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Article

Quality of Work Life and Organizational Performance: Workers' Feelings of Contributing, or Not, to the Organization's Productivity

João Leitão [1,2,3,4,*], Dina Pereira [1,2,3] and Ângela Gonçalves [1,2]

1 Universidade da Beira Interior, 6201-001 Covilhã, Portugal; dina@ubi.pt (D.P.); angela.goncalves@ubi.pt (Â.G.)
2 NECE–Research Center in Business Sciences, 6200-209 Covilhã, Portugal
3 CEG-IST–Centro de Estudos de Gestão do Instituto Superior Técnico, 1049-001 Lisboa, Portugal
4 ICS–Instituto de Ciências Sociais, 1600-189 Lisboa, Portugal
* Correspondence: jleitao@ubi.pt

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Abstract: This is a pioneering study on the relationship between quality of work life and the employee's perception of their contribution to organizational performance. It unveils the importance of subjective and behavioral components of quality of work life and their influence on the formation of the collaborator's individual desire to contribute to strengthening the organization's productivity. The results obtained indicate that for workers: feeling their supervisors' support through listening to their concerns and by sensing they take them on board; being integrated in a good work environment; and feeling respected both as professionals and as people; positively influence their feeling of contributing to organizational performance. The results are particularly relevant given the increased weight of services in the labor market, together with intensified automation and digitalization of collaborators' functions. The findings also contribute to the ongoing debate about the need for more work on the subjective and behavioral components of so-called smart and learning organizations, rather than focusing exclusively on remuneration as the factor stimulating organizational productivity based on the collaborator's contribution.

Keywords: organizational performance; productivity; quality of work life

1. Introduction

Employee workplace performance is related to a set of factors affecting workers' health, habits and environment, employees' well-being and quality of work life (QWL). QWL is associated with job satisfaction, motivation, productivity, health, job security, safety and well-being, embracing four main axes: a safe work environment; occupational health care; appropriate working time; and an appropriate salary [1]. As originally stated in [2], the concept embraces the effects of the workplace on job satisfaction, satisfaction in non-work life domains, and satisfaction with overall life, personal happiness and subjective well-being. Moreover, improving employees' QWL will positively affect the organization's productivity, while augmented productivity will strengthen QWL [3].

In the literature of reference, there is an ongoing and fruitful discussion about the components of QWL [3] and its different associations with metrics of non-economic performance, namely satisfaction and fulfillment of physical conditions considered basic to ensure functionality, health and safety in the workplace [1].

The most sensitive components of the QWL, still unexplored, are intrinsically related to the socio-emotional and psychological needs of employees, which require the application of more behavioral

lenses, in order to unveil the components that can most influence job satisfaction and motivation, but also productivity [4,5].

In the context of health organizations, the relationship between QWL and productivity was already investigated, suggesting the design of adequate strategies to reinforce the productivity in hospitals [6]. However, little is known about the different ways in which the behavioral and subjective components of the QWL can influence the employee's feeling of contribution to the productivity of the organization that they integrate.

As stated before, there is still room to advance knowledge about the effects associated with subjective components of assessment of satisfaction with QWL on organizational performance, considering a response variable of particularly critical importance in the context of reducing investment in resources and simultaneous pressure to maximize results, i.e., productivity [7]. Therefore, it is particularly opportune to investigate the non-economic (that is, subjective or behavioral) motivations that lead to collaborators' willingness to contribute to strengthening their organization's productivity.

Following the Organisation for Economic Co-operation and Development (OECD)'s view of productivity indicators, there are plenty of productivity differences across organizations that require further studies to open up the organizational 'black box', concerning internal productivity determinants [8]. In fact, there is a need to advance knowledge about the individual determinants of organizational productivity. An example of this challenging task is the recent project launched by the Global Forum on Productivity (GFP), entitled: 'The Human Side of Productivity'; considering a multidimensional approach applied to organizations, considering key people, such as workers, managers and owners [9].

Recently, in the context of public higher education, the role played by quality of life in determining satisfaction of internal stakeholders, such as students and collaborators (e.g., administrative staff, teachers and researchers), was also assessed. This opens up a research avenue concerning the lack of knowledge about the role played by the specificities of different organizational cultures in this type of institution, in influencing perception of academic quality of life by both internal and external stakeholders [10].

In this sense, there is still an open debate about the need for further understanding of the importance of organizational culture, using crossed perspectives on organizational and individual health, to be able to provide strategic lines for new organizational policies. These should be increasingly funded on a particular set of values and beliefs determining an organization's behavioral objectives, aligned with the desired self-efficacy in terms of employees' management and motivation [11].

