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The process of sustainable entrepreneurship: a multi-country analysis

Sara Proença[1] · Elias Soukiazis[2]

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Abstract

Sustainable entrepreneurship links entrepreneurial activities to the achievement of sustainable development in its three dimensions: economic prosperity, social equity, and environmental protection. This paper aims to explain the process of sustainable entrepreneurship, by providing empirical evidence on the interconnections between entrepreneurial activity, economic development measured by the human development index, and greenhouse gas emissions as a proxy for environmental quality. The interrelationship between these core variables is described by a cyclical process with feedback effects that makes the system self-sustaining. A simultaneous equation system is estimated based on the *3sls* approach that takes into control the endogeneity of regressors and the error correlation across equations. The empirical findings support the cyclical process involving entrepreneurial activity, human development level, and environmental quality. From a policy perspective, results highlight the central role of entrepreneurship as a driving force for change and sustainable development. Decision makers should engage in supporting innovative and sustainable entrepreneurial activities, but also reducing the barriers in the macroeconomic environment and improving human capital skills, including entrepreneurial competencies.

Keywords Sustainable entrepreneurship · Human development index · Environmental quality · Simultaneous equation system · Panel data

JEL Classification C33 · O11 · Q01 · Q56

✉ Sara Proença
sproenca@esac.pt

Elias Soukiazis
elias@fe.uc.pt

1 Polytechnic Institute of Coimbra/ESAC, CERNAS, Bencanta, 3045-601, Coimbra, Portugal

2 Faculty of Economics, CeBER, University of Coimbra, Av. Dias da Silva 165, 3004-512 Coimbra, Portugal

1 Introduction

In 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development, with 17 Sustainable Development Goals (SDGs), as an action plan for people, planet, and prosperity (UN, 2015). Entrepreneurship plays an important role in this agenda, contributing to sustainable development through different channels: it is the driver of economic growth fostering job creation and innovation; reduces social inequalities by offering new opportunities to all; introduces new technologies to mitigate climate changes; establishes environmentally sustainable practices and environmentally friendlier consumption patterns (UN, 2017).

In this context, over recent years the topic of the relationship between entrepreneurship and sustainable development has attracted the interest of many researchers in various areas. As a result, a new concept and field of research has emerged—the so-called sustainable entrepreneurship (SE), which links entrepreneurial activities to the achievement of the sustainable development goals. There are several definitions of SE in the literature (Terán-Yépez et al., 2020), which are generally based on two key research perspectives: (1) On the one hand, there are authors arguing that entrepreneurial activities must be committed to the triple-bottom-line (TBL) principles, i.e., environmental dimension, referring to long-term environmental protection; social dimension, focusing on the preservation and development of communities in which organizations operate; and economic dimension, which is concerned with the economic and financial performance of the organizations (Filser, et al., 2019; Sarango-Lalangui, et al., 2018). (2) On the other hand, there are authors who define SE as being the combination of the TBL principles and entrepreneurship, stressing the importance of the relationship that must exist between entrepreneurs and opportunities, and arguing that entrepreneurs are absolutely aware of the impact of their activities on the environment (Belz & Binder, 2017; Sarango-Lalangui, et al., 2018). This SE perspective postulates that sustainable development is the most important source of long-term business opportunities and therefore is the basis for creating sustainable business models.

Despite the increasing number of studies on SE over the last decade, there is still a lack of theoretical framework and empirical evidence that could bring more clarity to this issue (Kraus et al., 2018; Muñoz & Cohen, 2017; Terán-Yépez et al., 2020). In particular, the literature shows that although considerable research has been devoted to the study of the impact of entrepreneurship on economic growth (generally measured by the gross domestic product), very few studies have looked into its impact on economic development (Acs et al., 2012; Ferreira et al., 2016; Prieger et al., 2016). On the other hand, few papers analyze the impact of entrepreneurship on the environment (Neumann, 2020). Moreover, to the best of our knowledge, empirical studies exploring the interconnections between entrepreneurship, economic development, and environmental quality, and how this process operates, have not been employed in the literature yet. The present paper aims to fill this gap in the literature, by providing empirical evidence on the interconnections between entrepreneurial activity, economic development (measured by the human development index (HDI)), and greenhouse gas emissions (as a proxy for environmental quality) for a panel of 37 OECD (Organization for Economic Co-operation and Development) countries over the period 2000–2018. This study also explores the feedback effects between these core variables through an integrated empirical framework capable of explaining the underlying mechanisms. A simultaneous equation system is estimated by the three-stage least squares (*3sls*) approach that takes into consideration the endogeneity of regressors and the error correlation across equations. The remainder of this paper is structured as follows: Sect. 2

provides a brief literature review on the topic under study. The methodology and data used to carry out the empirical analysis are described in Sect. 3. Section 4 presents and discusses the results. Conclusions and policy recommendations are given in Sect. 5.

