the ratio of tax over earnings before interest and tax:

$$tax = \frac{Taxpaid}{Earningsbeforeinterestandtax} \quad (7)$$

In order to capture the exogenous influence of macroeconomic conditions, we also considered the rate of inflation and the presence of crisis. The inflation variable is the annual variation of the harmonized indices of consumer prices. Wasiuzzaman and Tarmizi (2010) argue that a positive effect of inflation on profitability may come as banks and creditors are able to anticipate inflation and adjust their interest rates accordingly. Therefore, they gain more profits before costs increase. However, companies would not be able to react so quickly. Instead, they suffer from costs increase, which is even stronger when the inflation

fluctuations are not anticipated. Crisis is the last variable included in the model, a dummy variable with 0values between 2003 and 2007, and 1 starting from 2008, capturing the financial crisis period.

3.2 Methodology

This paper intends to evaluate economic performance of companies listed on BSE over the long term, but also before and after 2007, in order to capture to what extent corporate performance was affected by the financial crisis. Performance will be considered as a function of various financial and economic indicators, internal or exogenous to companies, as presented in equation (8):

$$\text{Performance} = f(\text{equity, tangibility, size, liquidity, business risk, tax, inflation, crisis}) \quad (8)$$

The following equation expresses the linear model of performance:

$$ROA_{it} = \alpha_i + \beta_1 Equity_{it} + \beta_2 tang_{it} + \beta_3 size_{it} + \beta_4 liquid_{it} + \beta_5 risk_{it} + \beta_6 tax_{it} + \beta_7 inflation_t + \beta_8 Crisis_t + \varepsilon_{it} \quad (9)$$

where α_i represents the unknown intercept of every company, i = 1…41 for the sample with large companies and i = 1…38 for the sample with SMEs, t is the year analyzed (t = 2003...2014), βs are the coefficients of each explanatory variable, and ε_{it} is the error term.

The first stage of analysis refers to descriptive statistics and variables dynamics, capturing at a first glance the main influences over the economic activity of companies. Then, performance will be evaluated in terms of economic and financial indicators which play the role of explanatory variables in regression analysis. In order to test if the independent variables have a persistent influence on return on assets, comparative regression analysis will be conducted, starting with Pooled Ordinary Least Square (OLS), continuing with Fixed Effect (FE) and Random Effect (RE) models on panels of different-sized companies and time periods. The main advantage of panel data analysis is that it accounts for individual heterogeneity, controlling for unobserved differences in business practices across companies and time. Moreover, by means of Hausman Test, the accuracy of FE or RE model results can be determined. If the individual characteristics of companies are time-invariant the fixed effect model is recommended, while the random effect model is more appropriate when variation across entities is random and uncorrelated with explanatory variables.

An endogeneity issue is raised in terms of the inverse causality of exogenous variables towards the dependent variable. Linear regression methods such as OLS, FE and RE models may return inaccurate estimates under these conditions. To solve this problem, the generalized method of moments (GMM) proposed by Arellano and Bover (1995) and Blundell and Bond (1998) can provide solutions to simultaneity bias, reverse causality and potentially omitted variables, being employed as a final stage of analysis. This is a dynamic method used to solve endogeneity issues through a series of instrumental variables generated from lagged dependent variables.

4. Descriptive analysis

The return on assets mean indicates a limited economic efficiency for most Romanian companies listed on BSE (3.8%). The average total equity ratio demonstrates a preference for internal resources, as shareholders' equity represents approximately 65% of the capital structure. Regardless of the industries in which companies operate, the level of fixed assets is greater than current assets. On average, companies listed on BSE own just below 60% of fixed assets from their total assets. The level of sales turnover, reflecting the size variable, is large for most companies. With an average of 7.93, the size variable reflects annual sales of 85million lei. Disregarding the extreme values of liquidity ratio, for most companies comprised in the panels, short-term debt covers around 37% of their current assets. In theory, a liquidity ratio of two is normal and companies exceeding this value are likely to have an improper management of current assets. Although this degree might be problematic over long term, the "optimal" liquidity level is also specific to the industries in which companies operate. The business risk proxy shows volatile earnings: although based on the average risk Romanian companies do not face highly unstable earnings over long periods of time, the standard deviation of this variable is larger than its mean. Companies listed on the Bucharest Stock Exchange pay an average of 18.6% of their gross earnings as taxes. This is very close to the corporate income tax of 16% supported by all businesses except micro enterprises and foreign companies that have representation offices operating in Romania. According to the national statistic, inflation rate varied from 14.1% to less than 2%, with an average of 6.7% for the period analyzed.

Table 4.1 Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
ROA	0.038	0.093	-0.432	0.777
Equity	0.655	0.211	0	1
Tang	0.581	0.175	0.132	0.997
Size	7.928	0.92	0	10.29
Liquid	2.675	2.632	0.011	18.701
Risk	0.479	1.799	-8.353	7.737
Tax	0.186	0.172	0	0.975
Inflation	0.067	0.035	0.014	0.141

According to Fig. 4.1, for the overall period, SMEs perform better. However, in comparison to large companies, small and medium firms experienced a much stronger decrease. In the early years of the period analyzed, the average return on assets registered was above 10%. Net income gradually decreased until the SMEs listed on BSE registered, on average, a very low return on assets, almost null. During the financial crisis these companies had a boost in 2012 and 2013, when their economic performance exceeded 2%. Large companies reflect more volatile return on assets, varying from 5-7% in the first five years of the analysis, to approximately 3% after the crisis. As long as these companies do not face a

constant decrease, it can be assumed that they were affected by the financial crisis to a smaller extent. However, most large companies registered very low net income in 2013, as indicated by the average return on assets of approximately zero.

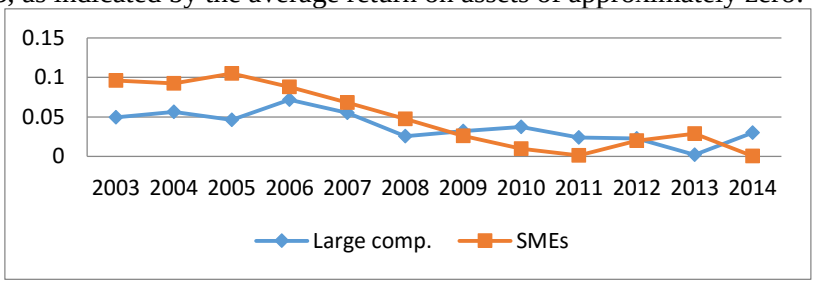

Figure 4.1. Return on assets - large companies versus SMEs

Regardless of their number of employees, all the companies analyzed have a preference for equity. The second common resource used by companies operating in Romania is current debt, while debt with extensive maturity represents below10% of the capital structure. More specifically, the capital structure in large companies consists of 60-70% internal resources. In small and medium companies this ratio is slightly higher, with a maximum average in 2009, when the equity ratio was approximately 75% of the capital. Since the crisis started, the trend of total equity decreased, while the needs for resources were covered on the basis of current liabilities.

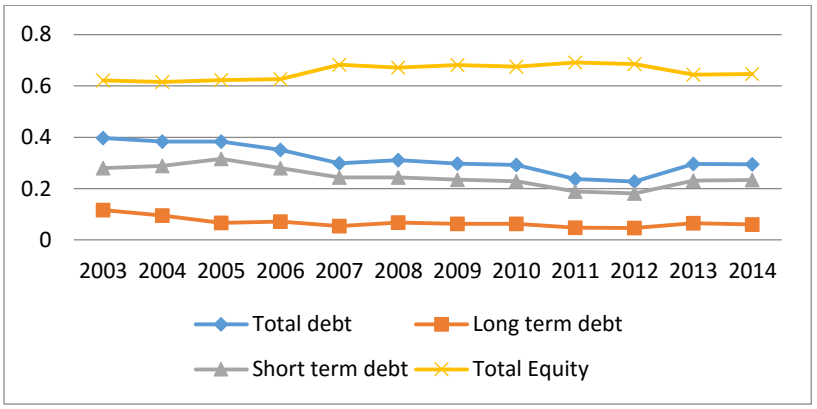

Figure 4.2. Capital structure ratios - large companies

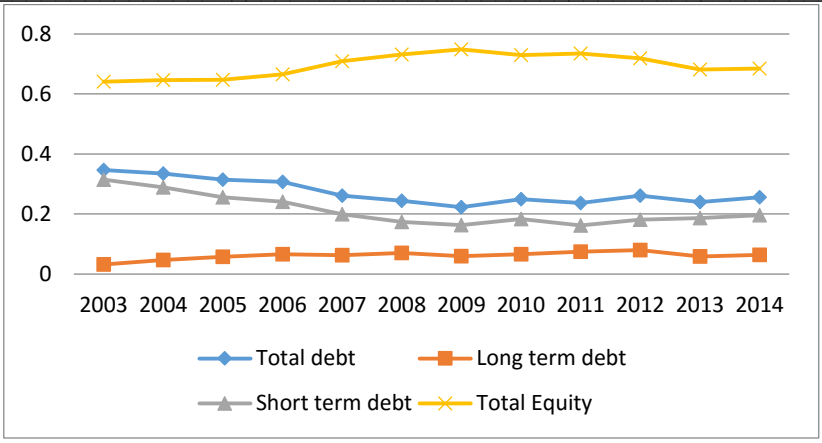

Figure 4.3. Capital structure ratios - SMEs

According to fig. 4.4 before the crisis companies had approximately 55% of fixed assets in their patrimony, large companies indicating a slightly higher percentage of tangible assets in total assets. However, from 2007, when the tangibility ratio reached 57% for all companies, regardless of their size, the SMEs experienced a large continuous growth, up to 64% of their total assets in 2014. Large companies also increased their level of tangible assets, but in a smaller extent, reaching 58% of fixed assets in 2014.

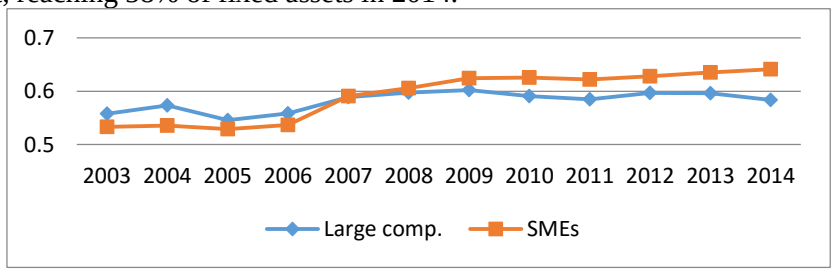

Figure 4.4. Level of fixed assets in total assets - large companies versus SMEs

Large companies maintained their level of sales until 2012, to an average of 100 million lei, even after the crisis started, but from 2012 they faced an important decrease, sales dropping with 50%. In the first period analyzed, SMEs registered an increase in their sales, from 8 to 11 million lei, but faced a gradual decline to only half a million lei since the crisis started.

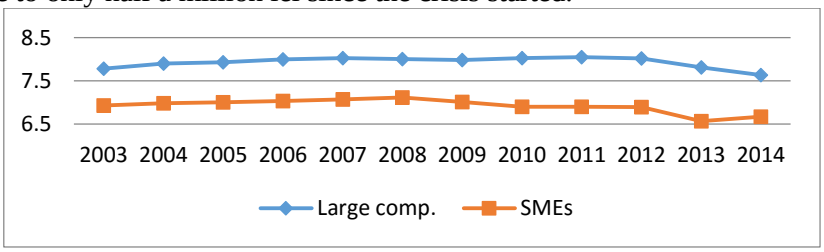

Figure 4.5. Level of sales turnover (size) - large companies versus SMEs

Before the crisis, liquidity ratio was higher for large companies, but from 2007 SMEs reduced their level of current debt, registering higher liquidity ratios compared to large companies. The crisis had an important influence on the companies' financing decisions since the management of current assets changed. Companies tried to lower their debt, and finance their current assets with internal resources and reduce their financial risks.