Following this debate, the current study is particularly relevant, from the view that there is still limited knowledge about the necessary conditions to promote the subjective or behavioral components of satisfaction with QWL, focusing on each collaborator's contribution to fostering the organization's productivity. For example, a myth revisited here, through lack of thorough existing knowledge, is that productivity depends mainly on the remuneration attributed to performing certain functions. As yet unexplored subjective or behavioral factors, such as the collaborator feeling appreciated by the supervisor, the availability of jobs not subject to routines and where innovation is possible, promotion of continuous learning environments, the feeling of protection promoted by the supervisor, the feeling of having a really important and useful job, the possibility of the job allowing the development of new skills and reinforcing the conditions for personal and professional growth, are given special attention in this study. A data survey, which is pioneering in European terms, is followed by statistical and econometric treatment to shed new light on a little-explored relationship. i.e., the relationship between QWL and organizational performance, using a subjective measure of assessment of satisfaction expressed through collaborators' feeling of contributing to organizations' productivity.

Despite the limitations associated with the use of this dependent variable with subjective nature, its use seems to be justified, on the one hand, given the lack of studies using the behavioral lens to study the relationship between QWL and organizational performance. On the other hand, as it is not the objective of the present study to compare the relationships and the associated significance,

using objective measures versus subjective measures, for the purposes of representing the dependent variable: organizational performance.

In turn, the current study aims to reveal employees' satisfaction with the opportunities and conditions provided by their employer in six European countries, by looking after their QWL and their interests in pursuing a healthier, more satisfactory and happier lifestyle, as well as how the workplace can provide opportunities for them to improve productivity.

This study contributes to the literature on QWL and organizational performance in two ways, firstly, by identifying the determinant factors that can have a significant influence on employees' understanding of their contribution to organizational performance, represented here by an alternative measure regarding the contribution to organizations' productivity. Secondly, it provides new insights into complete fulfillment of the functions of human capital managers, revealing the importance of subjective and behavioral components of QWL that can help to design desirable collaborator behavior more likely to strengthen productivity in the organizational context.

The research partners involved in the survey design and administration developed an innovative tool to gather information for assessment of QWL. Afterwards, the survey was administered to 514 employees of local companies and public organizations in six European countries. Some highlights from the preliminary results obtained from the survey's administration can be illustrated as starting points for the current study. Namely, 80% of respondents said they feel physically safe at work and more than 77% are satisfied with the fact that their workplaces are safe and sanitary. Almost 82% of respondents feel that their organization matches their skills with the needs of their jobs and 76% are satisfied with their workplaces' maintenance/cleaning conditions. A substantial group (80%) of employees feel they are contributing to the organization's productivity, and the great majority (83%) of employees revealed that having an important job is extremely important to be productive.

The first impression is that the collaborators seem to be aware of the importance of standard human capital management procedures and conditions oriented to the reinforcement of organizational performance. Nevertheless, it is worth noting that there is a need to address an organizational 'black box', an aim of the current study, that is, the set of subjective and behavioral components to promote QWL that can directly influence employees' feeling of contribution to organizational performance, especially concerning productivity.

The remainder of the paper is structured as follows. After a literature review leading to formulation of the research hypotheses, the research methodology is presented. Next, the results are discussed, followed by the conclusions, limitations and implications.

2. Literature Review and Research Hypotheses

2.1. Revealing the Relationship between Organizational Performance and QWL

There is no simple or universally recognized definition of what performance is at the level of an individual organization. Organizational performance is multidimensional, connected to its goals and objectives, and may be defined as an organization's ability to use its resources efficiently, and to produce outputs that are consistent with its objectives and relevant for its users [12]. Analyzing organizational performance is a crucial step in the organizational assessment process [13]. In doing so, in the literature of reference, three main domains of organizational performance have been reported, namely: financial performance; operational performance; and organizational effectiveness [14]. Concerning the conceptualization of organizational performance, four main elements should be taken into consideration: effectiveness; efficiency; relevance; and financial viability [13].

People are the organization's most important asset [15], and so the way an organization manages people's impacts has a major influence on organizational performance [16].

Performance management is a continuous process of identifying, measuring and developing the performance of individuals and teams and aligning performance with the organization's strategic goals [17,18]. The previous arguments are examples of cornerstone visions regarding the need to

advance the knowledge available on subjective and behavioral components affecting the relationship between organizational performance and QWL.