2 Literature background

Many studies in the literature have researched the relationship between entrepreneurship and economic growth, but very few have focused on the correlation between entrepreneurship, economic development, and environmental welfare. More importantly, there are no studies that have examined the interconnections between these three dimensions (Neumann, 2020).

A recent study by Stoica et al. (2020) examines the impact of three types of entrepreneurship on economic growth, using a panel data of 22 European countries over the 2002–2018 period. Early-stage, opportunity-driven and necessity-driven entrepreneurship are considered as the main categories of entrepreneurial activities to test their potential effect on economic growth, and whether their contribution differs according to the stage of the country's economic development. The authors provide evidence that all kinds of entrepreneurship positively affect economic growth for the whole group of European countries and that the opportunity-driven entrepreneurship is more pertinent for explaining economic growth in transition countries, while the necessity-driven entrepreneurship has a stronger influence on innovation-driven countries. In the same line of research, Urbano and Aparicio (2016) used the total entrepreneurial activity (TEA), opportunity TEA, and necessity TEA as three different types of entrepreneurship to test their impact on economic growth in 43 countries in the period from 2002 to 2012. The authors found that all kinds of entrepreneurship activities positively affect economic growth in all countries of the sample, but the positive effect of overall TEA is higher in OECD than in non-OECD countries. Hessels and Stel (2011), on the other hand, argue that export-oriented entrepreneurship contributes significantly to promoting economic growth, while Acs et al. (2012) claim that knowledge-based entrepreneurship is more important for growth promotion. Galindo and Méndez (2014), in turn, examine the feedback effects between entrepreneurship, innovation and economic growth identified through a virtuous cycle, where the three factors have positive effects on each other. Bosma et al. (2018) point out that productive entrepreneurship contributes to economic growth and that institutional quality, financial stability, small government, and perceived start-up skills are the most important predictors of such productive entrepreneurship.

Of particular interest to our research are the studies that tested whether the effect of entrepreneurship on economic performance depends on the stage of economic development. Stel et al. (2005), considering a sample of 36 countries from 1999 to 2003, found that the entrepreneurial activity rate has a negative effect on the poorer countries and positively affects the rich countries and that this is related to lower human capital skills of entrepreneurs in poorer countries. Similar conclusions are derived from the work carried out by Valliere and Peterson (2009), showing that entrepreneurship has a positive and significant impact on economic growth in developed countries, but not in emerging countries. Increasing survival or self-employed entrepreneurship is found to have counter-productive effects on economic performance in less developed countries, in a study conducted by Vivarelli (2013). Doran et al. (2018), in turn, showed that entrepreneurial activity has a positive effect on GDP per capita in high-income countries in contrast to the middle-/low-income countries, where the impact is negative. Ivanović-Djukić et al. (2018) also found that the impact of entrepreneurship on economic growth varies depending on the stage of economic development of a country. Using data for 21 European countries, the authors demonstrate that the positive impact of entrepreneurial activity on economic growth is higher in developed European countries than in developing countries. Additionally, the authors show that the greatest effect on economic growth is high-growth expectation entrepreneurship, followed by opportunity entrepreneurship, while the smallest impact was made by necessity-driven entrepreneurship. Almodóvar-González et al. (2020) analyzed 74 economies in a period of 6 years, suggesting that entrepreneurial activity plays a different role depending on the economic stage of the country in question. At a regional level, Audretsch and Keilback (2004), using data for Germany, found evidence supporting the positive link between different forms of entrepreneurship (total start-ups, high-tech start-ups, start-ups in information and communication sectors) and economic performance. The authors highlight that public policies seeking to promote entrepreneurship have a positive effect on regional growth.

Another strand of literature points out that the relationship between entrepreneurship and economic performance follows a nonlinear pattern. Ragoubi and Sana (2018), for example, using data for 33 high-income countries and 39 middle- and low-income countries over the period from 2004 to 2014, suggest an inverted U-shaped relationship between per capita income and new enterprise creation, meaning that entrepreneurship starts to increase with economic development, but from a certain threshold it subsequently decreases in advanced stages of development. Brás and Soukiazis (2018) also found evidence of a nonlinear concave relationship between TEA and per capita income, examining 26 developed countries over the period from 2004 to 2011. Instead, a cubic relationship between entrepreneurship and the country's development level is found by Acs and Szerb (2010), while other authors provide evidence of a U-shaped pattern (Stel and Carree, 2004; Carree & Thurik, 2008; Wennekers et al., 2005). It is thus evident that there is no consensus on the causal relation between entrepreneurship and economic development, which calls the need for further research.