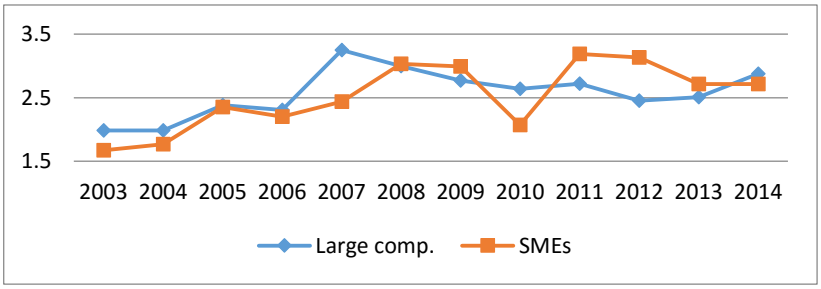

Figure 4.6. Liquidity - large companies versus SMEs

As fig. 4.7 illustrates, business risk increased over the period analyzed, especially for SMEs. Large companies managed to reduce and balance it during the crisis period. The average values of this risk variable prove the negative impact of the financial crisis, showing that earnings volatility during this unstable period is very high. In addition, the financial uncertainty for small and medium companies is extremely high during the crisis.

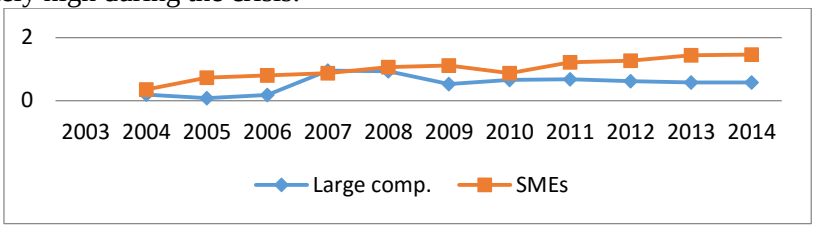

Figure 4.7. Risk - large companies versus SMEs

The state tried to cope with risks and loses involved by the crisis deepening, inducing constant changes in macroeconomic factors such as taxation or inflation. As observed in fig. 4.8, the inflation rate decreased continually from 2003, when it was 14.1%, to 1.4% in 2014. The level of taxes paid out from corporate profits is larger for SMEs. In 2003 these paid approximately 30% of their gross earnings, while large companies had tax expenses of 25%. Over time, these percentages decreased, to a level close to 13-14% regardless of the size of the companies analyzed. This lower percentage of taxes paid is an annual average, showing that by the end of the period analyzed, more companies were affected while the crisis continued in term of their gross earnings.

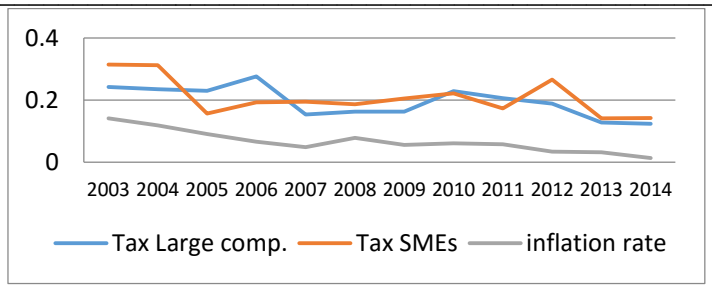

Figure 4.8. Level of taxes paid from earnings before interest and tax and rate of inflation - large companies versus SMEs

5. Findings

Table 5.1 and 5.2 present the main results of the comparative regression analysis, for large companies and SMEs, over the 2003-2014 period. The first model used, OLS is a Pooled Ordinary Least Square regression model applied on return on assets of large companies and respectively on SMEs listed on Bucharest Stock Exchange. The second model computed was fixed effects (FE), followed by random effects (RE) models, and for those panels where the Hausman test suggested that companies have specific characteristics which influence the relationships between variables, a corrected fixed effect model was used to receive more reliable coefficients. In case the Hausman test indicated that the sample or sub-sample is not affected by company characteristics, a RE corrected model was used, and included in the table only if these results were different from those obtained with the initial RE model. The final model employed was the Generalized Method of Moments using lagged dependent variable. Its results showed that, regardless of the company size or time period, return on assets is directly correlated to its previous year level. Sargan tests validate the over-identifying restrictions, with the highest probability of 99% for the overall period samples. The Arrelano Bond test for serial correlation in the first-differenced errors also validates the GMM models results. For every coefficient of independent variables t-values are specified in the tables.

Table 5.1. Factors with potential influence on the performance of large companies (2003-2014)

	OLS	FE	RE	GMM
L.ROA				0.471*** (33.36)
L2.ROA				0.066*** (3.71)
Equity	0.114*** (5.82)	0.104*** (3.44)	0.106*** (4.5)	0.059*** (7.00)
Tang	-0.095*** (-4.13)	-0.047 (-1.15)	-0.076** (-2.52)	-0.178*** (-20.38)
Size	0.006 (1.43)	0 (-0.04)	0.002 (0.50)	0.013*** (11.47)

Liquid	0 (0.25)	0 (-0.04)	0 (0.04)	-0.00*** (-8.93)
Risk	0 (-0.09)	0 (0.52)	0 (0.28)	0 (-0.35)
Tax	0.013 (0.70)	0 (0.03)	0.006 (0.32)	0.018*** (4.64)
Inflation	0.035 (0.20)	0.04 (0.28)	0.034 (0.24)	-0.183*** (-3.00)
Crisis	-0.034*** (-3.34)	-0.034*** (-3.71)	-0.034*** (-3.66)	-0.021*** (-12.20)
Cons	-0.013 (-0.32)	0.019 (0.34)	0.011 (0.24)	
R-Squared	0.13	0.21	0.26	
F / Wald Test	8.00***	4.34***	46.36***	121987.11***
Hausman			0.9633	
Sargan (prob.)				36.87 (0.99)
Arr-Bond test (prob.)				-3.29 (0.00) -0.79 (0.43)

*p< 0.1, **p< 0.05, ***p< 0.01; t statistics are reported in parenthesis
Source: our own calculations using STATA 13.0

Table 5.2. Factors with potential influence on the performance of SMEs (2003-2014)

	OLS	FE	RE	FE corr	GMM
L.ROA					1.339*** (15.50)
Equity	-1.007*** (-5.85)	-0.495* (-1.72)	-1.020*** (-5.07)	-0.495 (-1.53)	-0.571*** (-8.60)
Tang	0.194 (0.99)	0.602** (2)	0.253 (1.17)	0.602 (0.82)	2.320*** (97.78)
Size	-0.711*** (-12.56)	-0.975*** (-13.14)	-0.777*** -12.88)	-0.975*** (-3.11)	-0.134*** (-11.99)
Liquid	0.003 (0.72)	0.001 (0.23)	0.003 (0.51)	0.001 (0.48)	0.007*** (5.98)
Risk	0.020 (1.39)	0.023* (1.65)	0.022 (1.60)	0.023* (1.81)	0.022*** 5.53)
Tax	0.027 (0.19)	0.078 (0.53)	0.050 (0.35)	0.078 (0.88)	-0.047 (-1.15)
Inflation	-0.705 (-0.39)	0.214 (0.13)	-0.493 (-0.29)	0.214 (0.23)	1.984*** (3.53)
Crisis	-0.077 -0.75)	-0.143 (-1.49)	-0.086 (-0.86)	-0.143* (-1.82	-0.010 (-0.46)
Cons	5.719*** (11.74)	6.886*** (11.12)	6.099*** (11.83)	6.886*** (3.38)	
R-Squared	0.37	0.46	0.44	0.46	
F / Wald Test	30.65***	38.91***	263.61***	3.29***	33970.79***
	OLS	FE	RE	FE corr	GMM
Hausman			54.09***		

Sargan (prob.)					33.62 (0.99)
Arr-Bond test (prob.)					-0.97 (0.33) -1.32 (0.19)

*p< 0.1, **p< 0.05, ***p< 0.01; t statistics are reported inparenthesis
Source: our own calculations using STATA 13.0

Regression results indicate that capital structure has an important influence on the corporate performance, but this is specific to company size. Over the 12-year period, equity ratio is positively correlated to the performance of large companies, but has a negative influence on the SMEs. These results show that large companies are more profitable when they dispose of higher values of internal resources. On the contrary, profitable small and medium-sized companies depend more on borrowed resources. Raising equity through financial markets is more accessible for large companies. Risk-averse investors who want to mobilize their savings on the stock market assess these companies as more secure. In contrast, raising funds through equity or shares issuance remains a challenge for SMEs, despite the fact that over the past years their equity ratio constantly increased.

Table 5.3 and 5.4 include the regression models applied on the panel of large companies, over the sub-periods: pre-crisis period (2003-2007)and during the crisis period (2008-2014).Tables 5.5 and 5.6 present the regression models employed over SMEs database, over the sub-periods .For large companies, equity ratio had more influence on ROA before the crisis started. However, the coefficients of equity proxy were statistically significant at 1% level, confirming the direct impact of equity level on profitability. The financing decisions of SMEs were highly sensitive to economic changes produced during financial crisis. High equity ratios characterized profitable small and medium companies until 2007. However, since the crisis emerged, results show that SMEs are less profitable when their capital structure is predominantly consisting of internal resources.