Nevertheless, various performance management systems are found in the literature and these systems have some advantages, such as: increased motivation to perform; increased self-esteem; managers gain insights into subordinates; organizational goals are made clear; employee misconduct is minimized; organizational change is facilitated; motivation and commitment to stay in the organization are increased; and employee engagement is enhanced [19]. In fact, performance management systems are the source of information when making decisions about rewards and the allocation of resources, succession planning and staffing strategies [20].

Each employee's emotional intelligence has an effect on behavior which ultimately affects achievements and performance in the workplace [21]. The satisfaction of employees' needs through organizational development is at the core of the QWL movement [22]. Enhancing QWL will result in improved productivity, and in turn, gains in productivity will strengthen QWL [3].

Improving QWL and performance is of extreme importance, as productivity and innovation are part of the political agenda of European Union countries. With fewer people in the workforce due to an aging population there is a need to enhance labor productivity [23]. The quality of work life is covered in the guidelines for the employment policies of member states [24].

Previous applied empirical work [25] pointed out the existence of a positive and significant relationship between QWL and organizational performance, as well as a positive and significant association between QWL and employees' job satisfaction.

Another study [26] found that employee commitment partially mediates the relationship between QWL and organizational performance; and also unveiled that work environment significantly affects employee commitment and thus organizational performance. It was also advocated that improving the QWL of an organization could achieve a heightened job satisfaction, commitment and also improved performance [27]. In order to achieve a higher employee commitment and consequently a better organizational performance, it is suggested for managers to pay attention to the different dimensions of QWL [26].

In contrasting terms, previous scholars [28] reported a negative but non-significant relationship between QWL and organizational performance, although it was also found a positive relationship between employee's job satisfaction and organizational performance. This type of mixed evidences raises the interest for advancing knowledge about still unexplored subjective and behavioral components of the QWL and their influence on organizational performance.

2.2. Exploring Subjective and Behavioral Components of QWL

Quality of life is an elusive concept regarding the assessment of societal or community well-being from specific evaluation of individual or group cases [29]. The literature has associated a high quality of life with higher levels of productivity at the workplace. Therefore, increasing attention has been paid to the role played by occupational stress, including job demands, job control, job insecurity, organizational justice, intra-group conflict, job strain, effort-reward imbalance, employment level and shift work. In turn, this has been correlated with factors that negatively affect quality of life, namely insomnia, which results in impaired work performance and leads to significant productivity losses for organizations [30].

Quality of life is modulated by a wide range of factors, among them psychosocial parameters, health conditions and well-being in the workplace, as well as the adequacy of working resources and infrastructures provided. Policies and regulations created based on employees' individualized considerations have suggested significant productivity improvement due to subjective components, such as trust, commitment, satisfaction and control. Nevertheless, the research opportunity remains to deepen knowledge about the role played by both subjective and behavioral components of QWL.

For instance, social support, reflecting individuals' integration into a social group, has been reported as an important indicator of quality of life in occupational performance [31]. Infrastructures

also have an important role in providing well-being in the workplace and therefore modulating the quality of life. It has been suggested that providing green lawns in urban areas enhances quality of life in the workplace, maximizing employees' social interaction, physical activity and connection with nature [32]. Shiftwork has been reported as worsening the quality of life [33].

Cooperative decision making, adequate recognition and supportive supervisors are considered fundamental to QWL [34], with appropriate job performance feedback and favorable relations with supervisors being said to have a direct impact on QWL [35]. Another study [36] goes further and reveals that supervisory behavior is the most important component of QWL, contributing to the variance in the employee's role efficacy by as much as 21%.

Considering the previous statements in the literature, the following research hypothesis is derived:

Hypothesis 1 (H1). *Workers who feel that they are supported and appreciated by their supervisors are more likely to feel that they contribute to the organization's productivity.*

QWL is considered a multi-dimensional construct with no clearly accepted definition of the term. This subjective definition means accurate measurement of its parameters is complex. QWL differs from job satisfaction [2], as job satisfaction is considered one of the outcomes of QWL. In turn, QWL is mainly associated with job satisfaction, motivation, productivity, health, job security, safety and well-being [37].

Following [1], QWL involves four major parts: a safe work environment; occupational health care; appropriate working time; and fitting salary. According to [2], QWL involves the effect of the workplace on satisfaction with the job, satisfaction in non-work life domains, and satisfaction with overall life, personal happiness and subjective well-being.