Concerning the relationship between entrepreneurship and environmental quality, Shepherd and Patzelt (2011) argue that entrepreneurial activity can be linked to processes able to reduce atmospheric pollution, preserve the ecosystem, and improve services and agricultural practices. Youssef et al. (2018) found that promoting opportunity-driven entrepreneurship is a plausible solution to fight against environmental degradation and the consequences of climate change, while Silvestre (2015) points out that innovation-driven entrepreneurship transforms the economy, creates jobs, and increases sustainability. In the same vein, York and Venkataraman (2010) claimed that entrepreneurs can contribute to solving environmental problems through supporting institutions for achieving their goals and by creating new, more environmentally sustainable products and services. He et al. (2020) also found that opportunity-based entrepreneurship has a positive relationship with environmental quality of sustainable development. The statement that entrepreneurship should be viewed as the solution and not the cause of environmental degradation has been supported by other authors, like Terán-Yépez et al. (2020), Hall et al. (2010) and Dean and McMullen (2007), as well as by international institutions, such as the European Commission that in its strategic document "Europe 2020" points out entrepreneurship, innovation and sustainable development as key factors to ensure the future development of the whole society (EC, 2010).

The present study is grounded on the exiting literature, by analyzing the interconnections between entrepreneurship and the three dimensions of sustainable development (economic, social, and environmental), building an integrated empirical model that examines the feedback effects in these causal relationships. As shown in the review above, this three-dimension systematic analysis has not been modeled in the literature and our approach aims to fill in this gap. Furthermore, contrary to the previous research that focused on economic growth measured mainly by GDP, this study adopts the human development index (HDI) as a more accurate and broader indicator to measure the level of a country's socioeconomic development. We also innovate by employing a simultaneous equation system, which explicitly considers the three-dimension causalities between the entrepreneurial activity, the HDI, and the environmental quality. This research also contributes to the literature by testing two hypotheses: (1) the entrepreneurial process is consistent with the partial adjustment mechanism; (2) the relationship between entrepreneurship and the level of human development follows a nonlinear pattern, described by an inverted U-shaped behavior.

3 Methodology and data

The structural model comprises a three-way causal relationship between the three endogenous variables of the system, namely entrepreneurial activity (TEA), human development level (HDI), and environmental quality (GHGpc). The specification of the simultaneous equation system is as follows:

$$\mathrm{TEA}_{it} = \beta_i + \beta_1 \mathrm{TEA}_{it-1} + \beta_2 \mathrm{HDI}_{it} + \beta_3 \mathrm{HDI}_{it}^2 + \beta_4 \mathrm{GHGpc}_{it} + \beta_5 A_{it} + \varepsilon_{it} \tag{1}$$

$$\mathrm{HDI}_{it} = a_i + a_1 \mathrm{TEA}_{it} + a_2 \mathrm{GHGpc}_{it} + a_3 B_{it} + u_{it} \tag{2}$$

$$\mathrm{GHGpc}_{it} = \gamma_i + \gamma_1 \mathrm{HDI}_{it} + \gamma_3 C_{it} + w_{it} \tag{3}$$

Equation (1) is the entrepreneurship equation, where TEA denotes the total entrepreneurial activity measured by the proportion of the population between 18 and 64 years, who are either nascent entrepreneurs or owners–managers of a new business, using data from the global entrepreneurship monitor (GEM); HDI is the human development index taken from the United Nations, which is a composite measure of average achievement in key dimensions of human development, such as life expectancy, education level, and income; GHGpc denotes the greenhouse gas emissions per capita used as a proxy for measuring environmental quality; and A is a vector of other covariates that are assumed to potentially affect TEA, such as entrepreneurial education (i.e., the extent to which training in creating or managing SMEs is incorporated in the education and training system, according to GEM data), governmental policies (i.e., the extent to which public policies support entrepreneurship, according to GEM data), and the size of the population. The squared value of HDI is included in this equation to test the hypothesis that the level of human development influences the entrepreneurial activity rate in a nonlinear form.

Equation (2) is for human development, where HDI is the human development index, TEA is total entrepreneurial activity, GHGpc is greenhouse gas emissions per capita, and B is a vector of some other explanatory variables, such as human capital, gross fixed capital formation and the renewable energy in total final energy consumption.

Equation (3) is the environmental equation (GHGpc), which incorporates the effect of the development level captured by the human development index (HDI), as well as some other explanatory factors included in vector C, such as total final energy consumption, renewable energy consumption, and human capital.