Table 5.3 Factors with potential influence on the performance of large companies before the crisis

	OLS	FE	RE	FE corr	GMM
L.ROA					0.164** (1.99)
Equity	0.189*** (5.78)	0.190*** (3.29)	0.192*** (4.87)	0.190** (2.12)	0.163*** (3.46)
Tang	-0.155*** (-4.08)	-0.209*** (-2.87)	-0.155*** (-3.33)	-0.209** (-2.12)	-0.312*** (-4.01)
Size	0.010 (1.11)	0.117** (2.50)	0.016 (1.25)	0.117* (1.85)	0.022*** (3.58)
Liquid	-0.005*** (-2.67)	-0.009*** (-3.12)	-0.008*** (-4.09)	-0.009** (-2.01)	-0.011*** (-3.29)
Risk	0.001 (0.58)	0.001 (0.45)	0.001 (0.77)	0.001 (0.42)	-0.001 (-0.41)
Tax	-0.023 (-1.06)	-0.008 (-0.41	-0.014 (-0.7	-0.008 (-0.49)	0.019** (2.14)
Inflation	0.023	0.150	-0.015	0.150	-0.186

	(0.11)	(0.76)	(-0.09)	(0.56)	(-1.07)
Cons	-0.037 (-0.44)	0.019 (0.34)	-0.077 (-0.68)	-0.860 (-1.60)	
R-Squared	0.21	0.22	0.17	0.22	
F / Wald Test	6.03***	4.75***	35.29***	4.67***	52.41***
Hausman			17.04**		
Sargan (prob.)					5.16 (0.74)
Arr-Bond test (prob.)					-1.87 (0.06) 1.03 (0.31)

*p< 0.1, **p< 0.05, ***p< 0.01; t statistics are reported in parenthesis

Table 5.4. Factors with potential influence on the performance of large companies during the crisis

	OLS	FE	RE	GMM
L.ROA				0.426*** (6.40)
	OLS	FE	RE	GMM
Equity	0.090*** (3.35)	0.055 (1.03)	0.79** (2.38)	0.107*** (3.10)
Tang	-0.084*** (-2.86)	-0.063 (-0.98)	-0.071* (-1.82)	0.002 (0.05)
Size	0.005 (1.04)	0 (0.02)	0.001 (0.21)	0.042*** (12.08)
Liquid	0 (0.49)	0 (0.34)	0 (0.43)	0 (-0.76)
Risk	0 (-0.04)	0 (-0.46)	0 (-0.37)	0*** (5.49)
Tax	0.054* (1.79)	0 (0.33)	0.030 (1.01)	0.029 (1.06)
Inflation	0.034 (0.13)	0.080 (0.33)	0.056 (0.24)	-0.093 (-0.61)
Cons	-0.037 (-0.81)	0.019 (0.28)	-0.003 (-0.06)	-0.404*** (-13.13)
R-Squared	0.09	0.02	0.22	
F / Wald Test	3.75***	0.52	12.02*** *	2267.64***
Hausman			6.54	
Sargan (prob.)				16.67 (0.61)
Arr-Bond test (prob.)				-2.07 (0.04) 0.57 (0.57)

*p< 0.1, **p< 0.05, ***p< 0.01; t statistics are reported in parenthesis

Table 5.5 Factors with potential influence on the performance of SMEs before the crisis

	OLS	FE	RE	FE corr	GMM
L.ROA					0.445*** (8.06)
Equity	0.149*** (3.27)	0.220*** (3.36)	0.171*** (3.32)	0.220** (2.49)	0.127** (2.38)
Tang	-0.202*** (-5.73)	-0.404*** (-7.55)	-0.290*** (-7.08)	-0.404*** (-3.03)	-0.477*** (-5.95)
Size	0.014 (0.76)	0.059 (1.21)	0.016 (0.65)	0.059 (1.39)	0.006 (0.61)
Liquid	0 (-0.05)	-0.002 (-0.56)	-0.001 (-0.19)	-0.002 (-0.72)	-0.002 (-0.6)
Risk	0.003 (1.46)	0.005** (2.55)	0.004** (2.28)	0.004*** (5.83)	0.006*** (21.89)
Tax	-0.091** (-2.310	-0.103*** (-2.62)	-0.109*** (-3.00)	-0.103** (-2.52)	-0.188*** (-5.66)
Inflation	0.522* (1.97)	0.502** (2.25)	0.512** (2.43)	0.502* (1.99)	0.301* (1.82)
Cons	-0.023 (-0.15)	-0.263 (-0.72)	0.002 (0.01)	-0.263 (-0.79)	
R-Squared	0.27	0.45	0.43	0.45	
F / Wald Test	7.65***	12.27***	77.81***	8.38***	1532.54***
Hausman			14.97**		
Sargan (prob.)					4.25 (0.84)
Arr-Bond test, (prob.)					-2.85 (0.04) 1.30 (0.19)

*p< 0.1, **p< 0.05, ***p< 0.01; t reported in parenthesis

Table 5.6 Factors with potential influence on the performance of SMEs during the crisis

	OLS	FE	RE	FE corr	GMM
L.ROA					2.076*** (3.21)
Equity	-1.305*** (-4.94)	-0.481 (-0.89)	-1.249*** (-4.14)	-0.481 (-0.97)	0.091 (0.16)
Tang	0.315 (1.08)	2.489*** (3.91)	0.506 (1.49)	2.489 (1.21)	3.955*** (8.34)
Size	-0.076*** (-9.90)	-0.771*** (-6.68)	-0.797*** (-9.61)	-0.771*** (-3.72)	-0.372*** (-6.34)
Liquid	0.006 (0.94)	0.003 (0.40)	0.005 (0.76)	0.003 (0.94)	0.006 (0.81)
Risk	0.036 (1.6)	0.052* (1.84)	0.045* (1.88)	0.052* (1.80)	0.016*** (3.04)
Tax	0.117 (0.61)	-0.151 (0.78)	0.136 (0.72)	-0.151 (1.21)	0.007 (0.19)
Inflation	0.550 (0.18)	0.956 (0.34)	0.915 (0.31)	0.956 (0.39)	0.810 (0.44)
Cons	5.964*** (9.1)	4.061*** (3.83)	6.037*** (8.44)	4.061** (2.28)	

R-Squared	0.42	0.49	0.46	0.49	
F / Wald Test	26.34***	30.75***	192.52***	3.61***	245.92***
Hausman			14.79***		
Sargan (prob.)					6.06 (0.53)
Arr-Bond test, (prob.)					-0.87 (0.38) -1.42 (0.16)

*p< 0.1, **p< 0.05, ***p< 0.01; t statistics are reported in parenthesis
Source: Tables 5.3 – 5.6 include our own calculations using STATA 13.0

In terms of the level of fixed assets, different results were found depending on the size of the companies analyzed. The overall period indicated an opposite influence: large companies with lower ratios of fixed assets in total assets are more profitable, while SMEs register higher returns when they own more tangible assets. Although, for large companies, tangibility variable reflected a higher influence on performance before the crisis, its coefficients were statistically significant to a lesser extent after 2008. Before the crisis, small and medium-sized companies performed better with low levels of fixed assets. From 2008, profitable SMEs owned more fixed assets. Based on the influence of capital structure previously mentioned, since the crisis started, small and medium companies tend to raise more debt in order to expand and increase their profits. Borrowed funds are more accessible when companies prove their security with fixed assets used as collateral. Also, the increase in tangibility presented in the descriptive analysis shows that SMEs invested in order to develop their businesses and limited their level of current assets to reduce their inventory expenses.

The level of sales turnover, used as proxy for the size variable, also reflects different influences on companies listed on the BSE. The obvious relationship between sales and returns is a positive one, but it was confirmed only for large firms. For SMEs, regression results indicate that return on assets is affected by large levels of sales. This exceptional relationship is based on the fact that small and medium companies undertake investment opportunities in order to grow when their sales have a positive dynamics. An increase in sales induces an increase in returns. But during these performing periods, companies invest in fixed assets, inducing a higher increase in the level of assets compared to the increase in net income. Therefore, the return on assets shows a decrease during this period. Such investments prove their profitability and positive net present values only based on a constant sales increase in the future.

Liquidity should have a positive influence on return on assets, as long as its level is not extremely high due to a poor inventory and accounts receivable management. Based on comparative regression results, the companies with lower liquidity levels were more profitable, but during the crisis the influence turned into a direct one. Therefore, companies tried to secure their activity by reducing the level of short-term debt. This change in the corporate financing behavior was induced by the crisis. However, liquidity coefficients are very low and statistically significant only for large companies, before the crisis began. Although the management of current assets is extremely important for a profitable performance,

liquidity is not one of the most influential factors for the return on assets registered by listed companies.

Business risk is illustrated by the profitability coefficient of variation. The risk coefficients are very low, indicating a limited impact on return on assets. Moreover, results are not statistically significant for large companies, but for SMEs, volatile earnings are specific to more profitable companies. As the descriptive analysis captured, over the crisis period, the SMEs risks were highly dynamic, increasing every year. Regression results indicate that an increase in business risk is not necessarily linked to a poor performance, at least not over the short-term.

According to the method used to compute the tax ratio, taxes paid over gross profit, companies that pay higher taxes should be associated with higher returns, as the normal income tax rate is not progressive but a fixed percentage of gross profit. Tax coefficients resulted from regression models are positive for large companies, but mostly insignificant. Tax coefficients were statistically significant for all regression models only for SMEs panel, before the crisis. These results suggest that the unique income tax rate of 16% reduces earnings of small and medium businesses, limiting their profitability.

Considering the statistically significant coefficients, the inflation rate has a negative influence. For large companies only the relevant result is the one obtained with GMM model, applied on the overall period. This shows that large companies perform better over periods of reduced inflation. On the contrary, small and medium firms used to register higher return on assets during inflationary periods. In this case, results are statistically relevant before the crisis. Moreover, they support the descriptive analysis of the overall period, indicating highest ROA levels in 2003, 2004 and 2005, when the inflation rates were at their maximum level.

As the negative coefficients show, the crisis affect the economic performance of companies listed on BSE. Although differences in results prove that SMEs were forced to make changes in their financing and investment decisions since the crisis began, the economic downturn seemed to have greater impact on large companies, as the regression coefficients of the crisis dummy variable are statistically significant at 1% level, regardless of the regression model used.

6. Conclusions

Compared to studies related to identifying the determinants of capital structure, the impact of financing decisions on performance was less analyzed in Romania. According to our results, Romanian companies will keep their business operational with borrowed funds when they lack of significant profits. Alternatives for external resources are limited to loans because raising internal resources through equity issuance is difficult in less developed capital markets, like the Romanian one. Furthermore, our study proves that during the crisis, companies avoided long-term debt to protect against an increase in financial risks. The economic environment and the complexity and development stage of capital

markets influences decisions at financial management level but solutions offered to financial problems are limited. The main role of financial managers is to identify ways of raising capital and choose the cheapest resource, while maximizing the company's value.

It can also be noticed that companies listed on BSE comply with the basic rule of finance, using permanent resources (equity and long term debt) to finance fixed assets, and short-term debt to cover current assets. Although current liabilities represent most of the borrowed capital, these resources finance current assets, and are not used for investments. The results also highlight that companies operating in Romania follow the pecking order theory, since they access external resources only if the internal funds are insufficient. Although the theory mentions a specific hierarchy, our analysis indicates that companies rarely resort to raising equity through capital markets. Essentially, companies listed on BSE avoid raising capital by issuing preferred shares, and prefer short-term loans for raising production and long-term borrowed resources, thus signaling on the market a need for equity and opportunities for profitable investments. These results confirm those of previous studies on emerging countries (Fama and French, 2004; Beck et al., 2008; Pirtea et al., 2014).

Profitability is sensitive to the capital mix of the company, but also to its size. Large companies recorded higher performance based on higher equity ratios, while small and medium-sized companies are more profitable with higher leverage ratios. Since the crisis started, SMEs tend to increase the level of fixed assets, using them as collateral in order to access borrowed funds. Liquidity ratios show higher risk-aversion in the SMEs case, which need a better management of current assets, especially when it comes to their accounts receivable.

Nowadays, most companies experience the crisis effects and strive for the sustainability of their business. In the complex context of the economic environment evolution and dynamics, to ensure a proper and functional activity, companies depend on their financing opportunities under severe and competitive conditions. On this background, the financial crisis greatly affected the economic performance of all companies listed on BSE, and to a greater extent SMEs. Although these tried to take minimum risks, they faced major fallout in performance throughout the overall period, bearing important changes in financing and investment decisions.

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The impact of entrepreneurship on economic development through government policies and citizens' attitudes

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ABSTRACT

This research aims to investigate the field of entrepreneurship in the context of public sector governance in eight of the largest economies in the world (the G7 countries and Russia). To analyse the composition and evolution of entrepreneurship, data from the Global Entrepreneurship Monitor was collected, while the economic stability was based on GDP data from the World Bank. To understand the relationships between the public sector governance policies and attitudes towards entrepreneurship in terms of economic development, the 2001-2018 period was considered. The relationships studied were observed through correlation and regression analyses, based on indexes obtained through principal component analysis. Results indicate that there are strong positive correlations between GDP and cultural and social norms promoted in society, total early-stage entrepreneurial activity, physical and services infrastructure, and tax and bureaucracy, while the fear of failure affects the GDP. Besides, this research emphasises the fact that individuals' entrepreneurial attitudes and behaviour may reduce the level of GDP, while the entrepreneurial framework developed by the public sector would have an important role in increasing economic stability.