The factors relevant to employees' QWL include the social environment within the organization, the relationship between life on and off the job, the specific tasks they perform and the work environment [38].

Providing safe and healthy working conditions aims to ensure the employee's good health, thus, taking measures to improve QWL is expected to increase employee's motivation ultimately leading to the enhancement of performance and productivity [38].

Accordingly, a work environment that is able to fulfill the employee's personal needs will lead to an excellent QWL [39].

Thus, the following research hypothesis is considered:

Hypothesis 2 (H2). *Workers who feel that they are integrated in a good working environment are more likely than others to feel that they contribute to the organization's productivity.*

Researchers have proposed differentiated models concerning QWL. For example, in [39] a model is proposed in which the needs of psychological growth were connected to QWL. The same authors recognized several needs: skill variety; task identity; task significance; autonomy; and feedback.

In [2], a model is originally proposed founded on five critical key-factors concerning the satisfaction of workers' needs, namely: (i) work environment; (ii) job requirements; (iii) supervisory behavior; (iv) ancillary programs; and (v) organizational commitment.

The second vision is highly valued in organizations committed to playing a responsible role in society, since QWL benefits the employee's pride, social commitment, satisfaction and the organization's contribution to society [11,40]; and can also be positively influenced by organizational support, for instance by relieving fatigue and enhancing self-efficacy [41].

QWL has been considered as the condition experienced by the individual in terms of the dynamic pursuit of their hierarchically organized goals within work domains, whilst reducing the gap separating the individual from these goals can have a positive impact on the individual's general quality of life, organizational performance, and consequently on the overall functioning of society [42].

Furthermore, QWL is a phenomenon that can originate a change in terms of organizational culture, since the former corresponds to employees' interpretation of all the conditions in a workplace and their perception of those conditions [43].

In a related vein, QWL can be approached as an indicator of the overall quality of the human experience at work [44]. The same author advocates that it creates a favorable workplace, which enhances employee well-being and satisfaction.

Employees that feel they are treated with respect by people they work with, and employees who feel proud of their job, increase their feeling of belonging to the company, thus feeling that they are an asset to the organization [45]. Studies [46,47] found that feeling respected is a predictor of QWL, together with self-esteem, variety in daily routine, challenging job, autonomy, safety, rewards and good future opportunities; and as already mentioned an improved QWL is expected to lead to a higher productivity [48].

Considering the previous vision, the QWL construct can be completed by incorporating subjective measures related with employee satisfaction, motivation, involvement and commitment with respect to their lives at work [49]. In the same vein, QWL corresponds to the degree to which individuals are able to satisfy their important personal needs while employed by the firm. This gives rise to the following research hypothesis:

Hypothesis 3 (H3). *Workers who are respected as professionals are more likely than others to feel that they contribute to the organization's productivity.*

Employees can experience a better QWL if they have a positive perception of the degree of responsibility of the organization they belong to [50]. A related study about perceived QWL in Croatia found that employees positively value non-competitive, co-operative work environments for improved quality of life [51]. In addition, factors like job security, human relations and work-life balance influence QWL positively [52]. The analysis of the first European Quality of Life Survey found also that positive aspects of work (good rewards, job security, favorable career prospects and interesting work) have a greater impact on life satisfaction and particularly job satisfaction [53]. In turn, it should be noted that a poor work-life balance lowers employees' quality of life [53].

Work-life balance has been positioned in the reference literature as a key component of QWL [38,54–58], but it deserves to be noted that the employee's level of emotional intelligence could influence his/her work-life balance [59].

It should be noted also that in a previous empirical study [60] no significant association, neither positive nor negative, between work-life balance and productivity was detected.

Nevertheless, Work-life balance plays an important role in overall life satisfaction and influences experiences in work life by increasing job satisfaction and organizational commitment [61]. A high level of engagement in work life is likely to produce a positive effect in work-life balance, which can be further enhanced by goal attainment in work life [62]. Accordingly, the following research hypothesis is derived:

Hypothesis 4 (H4). *Workers who have the possibility to enjoy the adoption of work-life balance practices in their organizations, are more likely than others to feel that they contribute to the organization's productivity.*

QWL involves acquiring, training, developing, motivating and appraising employees in order to obtain their best performance, in accordance with the organization's objectives [28]. QWL is the foundation of employee well-being and leads to better performance [26].