Additionally, all equations include a country-effect component (β_i, a_i,γ_i) capturing differences between countries, which are invariant in time, such as country dimension, natural resources, institutions, language, religion, among others. The terms ε_{it}, u_{it},w_{it} are the idiosyncratic error terms with the usual stationary properties.

The core variables TEA, HDI and GHGpc are endogenous in the system originating feedback effects on each other. For this reason, the three equations are estimated simultaneously by the *3sls* approach to control for the endogeneity of regressors and capture the cross-equation error interdependence. This approach displays efficient and consistent estimates and belongs to the full information regression category.[1]

We introduce dynamics in the TEA equation by including its lagged value in the estimation approach. This specification allows for verifying whether past values are important for explaining current behavior of the entrepreneurial activity in the system. The dynamic specification of the TEA equation is consistent with the partial adjustment model,[2] which allows for distinguishing the short- and long-term effects of the explanatory variables and the speed of adjustment of the actual variation in TEA to its desired level.

The whole idea of the system described above is that a cyclical process is at work with expanding trends and reciprocal effects between entrepreneurship (TEA), the human development level (HDI), and environmental quality (GHGpc) that turn the process self-sustaining, as illustrated in Fig. 1. Pressure on the environmental quality is expected to generate new market opportunities associated with green business activities and circular business models, thus promoting sustainable development. In turn, higher levels of development are necessary for fostering economic activity through sustainable entrepreneurship and, consequently, for preventing environmental degradation.

We conduct the empirical analysis using an unbalanced panel of 37 OECD countries over the 2000–2018 period. Table 1 provides a summary of the definition, data source and descriptive statistics of all variables included in the model. The data of the three core variables of the model reveal that TEA, with 471 observations, records an average value of 8.5%, ranging between a minimum of 1.5% in Japan and a maximum of 27.4% in Colombia; HDI values range between 65.5 in Turkey and Colombia and 95.4 in Norway, with a mean value of 86.3, and a total of 703 observations; the GHGpc values range between a minimum of 2.7 tons per capita in Colombia and a maximum of 28.0 tons per capita in Luxembourg, with an average value of 11.4 tons per capita, and a total of 656 observations. The statistics of the remaining variables have a similar interpretation, and they are self-explanatory.

[1] The *3sls* approach estimates the three equations jointly in a unique model. The dependent variable is a vector constituted by three blocks, each one containing the data of the TEA, HDI, and GHGpc, respectively. The vectors of the explanatory variables are formed analogously. Specifically, this approach involves the following three steps: the first step estimates the reduced form of the system, regressing the endogenous variables in relation to all exogenous variables, and the fitted values of the endogenous variables are retained; the second step estimates the structural form of the system using the fitted values of the endogenous regressors found in the first step, and the residuals of the three equations are retained; the third step applies the generalized least squares (GLS) estimator to the joint form of the system using the residuals found in the second step to define the variance–covariance matrix of the error terms.

[2] For details on this approach, see Greene (2000), chapter 17 and Pindyck and Rubinfeld (1991), chapter 9.

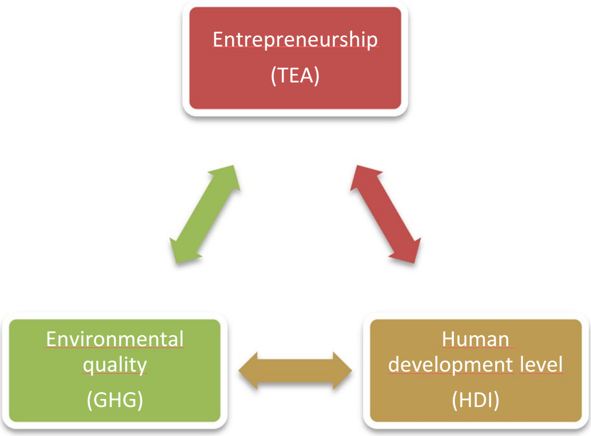

Fig. 1 Cyclical process between entrepreneurship (TEA), human development level (HDI), and environmental quality (GHGpc)

4 Results and discussion

This section introduces and discusses the main findings of this research. Table 2 reports the estimation results of the simultaneous equations system composed of the entrepreneurial activity (TEA), the human development level (HDI), and environmental quality (GHGpc), as endogenous variables. The variables that are not expressed as a percentage or index have been converted into logarithms for a better fit and easier interpretation of the estimates (elasticities and semi-elasticities). The optimal choice of the regression results, among different specifications is decided according to the assessment of the individual and global statistical significance of the coefficients.