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Introduction

Since the recent financial crisis, the global economy faces a series of pressures, such as the recession and rapid decline of national economies, massive reduction in consumption, or increased unemployment. Under these conditions, the policymakers were confronted with emergency measures intended to help in economic recovery. Accordingly, some of the most competitive economies realised that the business environment needs support to enhance productivity and future prosperity, and

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focused on fostering entrepreneurship to create jobs, provided better access to finance and more opportunities through education. As entrepreneurship is the heart of many economies and sustains the development of countries, the entrepreneurs also became a key element in securing economic development. Recognising the importance of entrepreneurship policies, governments started to implement general and specific policies that promote entrepreneurial activities. The general policies refer to taxes, labour law, and market regulations, while the specific ones may be focused on sustaining SMEs, innovation, or certain activities or industries (Lin et al., 2010; Oliyide, 2012; Wright et al., 2007). However, the policies' effects on entrepreneurship and economic development are different, as studies proved that government programs may affect entrepreneurship differently, based on its phases.

As long as small and medium companies represent the majority in the business environment, they become important supporters of employment and economic development. Accordingly, governments should promote public policies that foster entrepreneurial activity (Sarfati, 2012). Recent studies proved that policymakers are solving part of the problems related to the economic crisis by stimulating economic growth through several aspects, with direct impact on entrepreneurship: public expenditure on R&D and education, legal aspects which regulate certain conditions for startups or facilitate SMEs' access to external resources, innovative economic environment, human capital, etc. (Castaño et al., 2016; Méndez-Picazo et al., 2012). As long as these aspects are strongly interrelated but also components of various sectors (macroeconomics, business environment, public sector, etc.), this research will be more focused than previous studies, examining to what extent the global entrepreneurship proxies related to the national framework and entrepreneurial attitude and behaviour, determine the GDP growth and economic stability of a country. This will bring new insights compared to previous findings, as we focus on emphasising the influence that the entrepreneurial ecosystem has on economic growth and development. The 'entrepreneurial ecosystem' is a concept which correlates the firms behaviour and performance with an environment that supports ambitious entrepreneurs, innovation, and economic development (Cavallo et al., 2019). Accordingly, we considered the data on entrepreneurship from individual entrepreneurs and realised distinctive indexes, gathering individual behaviour and government policies to review their effect on economic development in developed countries. Commencing from the assumption that most developed countries are focused on providing the best measures for the development of entrepreneurship, we analysed eight countries, considered the most highly industrialized nations, also known as The Group of Eight or G8: France, Germany, Italy, the United Kingdom, Japan, the United States, Canada, and Russia. The last one was suspended from The Group of Eight in 2014 in response to the Russian invasion of Crimea.

The paper continues with the literature review, presenting a series of implications of entrepreneurial behaviour and attitudes, and entrepreneurial framework on economic stability. The second section presents the data and the methods employed for analysis, reflecting the relationship between Global Entrepreneurship proxies and the economy in G8 countries. Section 3 presents the main results, being followed by conclusions.

Literature review

One of the most common terms in the literature on entrepreneurship is 'innovation'. This is related to technology, strategy, or industry, but most importantly, to 'social entrepreneurship', which goes beyond the pursuit of profits, tackling social, cultural, and environmental issues (Robertson et al., 2020; Roundy, 2017). Some studies describe that innovation is generated by the private sector while the public sector is rather an obstacle to entrepreneurship (Windrum & Koch, 2008). Basically, the public sector is one of the key drivers of entrepreneurship, as economic growth and social development depend on efficient public sector organisations that deliver high-quality services. The research evidenced that the link between the public sector and innovation policies is flexible and complex (Castaño et al., 2016; D'Agostino & Scarlato, 2015). The nexus can be explained by numerous criteria, related either to R&D expenditure and policies or to the innovative economic environment: technological advances, entrepreneurs' risk aversion or their willingness to capitalise their resources or borrow funds to finance their own business, change in services or organisational and managerial structure, etc. In addition to innovation, to increase entrepreneurship, permanent communication and exchanges between the public and private sector and non-governmental organisations should exist, as they are all connected in a private-public-social sector.

Innovation employed in improving organisational performance is not necessarily a feature of the public sector in all economies. Moreover, there are significant differences in the organisational and operational aspects of the private and public institutions (Tosterud, 2014). More specifically, public sector programs are developed based on political aspects, which may change drastically from one election period to another. The private sector is usually developed on the free market signals, which may be disruptive but not of political nature. Another difference between the two sectors is related to profit. The private sector is focused on achieving profits or going bankrupt. In terms of the public agencies, their performance is more difficult to be evaluated as there is no aim for profit.

Public policies supporting industrial clustering are often employed in developed countries, and became of interest in developing and transition economies as well (Lin et al., 2010; OECD, 2010). Of course, government expenditures is the key in supporting the industrialised countries, for the development of R&D, especially for the digitalisation sector (Kotlebova et al., 2020). For instance, industrial parks were developed in Taiwan since the end of the last century: the Industrial Technology Research Institute incubated over 270 innovative companies having a significant impact on the economy of Taiwan, especially in the tech industry. In developing countries, governments tend to employ policies facilitating access to funds and other resources needed for business development, promoting entrepreneurial activities. For example, in Nigeria the following programs were established by the Federal Government or the Small and Medium Enterprises Development Agency: N-Power programme, Government Enterprise and Empowerment Programme (GEEP), or You-win programme (Oliyide, 2012). Similarily, in South Africa, the National Small Business Act was promulgated in 1996 to promote entrepreneurial activities. According to it, the National Small Business Council and the Ntsika Enterprise Promotion Agency should

work together and constantly report the development and trends of the small businesses, analyse how the small business sector impacts the economy or supports the development of the rural regions or the integration of the marginalised groups in the economy. The Agency and Council also offer recommendations in terms of legislation to remove any restrictions in the small business sector. Studies proved that the development of clusters has a positive effect on the economy through entrepreneurship, as strong clusters contribute to the survival of the new businesses, being associated with their growth and also with employment (Delgado et al., 2014). Dobeš et al. (2017) also indicated that large companies have higher chances of recieving financial support from government, becoming through these means even more competitive.

Government policies usually encourage two sides of the business environment: venture capital and entrepreneurial activities. To ensure the attractiveness of entrepreneurship, governments must create a favourable environment through several dimensions. First of all, education should be oriented towards entrepreneurial activities, especially at the university level. For this, creative ideas from students should be supported by the governmental framework while academia is providing help in developing such ideas. Regardless of these assumptions, in reality, most entrepreneurs come from the business environment and not from academia, and the entrepreneurial attractiveness is strongly influenced by the tax policy. Another important aspect is related to the investors' depth and knowledge of certain domains and locations. Usually, a country or a region that becomes an entrepreneurial hub is more attractive for investment. Therefore, nowadays, a pro-entrepreneurial environment is often seen as a requirement for governments in order to ensure the development of the regions (Mempel-Śnieżyk et al., 2020). However, the domestic organisations could be rapidly surpassed by international investors undertaking critical early investments (Lerner, 2014).

A reasonable governmental program must consider the needs of the private sector and the market trend. For example, a common problem is related to public venture capital initiatives which are ceased after a while due to poor results. This could also be related to the fact that such investment might take years until it becomes profitable, or that poor investment analysis is the main reason for decision failure. Also, governmental requirements could be detrimental to private sector development. While restricting the location of the business or the level of securities raised would affect the entrepreneurial process, receiving subsidies to retain the local citizens hired would represent a supportive measure. Another fact may be related to the market trend, which is often ignored by the government who encourage investments in regions with a lack of private interest, leading to a waste of public resources on ineffective programs.

Countries with an effective regulatory framework in terms of entrepreneurship are more competitive and ensure higher productivity through jobs and trade (Mihaila, 2015). Entrepreneurship supports employment, inducing a raise in the budget of those regions and increasing chances for a population growth in the area (Milovic et al., 2020). Accordingly, we expect a direct relationship between the regulatory framework and the development of the business sector, attracting more investments. Based on the components of the framework, fewer administrative burdens and more

simple legislation would support the development of firms, improving the business infrastructure in terms of the general performance of the economy and access to external funding. Although in the case of equity the common funding options for entrepreneurs refer to venture capitalists or business angels, the most important source of funds is, in general, bank finance (Elston & Audretsch, 2012; Moro et al., 2020).

In terms of attitude and behaviour regarding entrepreneurship, the cultural aspects should be very important for economic activity, as they have a strong impact on consumption and work, helping in establishing a social network and having a relevant impact on the number of start-ups developed, based on positive attitudes towards funding a business (Bergmann, 2009). Entrepreneurship may be affected by age, income, or skill self-perception, especially in developing countries and in those with a significant gender gap (Gunewardena & Seck, 2020). Although the vast literature on the topic observed different relationships, we expect both types of components of the Global Entrepreneurship Monitor to have a significant impact on entrepreneurship and economic development: our analysis will reveal which proxies of entrepreneurial behaviour and which framework proxies are most relevant in the economic development of the G8 countries.

Data and methodology

The model proposed for observing the relationship between entrepreneurial behaviour and attitudes, entrepreneurial framework, and economic stability is constructed in several stages. In terms of the Global Entrepreneurship Monitor (GEM) proxies, the data was collected from the official website, while the data on GDP was collected from the World Bank website. The data refers to annual scores over the period 2001-2018. We commenced our sample period in 2001 as none of the countries overviewed in our analysis had the entrepreneurship data available before this year. To complete the missing data, because some countries did not have all the GEM indicators available for the eight years, we adopted the data imputation method. For principal component analysis the panel must be strongly balanced, with no missing data. Accordingly, data imputation assumed the average value of the indicator for that country. The method of averaging the inputs from multiple imputed datasets was introduced by Rubin (1976) who considered that completing missing values with the same average value will produce unbiased inferences. However, the method should be carefully applied when a large amount of data is missing, as it might distort results, but this was not our case.

The indicators employed for the global entrepreneurship indexes are the following, with abbreviations specified in brackets: Total early-stage Entrepreneurial Activity (tea), Entrepreneurial intentions (entrepint), Perceived opportunities (percopp), Perceived capabilities (perccap), Fear of failure rate (fearfail), Governmental support and policies (govsuppol), Governmental programs (govprogr), Taxes and bureaucracy (taxbur), Internal market openness (intmkopen), Physical and services infrastructure (physservinfr), and Cultural and social norms (cultsocnorms). The first five indicators previously listed refer to the entrepreneurial behaviour and attitudes of individuals,

Table 1. Description of the global entrepreneurship indicators employed in this study.

Indicator	Description	Unit measure
Total early-stage Entrepreneurial Activity	individuals from 18 to 64 years who just became entrepreneurs or own/manage a new business	% of population
Entrepreneurial intentions	individuals from 18 to 64 years who are on the verge of becoming entrepreneurs or intend to start a business in three years	% of population
Perceived opportunities	individuals from 18 to 64 years who consider that starting a business in their living area is a good opportunity	% of population
Perceived capabilities	individuals from 18 to 64 years who have the skills and knowledge necessary to start a business	% of population
Fear of failure	individuals from 18 to 64 years who would not set up a new business due to their fear of failure	% of population
Governmental support and policies	the extent to which public policies support entrepreneurship as being a relevant aspect in the economy	From 1 to 5
Governmental programs	the quality of programs directly assisting SMEs at all governmental levels	From 1 to 5
Taxes and bureaucracy	the extent to taxes or regulations are either size-neutral or encourage new businesses and SMEs	From 1 to 5
Internal market openness	the extent to which new businesses are free to enter the markets	From 1 to 5
Physical and services infrastructure	access to physical resources at a price that does not discriminate against SMEs	From 1 to 5
Cultural and social norms	The extent to which social and cultural norms encourage actions for new business methods or activities that can potentially increase personal wealth and income	From 1 to 5

Source: GEM (2020b, 2020c) – Key Indicators.

while the last six represent the national context and how that impacts entrepreneurship. More details on the description of these variables are included in Table 1. For economic stability, the analysis will employ the logarithm of the annual GDP at purchasing power parity (PPP), to bring the GDP level to one that is similar to the level of the GEM indicators (with values that are less than 100).

Considering the data available and our research focus, we propose two hypotheses: (1) the more open citizens' are to entrepreneurship and the more risks they take to become entrepreneurs, the greater the economic development of a country will be; (2) the stronger the support from public sector towards entrepreneurship, the greater the economic development of a country will be.

The analysis will include three stages. First, correlations between GDP and global entrepreneurship indicators will emphasise the statistically significant relationships. The second stage of the analysis will refer to the construction of indexes, obtained through principal component analysis. The first ones (PC1, PC2) will be based on the first five GEM indicators, illustrating the individuals' behaviour and attitudes towards entrepreneurship; another set of indexes (PC3, PC4) will be based on the other six GEM indicators, representing the entrepreneurial framework developed by the government in relationship with the specific economic, social and cultural factors of each country. The final stage will be the regression analysis to observe the potential impact the indexes have on GDP. Through this analysis we will be able to emphasise the entrepreneurship indicators related to the society, government, and citizens, with the most influence on the economic stability in the G8 countries observed.

The regression analysis based on ordinary least squares models will consider the log GDP as the dependent variable, and the principal component indexes obtained from the global entrepreneurship monitor database as independent variables. Therefore, the general regression model is the following:

$$GDP_{it} = \alpha_i + \beta_1 PC1_{\ it} + \beta_2 PC2_{\ it} + \beta_3 PC3_{\ it} + \beta_4 PC4_{\ it} + \varepsilon_{it}, \quad (1)$$

where: α_i (country $i = 1 \ldots 8$) represents the unknown intercept of every country, t ($t = 2001 \ldots 2018$) is the year analysed, the βs are the coefficients for every independent variable (index obtained through the principal component analysis), and ε_{it} is the error term.

Results

In Table 2 we include a summary of the descriptive statistics (average and standard deviation) to observe any significant differences across countries. The standard deviation may be significant for some of the GEM variables but we also run tests (Levin-Lin-Chiu test) confirming that our panel data variables are stationary.

Between the G8 countries, in terms of economic development, the United States has the highest GDP (PPP) value, followed by Japan and Germany. Going forward to the entrepreneurial behavior and attitudes topic, in the United States and Canada, we find the most entrepreneurs who start a new business, or the most citizens who consider that setting up a business would be an opportunity in their community or have the highest skills and knowledge to start a business. France presents the friendliest environment for entrepreneurship from all the countries observed, having the highest percentage of citizens who are on the verge of starting their business or intend to start one in three years. On average, 37% of the G8 countries citizens between 18 and 64 years old would not start a new business due to their fear of failure; the highest percentage for fear of failure may be observed in Russia (43%) and Japan (41%).

Table 2. Descriptive statistics.

	GDP proxy (log of PPP)		Entrepreneurial behaviour and attitudes of individuals									
			Tea		Entrepint		Percopp		Perccap		Fearfail	
	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.
Canada	12.13	0.09	12.29	3.29	10.75	2.42	49.31	8.2	53.38	2.19	33.09	6.04
France	12.36	0.08	4.79	1.2	13.55	3.97	24.36	9.03	32.29	5.35	39.43	6.56
Germany	12.51	0.09	4.89	0.62	5.73	0.87	28.42	9.5	37.24	2.49	37.92	3.61
Italy	12.31	0.06	4.49	1.39	8.59	2.01	28.57	8.3	35.48	6.11	42.4	9.22
Japan	12.65	0.06	3.58	1.15	2.65	1.16	8.31	2.76	12.49	1.74	41.05	9.32
Russia	12.4	0.19	4.37	0.94	3.04	0.88	20.82	4.53	23.46	5.43	43.13	5.81
U.K.	12.36	0.08	7.02	1.45	6.69	1.58	35.17	6.42	47.55	2.7	34.15	2.11
U.S.	13.17	0.09	11.59	2	10.01	2.36	40.7	12.93	55.01	2.8	27.43	4.98
Overall sample	12.48	0.31	6.63	3.62	7.63	4.14	29.46	14.27	37.11	14.32	37.32	8.04

	The national framework that supports entrepreneurship											
	govsuppol		govprogr		taxbur		intmkopen		physservinfr		cultsocnorms	
	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.
Canada	2.92	0.21	2.96	0.14	2.6	0.26	2.99	0.29	4.24	0.21	3.33	0.11
France	3.25	0.2	3.23	0.14	2.91	0.22	2.39	0.18	4.19	0.15	2.36	0.21
Germany	2.85	0.21	3.47	0.10	2.46	0.28	2.83	0.13	3.98	0.22	2.61	0.13
Italy	2.21	0.23	2.27	0.17	1.73	0.13	2.51	0.13	3.08	0.21	2.5	0.29
Japan	2.92	0.2	2.46	0.15	2.15	0.21	2.53	0.18	3.89	0.35	2.32	0.13
Russia	2.31	0.18	2.08	0.13	2.07	0.13	2.23	0.16	3.27	0.16	2.59	0.25
U.K.	2.78	0.31	2.66	0.20	2.65	0.25	2.96	0.2	3.76	0.23	2.9	0.26
U.S.	2.85	0.3	2.83	0.25	2.7	0.41	2.97	0.36	4.2	0.34	4.12	0.27
Overall sample	2.76	0.39	2.75	0.47	2.41	0.44	2.68	0.35	3.83	0.47	2.84	0.61

Source: authors' computations.

From the national framework point of view, in Europe, we mention France with the highest levels of evaluation for governmental support, policies, and programs assisting SMEs, and also with prices that do not discriminate against SMEs. In terms of taxation and regulations that encourage new businesses and SMEs, France is also at the top of the G8 countries. Regarding market openness, the island countries (Canada, U.S., U.K.) and Germany provide the most support for new businesses to enter the market.

For the cultural norms that encourage actions for new business methods, the United States leads the G8 top, with a score of 4.12 compared to the sample average, of 2.84.

The Pearson correlation coefficients included in Table 3 indicate a statistically significant dependence between the global entrepreneurship indicators. Some of the entrepreneurship variables indicate a strong correlation between each other (e.g. percopp and tea, perccap and tea, perccap and percopp, physservinfr and taxbur etc.). However, there will be no autocorrelation issues in the regression analysis as long as the principal component analysis allows us to build a series of indexes characterised by uncorrelated linear combinations of the variables.

Considering the influential factors for GDP, it seems that most impact (in terms of statistical significance and coefficient values) comes from the Cultural and social norms promoted in society, Total early-stage Entrepreneurial Activity, Physical and services infrastructure, and from Tax and bureaucracy. These four variables have a direct impact on GDP, and their high values would support economic stability. The Fear of failure is also an indicator of entrepreneurship with a significant impact on GDP but carrying a negative influence. Based on the Pearson correlation matrix we may conclude that both the individuals' entrepreneurial behaviour and the entrepreneurial framework influence the economic stability of a country. The principal component analysis (PCA) stage allows us to reduce the number of independent variables correlated to each other and create a series of indexes that carry out the main characteristics of the individual behaviour and framework concepts in terms of entrepreneurship. The results of PCA are presented in Table 4.

The analysis provided two indexes from the individual behaviour and attitude variables, as they both explain 83.4% of the total variance (as evidenced by the cumulative proportion). The first two components also have an eigen value of approximately 1 or higher, which is another suggestion on retaining two factors from the behavioural side of entrepreneurship. Based on the factor loadings, we can determine the weights and correlations between the variables in every factor built. In the first one, the fear of failure is the only behavioural characteristic with a negative effect on the factor, but also with the smallest impact compared to the rest of the variables. The highest impact on the first factor comes from the perceived capabilities and opportunities, and total early-stage entrepreneurial activity, and thus we will refer to this factor as the individual interest for entrepreneurship (interest.entrep). However, for the second factor (PC2), fear of failure has a direct influence and the highest level of impact along with entrepreneurial intentions. Considering that the first factor concentrates the positive aspects of entrepreneurship (individual capabilities, opportunities, and incipient entrepreneurial activity), the second factor reflects the personal attitude towards entrepreneurship, gathering the effect of contrasting feelings: fear of failure and entrepreneurial intentions (we will refer to this factor as entrep.feel).

Table 3. Correlations between economic stability and global entrepreneurship indicators.

	GDP	entrepint	Tea	percopp	perccap	fearfail	govsupppol	govprogr	taxbur	intmopen	physservinfr	cultsocnorms
GDP	1											
entrepint	−0.0105	1										
tea	0.232***	0.515***	1									
percopp	0.0290	0.587***	0.792***	1								
perccap	0.101	0.514***	0.743***	0.810***	1							
fearfail	−0.193**	−0.0732	−0.377***	−0.264***	−0.542***	1						
govsupppol	0.0666	0.310***	0.156*	0.006	0.107	−0.216***	1					
govprogr	0.0205	0.407***	0.206**	0.240***	0.362***	−0.248***	0.692***	1				
taxbur	0.161*	0.475***	0.421***	0.343***	0.402***	−0.286***	0.649***	0.654***	1			
intmkopen	0.106	0.121	0.486***	0.398***	0.589***	−0.463***	0.339***	0.473***	0.438***	1		
physservinfr	0.200**	0.343***	0.434***	0.184**	0.323***	−0.361***	0.755***	0.691***	0.706***	0.556***	1	
cultsocnorms	0.487***	0.305***	0.786***	0.606***	0.714***	−0.563***	0.115	0.175**	0.405***	0.583***	0.410***	1

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: authors' computations.

Table 4. Indexes resulted from the principal component analysis.

				Factor loadings	
Component	Eigen value	Cumulative proportion	Variable	PC1	PC2
Comp1	3.194	0.639	tea	0.497	0.032
Comp2	0.978	0.834	entrepint	0.383	0.526
Comp3	0.456	0.926	percopp	0.507	0.187
Comp4	0.247	0.975	perccap	0.516	−0.151
Comp5	0.125	1	fearfail	−0.287	0.815
				Factor loadings	
Component	Eigen value	Cumulative proportion	Variable	PC3	PC4
Comp1	3.62	0.603	govsuppol	0.421	−0.415
Comp2	1.153	0.796	govprogr	0.434	−0.285
Comp3	0.476	0.875	taxbur	0.445	−0.078
Comp4	0.333	0.93	intmkopen	0.369	0.463
Comp5	0.237	0.969	physservinfr	0.476	−0.074
Comp6	0.181	1	cultsocnorms	0.273	0.722

Source: authors' computations.