Globally speaking, the goodness of fit is quite high, showing a satisfactory degree of explanation of the covariates, which account for about 85% in the TEA equation, 97% in the HDI equation, and 99% in the GHGpc equation. This high degree of explanation reduces substantially the potential bias in the estimated coefficients, due to omission of relevant explanatory variables. Furthermore, the high values of the F-statistics (and p-values close to zero) ensure the joint significance of coefficients in all equations at the highest level of statistical significance (p-value < 1%), as shown in Table 2.

Regarding the TEA equation, results show that its lagged value is statistically significant at the highest level of 1%, confirming therefore the formulated hypothesis that past values of entrepreneurial activity are significant for explaining its current values, and indicates that the entrepreneurial process is consistent with the partial adjustment mechanism. This mechanism assumes the following hypothesis:

$$\left(\mathrm{TEA}_{it} - \mathrm{TEA}_{it-1}\right) = \delta\left(\mathrm{TEA}_{it}^{*} - \mathrm{TEA}_{it-1}\right) \quad \text{with} \quad 0 < \delta < 1 \tag{4}$$

where $\mathrm{TEA}_{it}{}^{*}$ is the long-run equilibrium level of entrepreneurial activity (or its desired level), and δ the partial adjustment coefficient. This relation shows that the actual variation of TEA is a fraction of its desired variation, and the closer δ is to 1 the higher the speed of adjustment, the closer δ is to 0 the lower the speed of adjustment. In this specific case, the long-run relationship of $\mathrm{TEA}_{it}{}^{*}$ is given by the following equation:

Table 1 Variables, sources, and descriptive statistics

Variables	Definition	Source	Obs	Mean	SD	Min	Max
TEA	Total Entrepreneurial Activity (%). Percentage of the population between 18 and 64 years who are either nascent entrepreneurs or owner-managers of a new business	Global Entrepreneurship Monitor (GEM) http://www.gemconsortium.org/data	471	8.4631	4.6635	1.48	27.35
HDI	Human Development Index (0–100). A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge, and a decent standard of living	United Nations (UN) http://hdr.undp.org/en/data	703	86.2987	5.7805	65.5	95.4
GHGpc	Greenhouse Gas Emissions per capita (Tonnes of CO2 equivalent)	OECD Data https://data.oecd.org	656	11.3623	5.3361	2.6608	28.0011
EE	Entrepreneurial Education (scores 1–5). The extent to which training in creating or managing SMEs is incorporated in the education and training system	GEM	429	2.4690	0.2966	1.69	3.56
INS	Governmental Policies (scores 1–5). The extent to which public policies support entrepreneurship	GEM	450	2.7993	0.4305	1.72	3.75
POP	Population (persons)	OECD Data	703	3.45e + 07	5.53e + 07	281,200	3.27e + 08
HK	Human Capital. Mean years of schooling	UN	703	11.2266	1.7166	5.5	14.1
Kpc	Gross Fixed Capital Formation per capita (million US dollars)	OECD Data	703	0.0075	0.0035	0.0009	0.0257
RENpc	Renewable energy consumption per capita (kilo-tonnes of oil equivalent)	IEA Data https://www.iea.org/	684	0.00022	0.00018	9.45e-06	0.0011
TECpc	Total Final Energy Consumption per capita (kilo-tonnes of oil equivalent)	IEA Data	684	0.0029	0.0016	0.0008	0.0092

Table 2 *3sls* regression results of the joint estimation of TEA, HDI, and GHGpc equations

Independent variables	Equation (1) Dependent variable: TEA_{it}	Equation (2) Dependent variable: HDI_{it}	Equation (3) Dependent variable: $lnGHGpc_{it}$
TEA_{it-1}	0.4435 (0.0445) [0.000]***		
HDI_{it}	7.8660 (3.6202) [0.030]**		-0.0082 (0.0029) [0.004]***
HDI^2_{it}	-0.0414 (0.0212) [0.051]*		
$lnGHGpc_{it}$	3.2962 (2.0332) [0.105]*	-4.3866 (0.6707) [0.000]***	
EE_{it}	0.8689 (0.5234) [0.097]*		
INS_{it}	-0.3942 (0.5029) [0.433]		
$lnPOP_{it}$	7.2977 (3.1247) [0.020]**		
TEA_{it}		0.2375 (0.0340) [0.000]***	
HK_{it-1}		0.9560 (0.1150) [0.000]***	-0.0248 (0.0078) [0.002]***
$lnKpc_{it}$		1.5879 (0.2755) [0.000]***	
$lnRENpc_{it}$		0.6572 (0.2055) [0.001]***	-0.0679(0.0115) [0.000]***
$lnTECpc_{it}$			1.0123 (0.0411) [0.000]***
Constant	-498.0534 (187.2211) [0.008]***	71.6357 (3.7566) [0.000]***	2.0325 (0.3146) [0.000]***
Observations	318	318	318
R-squared	0.8530	0.9705	0.9897
RMSE	1.6726	0.8041	0.0449
F-stat	53.57 [0.000]***	283.23 [0.000]***	841.59 [0.000]***
Speed of adjustment (δ)	0.5565	–	–
Turning point	95	–	–