From the framework point of view, the principal component analysis returned two main factors with eigen values higher than 1, which explain 79.6% of the total variance (expressed by the cumulative proportion). All the framework variables have a positive impact on the first factor (PC3), but most influence comes from the physical and services infrastructure, taxes and bureaucracy, governmental programs, and governmental support and policies. This factor is mostly related to the public sector, public policies and public services and thus we abbreviate it as public.pol.entrep. The second factor (PC4) is positively influenced by the cultural and social norms and the internal market openness, while the rest of the framework variables carry a negative impact on PC4. However, only governmental support and policies have a high level of weight in the factor (0.415). Considering that this factor is positively influenced by the market, society, and culture, and restrained by the public governance and policies, we will refer to it as the external environment with an impact on entrepreneurship (ext.environ.entrep).

Table 5 presents the results from the final stage of the analysis, i.e. regression analysis based on ordinary least squares models. We considered three models to verify the consistency of the results: one for reviewing the impact of the individual behaviour and attitudes towards entrepreneurship on GDP, one for reviewing the impact of the entrepreneurial framework on GDP, and another one for testing the effect of the overall context of entrepreneurship on GDP.

The first model regresses the entrepreneurial behaviour and attitude indexes (interest.entrep and entrep.feel) on GDP. Results indicate a statistically significant relationship between the feelings towards entrepreneurship and GDP, suggesting that the personal attitude towards entrepreneurship have a restricting effect on GDP, as a high level of fear of failure and entrepreneurial intentions will induce a decrease in the level of GDP in G8 countries.

The second model employed regresses the indexes resulted from the framework of entrepreneurship and emphasizes the positive influence of both factors (public.pol.entrep and ext.environ.entrep) on GDP. More specifically, considering that the two factors gather the direct influences of all the six framework variables, we conclude that the general framework related to entrepreneurship has a positive effect on GDP.

Table 5. OLS regression results on economic stability.

	Dependent variable: GDP		
	Model 1	Model 2	Model 3
interest.entrep	0.023		−0.055***
	(0.014)		(0.021)
entrep.feel	−0.053**		0.008
	(0.026)		(0.002)
public.pol.entrep		0.033***	0.071***
		(0.013)	(0.017)
ext.environ.entrep		0.092***	0.141***
		(0.023)	(0.031)
constant	12.485	12.484	12.485
	(0.026)	(0.024)	(0.024)
R-squared	0.0449	0.1393	0.1806
F-test	3.32**	11.41***	7.66***

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; standard errors in parentheses.
Source: authors' computations.

The last OLS model performed is based on all the four indexes resulted from the previous stage of the analysis. This time, the statistically significant factors are interest.entrep, public.pol.entrep and ext.environ.entrep. The first index, related to the citizens' interest in entrepreneurship has a negative influence on GDP, while the factors related to the entrepreneurial framework carry a positive influence on GDP. Overall, the regression results suggest that the subjective side of entrepreneurship, reflected by the individuals' entrepreneurial attitude and behaviour may reduce the level of GDP (as there is a statistically significant indirect relationship between interest.entrep and GDP, and between entrep.feel and GDP), while the entrepreneurial framework developed by every country would have an important role in increasing economic stability (based on statistically significant direct relationships between public.pol.entrep and GDP, and between ext.environ.entrep and GDP).

Based on the indicators of goodness of fit, these models are adequate to explain only a limited part of the variation in GDP. More specifically, up to 18% of the variation in GDP may be explained through the variation in the framework of entrepreneurship, and based on behaviour, through individual capabilities, opportunities, and incipient entrepreneurial activity.

Conclusions

The analysis of the G8 countries revealed that entrepreneurial attitude and behaviour and framework have a significant impact on the economy. The fear of failure carries a negative effect on economic stability, being an obstacle for business foundation. This result is similar to Gunewardena and Seck (2020), who concluded that fear of failure is affecting the self-perception of personal skills and abilities and is also related to risk aversion, deterring engagement in entrepreneurial activities. The perceived capabilities and opportunities also have a negative effect on economic stability, indicating that although there may be good opportunities for starting a business, economic growth is affected. This aspect could be explained by the fact that the intentions to start a business or the success of an entrepreneur may be nascent, and these feature are not that common among the citizens of G8 countries. Furthermore,

the total early-stage entrepreneurial activity would be associated with a low level of GDP when considered in the index gathering the positive aspects of entrepreneurship. Therefore, for G8 countries, the economy is more stable when less of its population is either a nascent entrepreneur or owner-manager of a start-up, because these economies are strongly industrialised.

Compared to the subjective side of entrepreneurship, relevant through behaviour and attitudes, the framework has more impact on the economy in the countries analysed. Based on the most relevant components of the indexes built, the cultural and social norms are very important for economic growth, followed by infrastructure, taxes and bureaucracy, governmental programs, support, and policies. Our results prove that there is a positive impact from government policies supporting entrepreneurship or from specific laws and regulations towards economic development, as Oliyide (2012), Lerner (2014), or Mihaila (2015) evidenced in their studies. In conclusion, the entrepreneurial framework has the capabilities of generating favourable effects on GDP, especially in the industrialised countries, characterised by great market openness and social and cultural norms specific to the entrepreneurial spirit.

For study limitations we mention the missing data from GEM database, resolved by data imputation with country average values of the indicators. Other data imputation techniques may be undertaken and the database could be retested to observe the robustness of the results. Further research could consider a dummy variable for time, or subsamples based on certain periods, in which we expect a significant variation in GDP and entrepreneurial indicators. For example, results may differ if we estimate the same results from a database including only the period of the financial crisis. In addition, for a comprehensive analysis, a broader database could be obtained by extending the geographic area beside the G8 countries, with European developed economies. The sample could also be divided into European countries and the rest, as the descriptive statistics emphasised several differences in the GEM indicators of the G8 countries, especially in terms of citizens' willingness and interest in setting up a business, market openness, and social and cultural norms supporting entrepreneurship, which are more common and developed in the United States or Canada compared to the European countries.

According to the main results of our research, entrepreneurship is very important for economic development and stability, being driven by government policies, the level of development of a country, and entrepreneurial behaviour. Although the behavioural component seems to restrain the level of GDP, an educational system oriented towards entrepreneurial activities could have a positive effect on the growth of entrepreneurship in G8 countries, also inducing a sustainable growth in GDP.

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CONFERENCE PAPER

Quality of Government and Well-being: Assessing the Gap in European Countries

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Abstract: *This paper analyses the influential factors which determine the differences between social and economic dimensions in the European Union. The main objective was to construct a composite indicator of the quality of government and citizens' well-being, and rank the EU countries based on it. The dataset refers to variables specific to economic and social wellness (latest year available is 2015), focusing on both, the objective and subjective dimension of the governance and well-being. The results obtained indicate that the countries with the highest performance in terms of the quality of government and citizens' well-being are Denmark, Sweden, Finland, followed by Austria and the Netherlands. Differences to the rest of the EU member states are based on economic and social policies, as these countries have the highest employment rates and social protection expenditures, focusing on the risks related to unemployment, social exclusion, invalidity or aging to increase citizens' overall life satisfaction.*

Keywords: quality of government; well-being; composite indicators; EU

JEL Classification: E02, I31, C43

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Introduction

In terms of social and economic development, there are some differences within the European Union (EU). Several possible explanations were offered over time, ranging from macroeconomic policy conditions to the cultural exodus phenomenon within the Member States. A further explanation would be related to the quality of the government, which is not the best in many countries. In general, statistics describe the economic performance through a series of indicators related to Gross Domestic Product (GDP). Although these economic indicators are important, they do not show us a complete picture of the well-being of a society.

The objective of this paper is to identify the main factors influencing the differences between the EU countries, in terms of quality to citizens' well-being through a comparative analysis, using a composite indicator that includes the main components of the social and economic dimensions available for 2015. The paper will present part of the literature related to measuring the "quality of government", and some of the results obtained in previous studies, explaining the variations between the EU Member States.

Another important issue that needs to be addressed is the definition of the "quality of life" of EU citizens. Related to the state development, this dimension is more subjective, involving multilateral analysis. International surveys already identified the most influential factors that determine citizens in one state to form a certain degree of satisfaction related to general life conditions, including the degree of trust in public institutions.

In order to identify and effectively compare the main disparities within the EU, the case study consists in realising a composite index, using the Organisation for Economic Co-operation and Development (OECD) methodology. The purpose of this index is to include several individual variables, related to objective (economic) aspects as well as subjective (social) ones. In this way, the indicator is capable of an overall evaluation of the quality of governance and citizens' well-being in the EU member countries.

The conclusions of the paper summarise important differences in terms of economic and social development in the EU. The variance is due to a lack of government transparency and increased corruption in some countries, affecting citizens' confidence in public institutions and their general well-being. For all the EU member states to be successful in implementing policies and increasing citizens' confidence, governmental reforms should consider the Scandinavian model, as this is the most efficient in terms of both, government efficiency and quality of life.

The Concept of the Quality of Government

Although the quality of governance and citizens' satisfaction at a national and international level has already been debated in the literature, there is no standard definition for the "quality of governance". The governance concept would refer to the institutions through which a state exercises the authority. On one hand, it is about Government's ability to effectively implement the best policies. On the other hand, governance depends on the respect offered by the citizens and the state towards the institutions that regulate the economic and social interactions between them.

Rothstein and Teorell (2008) considered the relationship between high-quality government and democracy, observing whether or not the two are concurrent. Although democracy, which refers to access to state power, is absolutely necessary for measuring the quality of governance, it is insufficient as an exclusive indicator. If the two concepts would be equal, the ways through which power was exercised by the government would be left externally, while the emphasis would be more on the means through which it was obtained. Collier (2007) showed that both notions are essential as long as the international community is focused on promoting democratic means to increase the power in the state, especially in developing countries. It seems that the relationship between democracy and quality of government is a curvilinear one, indicating that democratic states may sometimes be inferior in terms of the quality of government when compared to non-democratic states. Simultaneously, for countries in which the democratic regime has been established for a long time, it is more likely for their citizens to benefit from a higher level of government quality. However, examples of post-communist regimes show that the transition is not a simple, nor a fast process.

Good governance is not necessarily linked to democracy, as some of the most advanced countries, such as Hong Kong or Singapore, significant results for good governance, but they are not democratic. Excluding such examples from the analysis realised in this paper, it can be stated that high-quality governance requires a democratic access to power and impartiality in exercising this power in a state. Therefore, the democracy should be considered as an essential element in the quality of government, but it is far from being the only condition.

Regarding the differences across EU members, states tend to receive a higher score if, first of all, they are perceived as resistant to a government changeover, without experiencing significant interruptions of the daily administrative services. Secondly, if the potential for corruption in the form of abuse of power, nepotism, parties' secret funds, or ties between political parties and business environment, is perceived as a phenomenon that is rarely encountered, countries receive better scores.

In general, political aspects and changes in the political environment are those that differentiate more developed countries. Referring to developing countries, Kaufmann et al. (2009) mentioned that despite the fact that the government corruption seems to be the real challenge for the developing world, this view can be disapproved. The

general tendency from the empirical analysis shows that, on average, European countries do not have a clear improvement in their level of governance quality over the past two decades. In fact, for many EU countries, the trend is rather negative. Either these levels are due to some measurement errors, or the countries are indeed subject to an important decline in the quality of government, which requires an increased attention from the authorities.

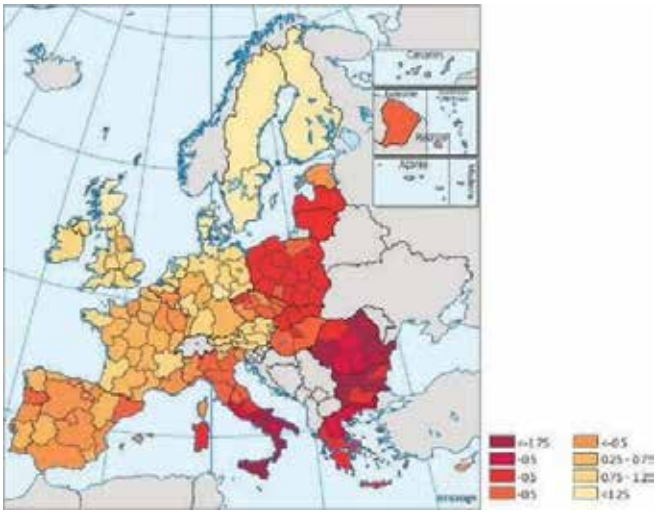
Measuring the Quality of Government and Quality of Life

According to recent data, most indicators on the quality of government show that, although the average level in the European Union is higher compared to other regions of the world, there are significant discrepancies between member countries. As measuring indicators such as bureaucracy or corruption can often be difficult, there is more debate on the best way to measure the quality of governance. Many researchers have doubts on how the indicators nowadays can present valid measures for certain governance concepts such as "corruption", "rule of law" or "bureaucratic efficiency". Therefore, any measures undertaken will not be able to capture all the government aspects. However, researchers in comparative policy and economic development agreed on the fact that the quality of government is a broad concept, and it needs to be disaggregated into several categories. Kaufmann et al. (2009) listed them into six governance dimensions: i) control of corruption; ii) government effectiveness; iii) rule of law; iv) regulatory quality; v) political stability and absence of violence and terrorism; vi) voice and accountability, expressing the democratic power of the electoral authorities. Besides the quality of government, these aspects also measure the public sector performance, and allow a meaningful comparison across the EU countries, at the national level. Based on the aspects previously listed and aggregated into one index, every country can now be described by the Worldwide Governance Indicators (WGl).

Following the study on WGI, the Quality of Government Institute of Gothenburg University from Sweden realised a report for the European Commission on the quality of governance in the EU. In this study, a new index at the EU level was developed, entitled the European Quality of Government Index (EQI). The construction of this index was realised through a database obtained from a survey involving approximately 34,000 EU citizens, is the largest study ever conducted to measure the quality of governance at national and regional level.

A brief examination of the variance in the EQI index at a regional level is illustrated in Figure 1, and it reveals fairly predictable models regarding the quality of government among the regions. All regions from the best performing EU Member States – Denmark, Sweden, the Netherlands – are in the first 15% of the total.

Figure 1: EQI at inter-regional level. Standard deviation and interval from inferior (negative) to superior (positive) quality



Source: data.worldbank.org

From the new member states, all except one are in the lower rank of 50%, registering a negative score. The northwestern side of Romania is the exception, with a score of 0.21%. Most regions of the first 15 EU countries are in top 50%, except Portugal and Greece which have all regions classified under the average. Moreover, a few regions from France and Italy are listed below the EU average, under the last 10%. The data shows variations from one region to another at the national level. Applying the error margins (95%) to the regional estimated values, we find that some countries display very similar interregional results groups, while others record differences in the quality of government within the respective regions, and these differences are statistically significant. Table 1 presents a restructuring of EU countries in terms of the variations in the regional level.

Table 1: The level of internal variations in the EU member states

High	Average	Low
Belgium	Czech Republic	Denmark
Spain	Germany	Netherlands
Italy	France	Sweden
Portugal	Greece	Poland
Romania	United Kingdom	Slovakia
Bulgaria	Hungary	Austria

Source: data.worldbank.org

From these results, several interesting conclusions can be drawn. One of them is that the number of regions in a country is not an indicator to predict inter-regional variations. For example, while Denmark and Slovakia have only four or five regions, Poland, with 16 regions, shows the same variation within the country. On the other hand, Belgium and Portugal, with only three and six regions, show relatively large discrepancies in the quality of government from one region to another. France, with the largest number of regions in the analysis, presents only moderate variation inside the country.

It was also revealed that a federal administration system or a very centralized system does not assume a reliable indication of predicting the precise level of regional variation. For example, federal countries such as Germany and Austria, present a moderate to low level of variation, while other federal / semi-federal provinces such as Italy, Belgium, and Spain have a significantly high degree. Slovakia and Netherlands are countries with a centralized administration system, showing a low variation within the country, while Romania or Bulgaria demonstrates high levels of variations, even though most of the regions within them are in the last 15% between the survey results. This demonstrates that variations in the quality of government can be closely linked to political or administrative choices (e.g. Italy, Belgium, Spain), but also to how well-distributed is the workforce. The latter also affects more centralized countries.

Lastly, the fact that the country analysed is a founding member or a new member of the EU can not predict regional variations. Results show that the highest variance is in both categories, the first 15 EU Member States, including two of the founding states, but also in two new member countries.

The "quality of life" is a broader concept than the level of economic development, including a range of factors that influence what citizens care for, beyond the material aspects. Therefore, this concept is multidimensional, comprising a set of indicators. Within this framework, indicators can be statistically measured in order to present complementary aspects of quality of life, and at the same time complement the GDP, which is the traditional indicator of economic and social development.

Eight of the factors referred to citizens' capacity to reach a certain level of well-being, according to own standards, values, and priorities. These are material living standards, employment, education, health, leisure and social interactions, economic and physical safety, governance and human rights, living environment. There is a ninth factor, the overall life satisfaction, referring to the personal perception of life quality, related to the individual life scope.

In 2013, Eurostat introduced a model regarding the subjective well-being, using statistics related to income and life conditions. This presents a set of variables with personal opinions on life in general, but several dimensions of life quality to which data on income to the conditions of life were added. These are often used in the con-

text of assessing the poverty and social exclusion. The perception of the citizens on the quality of life represents the concept of "subjective well-being", and thus, for the first time, the quality of life in the EU was assessed, respecting the quality standards for official statistics in terms of objectivity and subjectivity. This data was analysed along with other factors affecting the quality of life, such as education and health level, or financial and family situations.

This study illustrates the need to analyse more into depth the macroeconomic indicators, to monitor both, economic and social progress. Considering that an exclusive analysis of GDP would lead to different results and conclusions, this analysis will relate to additional indicators of welfare and governance.

Data and Methodology

According to the OECD methodology on developing composite indicators, the theoretical framework provides a basis for selecting and combining the variables into a significant composite indicator, useful in providing the desired information. In order to measure the quality of governance and citizens well-being, and compare it across the EU, a composite index will be computed in order to offer us a clear picture on the discrepancies between the states.

Two dimensions will be integrated into this index: the objective dimension related to the economic aspects, and the subjective dimension, related to social aspects. The economic dimension will include the following three ratios:

- Employment rate (% of GDP) - this indicator is computed by dividing the number of employees between 20 and 64 years, in relation to the total population of the same age group, and it is based on the EU Labor Force Survey. The employed population is made up of individuals who, during the reference week, realised paid activities for at least one hour, or did not work at the moment but were officially employed.
- Public Investment Ratio (% of GDP) - this indicator is defined as the gross capital formation, expressed as a percentage of GDP, to be invested in the public, private and household sectors. This report indicates the share of GDP used for the gross investment.
- Social Protection Expenditure Ratio (% of GDP) - social protection expenditures refer to social benefits, which consist of cash or in-kind transfers to individuals and households, in order to reduce or eliminate the burden of the risks and needs. This indicator also refers to the costs of public administration system and other expenses, consisting of various expenses of the social protection systems.

The social dimension comprises two indicators:

- Confidence in EU Institutions (% of the population) - is expressed as a share of positive opinions offered by those who say they tend to trust the European Union institutions (the Council of the European Union, European Parliament, and European Commission). This indicator is based on the "Eurobarometer", a survey conducted twice a year, since 1973, to observe public awareness in the Member States. Regarding the answers possible to the question regarding the level of trust ("I trust", "I do not trust" or "I do not know") and the fact that trust is not accurately defined, leaves room for personal interpretations for those interviewed.
- Quality of Life (% of the population) - is the way in which a person evaluates or appreciates life as a whole. This indicator is intended to express a broad and more reflective assessment by interviewees. It is not intended to present the emotional state of the respondents, but a reflective judgment on the level of general satisfaction of life (financial situation, housing, workplace, living environment, leisure and social life). The indicator reflects the percentage of respondents who showed a high level of life satisfaction.

All the indicators used in this analysis are from 2015, referring to every EU member state. The source of data was Eurostat, providing information on the public investment ratio, social protection expenditure ratio, employment rate, confidence in EU institutions, and quality of life.

The multivariate analysis using the Principal Component Analysis (PCA) is a statistical method that converts of a set of correlated variables into a set of linear and uncorrelated variables. The new set is known as principal components and may be consisting of less or the same number of variables. Under this transformation a set of components is obtained: the first major component has the largest variance possible, with successive components having smaller variances. PCA objective is to explain the variance in a dataset, using linear combinations between the original data. The first step is to analyze how closely related the selected indicators are, in order to realise the composite index. For this, we start by analysing the correlation coefficients between the variables. Then, we observe the principal components corresponding to the number of indicators, and select the first components that retain a significant amount of the cumulative variance in the original data.

Even though the analysis considers "n" variables (in this case there will be five), $x_1, x_2, \ldots, x_n$, a large amount of the data variation can be determined by a small number of the principal components, noted $Z_1, Z_2, \ldots, Z_n$, and computed as presented in the equations below:

$$\begin{aligned} Z_1 &= a_{11} x_1 + a_{12} x_2 + \ldots + a_{1n} x_n \\ Z_2 &= a_{21} x_1 + a_{22} x_2 + \ldots + a_{2n} x_n \\ &\ldots \ldots \ldots \\ Z_n &= a_{n1} x_1 + a_{n2} x_2 + \ldots + a_{nn} x_n \end{aligned} \quad (1)$$

The weights, a_{ij}, known as component loadings, that apply to x_j variables, are chosen so that the main components, Z_i, have fulfilled the following conditions: i) they should not be correlated; ii) the first and main component includes the maximum amount of the variation in the dataset, the second component is the inclusion of the maximum variation remained until the last of the main components absorbs the remaining variance that is not embedded by the previous components.

Results

Table 2 includes the correlations between the variables used in the analysis. We observe that the indicators show positive and negative correlations, with the highest coefficients for the direct relationships between employment rate and quality of life, and public investment ratio and confidence in EU institutions (correlation coefficients of 0.52, and 0.51 respectively). From now on, the abbreviations used for the variables will be the following: Employment Rate – Empl.; Public Investment Ratio – Publ. Invest.; Social Protection Expenditure Ratio – Soc.Prot.Exp.; Confidence in EU Institutions – Confid.; Quality of Life – QoL.

Table 2: Correlation matrix between variables

	Empl.	Publ.Invest.	Soc.Prot.Exp.	Confid.	QoL
Empl.	1	0.38	0.14	0.35	0.52
Publ.Invest.		1	-0.31	0.51	0.19
Soc.Prot.Exp.			1	-0.21	0.45
Confid.				1	0.35
QoL					1

Table 3 includes the loadings of the components for individual indicators. High and average loadings (> 0.50) indicate how individual indicators are influenced by the principal components.