Endogenous variables: TEA, HDI, GHGpc

Exogenous variables: TEA_{it-1}, HDI^2, INS, lnPOP, HK_{it-1}, lnKpc, D1, …, D36, lnRENpc, lnTECpc

Standard errors are reported in brackets and p-values are reported in square brackets

***, **, *Denote statistical significance of coefficients at 1%, 5%, and 10% levels, respectively

The coefficients of the dummy variables (D1 to D36) capturing the country-specific effects are not reported due to space limitations

$$\mathrm{TEA}_{it}^{*} = \beta_i + \beta_1 \mathrm{HDI}_{it} + \beta_2 \mathrm{HDI}_{it}^2 + \beta_3 \ln \mathrm{GHGpc}_{it} + \beta_4 \mathrm{EE}_{it} + \beta_5 \mathrm{INS}_{it} + \beta_6 \ln \mathrm{POP}_{it} + \varepsilon_{it} \tag{5}$$

By substituting Eq. (5) in Eq. (4) and rearranging the terms, we define the short-run model as:

$$\begin{aligned}\mathrm{TEA}_{it} = \delta\beta_i + \delta\beta_1 \mathrm{HDI}_{it} + \delta\beta_2 \mathrm{HDI}_{it}^2 + \delta\beta_3 \ln \mathrm{GHGpc}_{it} + \delta\beta_4 \mathrm{EE}_{it} \\ + \delta\beta_5 \mathrm{INS}_{it} + \delta\beta_6 \ln \mathrm{POP}_{it} + (1-\delta)\mathrm{TEA}_{it-1} + \delta\varepsilon_{it}\end{aligned} \tag{6}$$

In the long run, it is assumed that $\delta=0$ and by replacing this in Eq. (4) we define the steady-state condition that $\mathrm{TEA}_{it}=\mathrm{TEA}_{it-1}$. By replacing this equality in Eq. (6) and rearranging the terms, we define the long-run model of entrepreneurial activity, provided as:

$$\begin{aligned}\mathrm{TEA}_{it} = & \frac{\delta\beta_0}{1-(1-\delta)} + \frac{\delta\beta_1}{1-(1-\delta)}\mathrm{HDI}_{it} + \frac{\delta\beta_2}{1-(1-\delta)}\mathrm{HDI}_{it}^2 + \frac{\delta\beta_3}{1-(1-\delta)}\ln \mathrm{GHGpc}_{it} \\ & + \frac{\delta\beta_4}{1-(1-\delta)}\mathrm{EE}_{it} + \frac{\delta\beta_5}{1-(1-\delta)}\mathrm{INS}_{it} + \frac{\delta\beta_6}{1-(1-\delta)}\ln \mathrm{POP}_{it} + \frac{\delta}{1-(1-\delta)}\varepsilon_{it}\end{aligned} \tag{7}$$

As Eq. (7) demonstrates, the long-run effects of the covariates are given by dividing the short-run effects of Eq. (6) by the partial adjustment coefficient δ.

The estimation results of the short-run model Eq. (6) are shown in the first column of Table 2. According to these findings, the adjustment coefficient δ is around 0.56 showing that only 56% of the actual variation in entrepreneurial activity is adjusted to its desired level in the same period, which reflects a modest speed of adjustment.

Another interesting result is the evidence of an inverted U-shaped nonlinear relationship between entrepreneurial activity and the human development level, since the impact of HDI on TEA is positive and the impact of HDI^2 is negative, and both are statistically significant at the 5% and 10% level, respectively. This finding implies that the HDI enhances TEA only up to a certain level. Beyond that level, further human development tends to affect entrepreneurial activity adversely. This outcome is consistent with the idea of entrepreneurship driven by opportunity and associated with innovation and with more growth-oriented businesses, which is in line with previous research conducted by Ragoubi and Sana (2018) and Brás and Soukiazis (2018). It should be noted that our sample only comprises medium- and high-income countries associated with a high accumulated stock of entrepreneurial human capital and business activities. Specifically, in the short run, it is estimated that a one percentage point increase in HDI is associated with a 7.78 percentage point increase in entrepreneurial activity,[3] everything else remained constant. The long-run effect, which is given by dividing the short-run effect by the partial adjustment coefficient, indicates a 13.98 percentage point increase in TEA given a unit change in HDI. The turning point of the inverted U-shaped curve is around 95 (on a scale of 0 to 100),[4] which means that beyond this stage of development entrepreneurial activity declines. Checking the data, we found that only Norway has reached such a threshold of human development level.

Other covariates with statistically significant impact on entrepreneurial activity are greenhouse gas emissions (GHGpc), as a proxy of environmental quality, entrepreneurial

[3] This result is obtained as follows: $\frac{\partial \mathrm{TEA}_{it}}{\partial \mathrm{HDI}_{it}} = 7.8660 - 2 \times 0.0414\mathrm{HDI}_{it} = 7.7832$.

[4] Setting the first derivative equal to zero and solving for HDI_{it}, we have: $\mathrm{HDI}_{it}=7.8660/(2 \times 0.0414)=95$.

education (EE) and population (POP). Results show that there is a positive relationship between GHGpc and TEA, revealing that higher environmental degradation encourages entrepreneurs to search for environmentally friendlier solutions and develop sustainable business models, as advocated by other authors (Belz & Binder, 2017; Harini & Meenakshi, 2012; Sarango-Lalangui, et al., 2018). In the short run, a 0.03 percentage point increase in TEA is expected when GHGpc increases by one percent, while the long-run effect is even higher and approximately equal to 0.06, everything else is constant. The variable entrepreneurial education (EE), measured in the extent to which training in creating or managing SMEs is incorporated in the education and training system, has a positive impact on total entrepreneurial activity, as expected. Results suggest that, in the short run, one-point increase in EE is associated with 0.87 percentage point increase in TEA, while the long-run impact is even higher, accounting for 1.56 percentage point increase, everything else being constant. The positive impact of entrepreneurial education on TEA has also been found by Ndofirepi (2020) and Hernández-Sánchez et al. (2019). Concerning population, used as a proxy for labor force, results reveal a positive effect on TEA. Finally, we found that governmental policies to support entrepreneurship (through the scale variable INS) do not have a statistically significant effect on entrepreneurial activity, suggesting that more efforts should be made at the political level to boost entrepreneurship (Castaño, et al., 2016; Minniti, 2008).

The second equation of the system represents the country's development level, as measured by the human development index (HDI), which is a composite indicator of income, health, and education. The regression results reported in Table 2 show that HDI is positively related to entrepreneurial activity and that this effect is statistically significant at the highest 1% level. More explicitly, a one percentage point increase in TEA is responsible for 0.24 percentage point increase in the HDI. This empirical result supports our proposition that entrepreneurship has a significant positive impact on country's level of development. This evidence is in line with previous studies in the literature, showing that the creation of new companies, self-employment, and business ownership, as measures of entrepreneurship, have a positive effect on economic performance (Audretsch et al., 2015; Carree & Thurik, 2008; Koellinger & Thurik, 2012; Matejovsky et al., 2014; Neumann, 2020; Stoica et al., 2020). The variable greenhouse gas emissions (GHGpc) reveals a negative impact on the level of human development, with statistical significance at the 1% level. A one-percent increase in GHGpc is expected to bring HDI down by 0.04 percentage point, everything else being constant. Therefore, as expected, environmental deterioration negatively affects the process of human development, in line with the results of Asongu (2018) and Pîrlogea (2012). Additionally, we have robust evidence that the transition to more sustainable energy sources such as renewable energy positively affects the level of human development (Soukiazis et al., 2019). As shown in Table 2, the coefficient of the RENpc variable is positive and statistically significant at the highest 1% level. We can therefore infer that reducing greenhouse gas emissions and developing green energy sources are key strategies to improve environmental quality and hence the population´s standards of living. Other factors affecting positively the development level are human capital (HK), measured by average educational attainment of the population, and physical capital (Kpc), as predicted by the theory. The former is lagged one period since it takes time to produce real effects and the latter is measured in per capita terms to count the population size. Evidence suggests that a unit increase in human capital of the previous period is associated with 0.095 percentage point increase in the development level and that the increase in HDI is 0.16 percentage points given a unit increase in physical capital per head, *ceteris paribus*. These findings are consistent with endogenous growth theory, which stresses the importance of human capital as the driver of economic growth (e.g., Barro, 2001; Lucas, 1988; Romer, 1986).