Table 3: Loadings of the principal components for individual indicators

Loadings	PC(1)	PC(2)	PC(3)	PC(4)	PC(5)
Empl.	0.283	0.026	0.415	0.238	0.038
Publ.Invest.	0.222	0.162	0.065	0.548	0.003
Soc.Prot.Exp.	0.001	0.544	0.010	0.138	0.306
Confid.	0.257	0.074	0.449	0.071	0.149
QoL	0.237	0.195	0.061	0.004	0.504

In order to compute the values for the principal components, we will use the equations mentioned above. For example, the value of the first principal component, PC(1), for a country with variables x_j, would become:

$$PC(1) = 0.283\ x_1 + 0.222\ x_2 + 0.001\ x_3 + 0.257\ x_4 + 0.237\ x_5 \quad (2)$$

After computing all the values for the principal components for every EU country, the correlation matrix between them showed that all the coefficients are null. Therefore, the principal components are not correlated.

The variance in the principal components is presented in Table 4. The first principal component has a variation of 2.16 explaining the maximum variation of all individual indicators (43.1%). The second principal component explains the maximum value of the residual variance, 31%, with a variation of 1.54. The third component has a value of 0.57, and the last two main components explain the remaining 14.6% of the variance in the dataset.

Table 4: The variance of the principal components

	PC(1)	PC(2)	PC(3)	PC(4)	PC(5)
Variance of principal component (eigen value)	2.16	1.54	0.57	0.43	0.30
% of the total variance explained by the principal component	43.1%	31%	11%	9%	6%
Cumulative % of the total variance explained by PC	43.1%	74%	85.4%	93.9%	100%

In order to proceed to the following step in the analysis, we select the principal components that individually include more than 10% of the total variance, and more than 60% cumulative (PC1, PC2, and PC3). Altogether, these components explain a significant amount of 85.4% of the total variations in the dataset.

For the weighted aggregation of the individual indicators, in order to build the Composite Index for Quality of Government and Citizens' Wellbeing (CIQGCW), it is necessary to determine the correlation between each of the main components chosen in the previous step. Therefore, a higher correlation coefficient indicates a more significant contribution of the indicator to total variations. Depending on the contribution to the total variation, it will be possible to apply the weights for every variable in the composite index calculation process. Since there were three principal components selected, CIQGCW will be built on three sub-indicators. They will be calculated based on the correlation coefficients of every individual indicator with three squared sub-indicators. Moreover, due to the fact that the three principal components comprise 85.4% of the total variance, instead of 100%, the coefficients obtained will be weighted once again depending on the maximum value (85.4%), in order to obtain 100% for the sum of the final weights. This way, the weights of the individual indicators will be translated by multiplying the normalised correlation coefficients of every indicator with the weights of the total variance in the principal components. For example, the weight of the individual indicator Employment rate will be computed as:

$$W1=0.28 \times 0.51+0.03 \times 0.36+0.42 \times 0.13 \quad (3)$$

Detailed results on the correlation coefficients computed and normalised are presented in Table 5, along with their weights.

Table 5: Correlation coefficients (computed and normalised) and corresponding weights

Individual indicators	PC(1)	PC(2)	PC(3)	PC(1)	PC(2)	PC(3)	$PC(1)^2$ normalised	$PC(2)^2$ normalised	$PC(3)^2$ normalised	**Weight**
Empl.	0.78	0.20	-0.49	0.61	0.04	0.24	0.28	0.03	0.42	**0.21**
Publ.Invest.	0.69	-0.50	-0.19	0.48	0.25	0.04	0.22	0.16	0.07	**0.18**
Soc.Prot.Exp	0.05	0.92	0.08	0	0.84	0.01	0	0.54	0.01	**0.20**
Confid.	0.74	-0.34	0.51	0.55	0.11	0.26	0.26	0.07	0.45	**0.22**
QoL	0.71	0.55	0.19	0.51	0.30	0.03	0.24	0.19	0.06	**0.20**
Variance in principal component	2.16	1.54	0.57							
Weight in total variance	0.51	0.36	0.13							

In order to obtain the final composite index (CIQGCW), the additive aggregation linear method will be used. The index for a country "c" will be computed based on the following formula:

$$CIQGCW = \sum_1^n w_n \, I_{nc} \quad (4)$$

where w_n is the weight of the individual indicator, and I_{nc} represents the value of the indicator in country "c". Based on the results in table 5, we replace the values in the last formula and obtain:

$$CIQGCW_c = 0.21 \times Empl + 0.18 \times Publ.Invest. + 0.20 \times Soc.Prot.Exp. + 0.22 \times Confid. + 0.20 \times QoL \quad (5)$$

The final composite indicators computed for every country in the EU can be observed in Table 6. In order to simplify the further analysis, we grouped the countries in three categories:

- Leaders (CIQGCW ≥ 40) – countries with high degree of development, and a level of quality of government and citizens' well-being above the EU average.
- Potential leaders (CIQGCW between 35 and 39) – countries with a level of quality of government and citizens' well-being around the EU average.
- Dynamic implementers (CIQGCW ≤ 34) – countries that have a level of quality of government and citizens' well-being below the European average.

Table 6: The composite index for Quality of Government and Citizens' Well-being for EU Member States (descending order)

	Country	Empl.	Publ.Invest.	Soc.Prot.Exp.	Confid.	QoL	CIQGCW
LEADERS	**1. Denmark**	76.5	19.23	32.9	59	42.7	**47**
	2. Sweden	80.5	23.65	29.6	*56*	35.1	**46**
	3. Finland	72.9	20.46	31.9	59	38.6	**46**
	4. Austria	74.3	22.61	30	52	37.9	**44**
	5. Netherlands	76.4	19.43	30.9	53	26.1	**42**
	6. Luxembourg	70.9	18.98	22.7	58	25.7	**40**
	7. Germany	78	19.91	29.1	43	25	**40**
POTENTIAL LEADERS	**8. Malta**	67 8	25.38	18.2	*58*	22.5	**39**
	9. Belgium	67.2	22.99	30.3	50	20.9	**39**
	10 Poland	67.8	20.07	19.1	52	29.4	**39**
	11. Lithuania	73.3	19 27	14.7	61	18.8	**39**
	12. Romania	66	24.76	14.8	60	19.7	**38**
	13. Slovakia	67.7	23.01	18.5	50	25	**38**
	14. Ireland	68.7	21.2	20.6	43	30.6	**38**
	15. Czech Republic	748	26.31	19.7	41	21.3	**37**
	16. France	69.5	21.51	34.3	38	16.1	**37**
	17. Estonia	76.5	23.65	15.I	49	13.5	**36**
	18. United Kingdom	76.8	16.93	27.4	27	27.8	**36**
	19. Hungary	68.9	21.67	19.9	52	11.3	**36**
	20. Slovenia	69.1	19.51	24.1	41	20.4	**36**
	21. Latvia	72.5	22.58	14.5	48	12.6	**35**
	22. Portugal	69.1	15.27	26.9	44	13.8	**35**
DYNAMIC IMPLEM.	**23. Bulgaria**	67.1	21.01	18.5	52	*5.9*	**34**
	24. Croatia	606	1949	21.6	45	15	**33**
	25. Italy	60.5	16.81	29.9	39	14.2	**33**
	26. Spain	62	19.72	25.4	28	18.4	**31**
	27. Cyprus	67.9	13.31	23	32	14.2	**31**
	28. Greece	54.9	11.55	26	32	12.8	**28**

These final results indicate that in the Leaders group we have the Scandinavian countries (Denmark, with the highest composite index, followed by Sweden and Finland), together with Austria, the Netherlands, Luxembourg, and Germany. In the Potential Leaders group, we find developed countries such as Belgium or France, as well as emerging ones. Romania is on the 12th place, with an index of 38, equal with the average at EU level. Dynamic implementers include Bulgaria, Croatia, Italy, Spain, Cyprus, and Greece - with the lowest indicator of 28.

Generally, there should be a direct relationship between employment rate and quality of life, as the population that is part of the labor force market, or is on the improvement stage in terms of education, tends to be more satisfied with the government policies and the EU institutions. This explains why Denmark, Sweden or

Finland show such high composite index values, as these countries have the highest employment rates in the EU. On the contrary, Greece, with the lowest level of employment rate, shows a low level of quality of life, confidence in government or the EU institutions, which induced the weakest position in the EU ranking.

Another important indicator is the rate of social protection expenditure, reflecting the level of importance granted by every country to this sector. In countries such as Denmark, Finland or Netherlands, this represents more than 30% of GDP, showing that these countries are investing significant resources in government policy programs in order to reduce poverty and citizens' vulnerability. These policies are implemented through the promotion of efficient labor markets, by reducing the exposure of the population to risks and increasing their capacity to manage social and economic risks, such as unemployment, social exclusion, aging, illness or disability. By adopting such measures, the countries increase the level of confidence of civil society in government institutions, as observed in the process of developing the CI-QGCW composite index.

Conclusions

This paper offers an overview of the issues and gaps in terms of the quality of government and citizens' well-being in the European Union. After measuring and comparing the quality and well-being indicators, we can state the fact that, there are a series of indicators that prevail in quantifying and estimating their dimensions. Among them, there is the level of corruption, public administration efficiency, the level of budget allocations in different sectors, the level of citizens' confidence in the public authorities, etc.

An in-depth analysis is needed in order to define the measurement of the quality of life or its satisfaction, because there is a strong subjective side of the indicator, based on which individuals quantify life satisfaction differently, depending on the social or cultural aspects of every country. The index computed in this paper includes several aspects defined by sociologists (life conditions, health, education, environment, etc.), and they do have a strong impact on the quality of government. Aspects such as the rate of investment in the education system or social protection outline a bi-directional relationship between the economic and social dimension of the well-being. Although the general satisfaction of life depends on several socio-demographic factors (age, income or education) the perception of the quality of life differs as long as citizens have different expectations as individuals.

In order to compare the EU countries using an analytical approach to the issues previously mentioned, we built a composite index of the quality of government and citizens well-being, computed based on data from 2015. Based on this index, we

identified "leaders", "potential leaders", and "dynamic implementers" between the European countries. Scandinavian countries, headed by Denmark, register the highest scores. This performance could be explained by the fact that their government is subject to systematic control from citizens (information on public authorities activities is available to all citizens). In addition, the reduced level of corruption determines citizens to have confidence in government, paying higher taxes than anywhere else in EU. Scandinavian countries also registered the highest level of public investments and large social protection expenditures in 2015.

The employment rate was also important in the index development, varying from 80.5% in Sweden to 54.9% in Greece. This major difference explains the issues on integrating EU citizens into the labor market. Greece, Spain, and Croatia, with low employment rates, also indicate a low confidence on public institutions and government. This is strongly affecting life satisfaction, as these countries have the least citizens to evaluate their quality of life with "high".

From this paper, we can conclude that there are important differences in terms of economic and social development in the EU. The variance is due to economic shocks, or to government transparency and corruption. All these are affecting citizens happiness and their confidence in public institutions. Therefore, a big problem in many countries may be the failure of political parties and the lack of credible institutions.

For the EU to have success in promoting and implementing policies across member states, in order to gain the citizens confidence, governmental reforms are needed, in order to ensure the public institutions transparency and limit the corruption. As the Scandinavian model is the most efficient, countries can implement similar policies in order to return to a sustainable growth path.

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