The third equation of the system aims to explain environmental quality through the greenhouse gas emissions measured per capita (GHGpc). The regression results are shown in column 3 of Table 2. The first finding to note is the strong relationship between the GHGpc and the development level, which is statistically significant at the highest 1% level. Specifically, a 0.82% reduction in GHGpc is expected given a one-percentage-point increase in HDI, which is consistent with the idea of sustainable development. Human capital is also important for improving the environmental quality. It is shown that a one-percentage-point increase in average years of education (of the previous year) is associated with 2.48% reduction in greenhouse gas emissions per capita, *ceteris paribus*. This is an encouraging result highlighting that education is the means of encouraging individuals to take action in favor of the environment, corroborating previous outcomes obtained by Kim and Go (2020) and Lan and Munro (2013). In addition, higher human capital skills are required to develop new eco-friendly technologies. Results also show that the deployment of renewable energy sources helps to reduce greenhouse gas emissions, as expected. It is predicted that one-percent increase in renewable energy consumption per capita is responsible for 0.07% reduction in GHGpc, everything else being constant. Therefore, promoting the use of renewable energy is a recommended policy for improving the environmental quality and achieving higher levels of sustainable development. Finally, as expected, total energy consumption per capita (TECpc) has a positive and exact proportional impact on greenhouse gas emissions, and this relationship is reflected in the unit elasticity found in the regression results. This evidence is consistent with energy-saving policies through the demand for low-consumption household equipment and appliances. These findings are in line with previous studies such as those found by Soukiazis et al. (2019) and Mahmood et al. (2019).

Combining the findings of the joint estimation of Eqs. (1), (2), and (3), a reciprocal relationship is established between the countries' total entrepreneurial activity (TEA), the human development level (HDI), and the environmental quality (GHGpc) with feedback effects, hereby supporting the cyclical process illustrated in Fig. 1.

5 Conclusions

The main purpose of this paper is to examine and quantify the interconnections between entrepreneurship (TEA), the socioeconomic development level (HDI), and environmental quality (GHGpc), a process that has not been yet analyzed in the literature. It is argued that a cyclical process might be at work, where pressures on the environment will create new business opportunities that are environmentally friendlier, which in turn will improve the country's development performance. Human capital skills, including entrepreneurship education, are counterparts in the cyclical process to work and be self-sustaining.

Empirically, the cyclical process is described as a system of three equations, which are estimated simultaneously by the *3sls* approach. The estimation method takes into consideration the feedback effects of the system's core variables (TEA, HDI, and GHGpc) and the error interdependence across equations, thereby providing consistent estimates. Panel data are used to estimate the model considering a sample of 37 OECD countries over the 2002–2018 period.

The overall regression results are satisfactory and consistent with our predictions based on economic theory, supporting the cyclical process between the entrepreneurial activity, the human development level and the environmental quality of countries and thus the idea of sustainable entrepreneurship.

In particular, the empirical results suggest that the relationship between entrepreneurship and human development level is nonlinear, which supports the inverted U-shaped hypothesis. A threshold is reached, from where entrepreneurial activity declines with higher level of development. This threshold is, however, very high (95 on a scale of 0 to 100) and only crossed by Norway. The results also show that the past values of entrepreneurial activity are important for explaining its actual level, which is consistent with the partial adjustment mechanism that allows the short- and long-run effects of the covariates to be distinguished. The adjustment mechanism is shown to be modest, revealing that only 56% of the actual variation in entrepreneurial activity is adjusted to its desired or long-term equilibrium level. This indicates some kind of inertia that should be corrected by policies that promote sustainable entrepreneurship. Entrepreneurial education and training programs for businesses creation and management are key policies to foster entrepreneurial activity.

Additionally, empirical findings show that entrepreneurship contributes significantly to improving the development level and standards of living, establishing reciprocal causality, and this supports the cyclical process of sustainable entrepreneurship. The level of development is shown to be driven by human capital skills and investment plans as theory predicts, and also by renewable energy. These are encouraging results from the policy recommendation perspective, suggesting that reinforcing educational programs and investment plans is at the root of further development, and that green energy programs are beneficial to economic growth and development. Due to the reciprocal effect between entrepreneurship and development, the same strategies contribute indirectly to create a propitious climate for developing business activities. Moreover, greenhouse gas emissions influence negatively the development level; therefore, environmental sustainability policies are not only imperative for a sustainable development, but also can create new market opportunities to be explored by the entrepreneurial initiative. Higher environmental degradation drives entrepreneurs to find environmentally friendlier solutions and develop sustainable business strategies.

Finally, we provide evidence that environmental quality can be improved by developing alternative energy sources, such as renewable energy, policies aimed at reducing total energy consumption (energy-save projects), measures to improve the human capital skills, and all initiatives that promote sustainable development, through entrepreneurial activities.

This study stresses the central role of entrepreneurship as a driving force for change and sustainable development. Efforts should be made by decision makers to support innovative and sustainable entrepreneurial activities, but also to reduce the barriers in the macroeconomic environment (such as taxes, bureaucracy and legal framework) and to improve human capital skills, including entrepreneurial competencies.

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