Skills, occupational improvement and opportunity for training are considered sub components of QWL [45,63,64]. The development of skills and abilities can improve job satisfaction and overall QWL, and for its turn QWL can influence the employee's performance [65,66]. Thus, employees expect to develop their skills and get promoted, ensuring a better performance for the organization [67]. In turn,

training is an activity aimed at enhancing performance, by ensuring the opportunities for development of skills and encouragement given by the management team [38].

As previously revealed through the empirical evidence obtained in [68], both QWL and motivation influence employees' performance positively. High levels of QWL lead to job satisfaction, which ultimately results in effective and efficient performance [49]. Considering the previous statements and empirical evidence, the following hypothesis is derived:

Hypothesis 5 (H5). *Workers who feel that their organizations invest in their careers, for example through continuous learning, the development of new skills or supporting professional growth, are more likely to feel that they contribute more than others to the organizations' productivity.*

3. Empirical Approach

3.1. Methodology and Data Characterization

The research methodology was developed using different questionnaires, which were designed taking into consideration a set of eleven selected international benchmarks, namely: (i) Health and well-being at work: a survey of employees, 2014, UK, Department for Work and Pensions; (ii) ACT Online Employee Health and Wellbeing Survey 2016, Australian Capital Territory Government; (iii) British Heart Foundation 2012, Employee survey; (iv) British Heart Foundation 2017, Staff health and wellbeing template survey; (v) Rand Europe (2015), Health, wellbeing and productivity in the workplace—Britain's Healthiest Organization summary report; (vi) South Australia Health, Government of South Australia Staff needs assessment, Staff health and wellbeing survey; (vii) Southern Cross Health Society and BusinessNZ, Wellness in the Workplace Survey 2017; (viii) State Government Victoria, Workplace Health & Wellbeing needs survey; (ix) East Midlands Public Health Observatory, Workplace Health Needs Assessment for Employers, February 2012; (x) Tool for Observing Worksite Environments (TOWE). U.S. Department of Health & Human Services; and (xi) Measure of QWL, as originally proposed in [2].

The survey was conducted from April to July 2018. Twelve partners from Italy, Bulgaria, Cyprus, Portugal, Greece and Spain participated in data collection, by interviewing employees. The sample covers 15 private companies and five public entities or large firms per partner, involving two employees per organization and totaling 514 questionnaires. It was not intended to interview company owners or general managers to avoid bias in the responses.

A convenience sample procedure based on random selection was used. In each organization, a contact person was identified to ensure completion of the questionnaire, which was afterwards validated by the research team. The questionnaires were applied by personal interviews to ensure a maximum response rate.

The partners followed the following instructions in selecting interviewees: 15 companies among micro, small and medium-sized firms (10% of interviewees for each category—EU definition of SME), plus five among large firms and public entities.

The main aim of the study is to assess the influence of workers' QWL on the perception of their contribution to organizational performance. The degree of novelty here lies in the innovative assessment of both subjective and behavioral components of workers' QWL, embracing different types of organizations (e.g., public or private) with distinct dimensions and economic activities. A total of 514 questionnaires were collected involving organizations from the six European countries engaged in the data collection process.

The questionnaire includes two sections: (1) QWL (needs, work environment, work requisites, supervisor behavior, auxiliary programs inside the organization, organizational pressure, and organizational performance and commitment); and (2) sample characterization (gender, age, marital status, position in the organization, level of qualifications, organization's sector of activity, size and age of the organization, type of employee contract and employee qualifications). In the first

section, Likert scales (e.g., ranging from 1 to 7) were used to assess the level of agreement with a set of sentences in each sub-section, scales that had been transformed into binary considering the variables under analysis, namely the Feeling of contributing to productivity, Supervisors' support, Good work environment, Professional respect and Work-life balance. In the second section, levels of answer were used. Below, the sample is characterized and a set of results for the whole sample is presented.

3.2. Sample Characterization

Sample and Descriptive Statistics

Concerning respondents' gender, 48% were women and 52% men. Relative to age, 9% were aged between 20 and 25, 34% between 26 and 35, 37% between 36 and 45, 14% between 46 and 55 and only 7% were older than 55. 35% were single, 59% married and almost 7% are in another non-defined situation. In terms of organizational role, 18% said they occupied a managerial role inside the organization, 67% a qualified role and 16% a non-qualified position. Regarding education, 51% have a college degree and 22% a post-graduate degree, 19% completed secondary education, 7% completed 9 years at school and only 1% completed 4 years. Concerning the sector of activity of the respondents' organizations, almost 2% belong to the primary sector, 14% to the secondary, 77% to the tertiary and 7% to public organizations. The majority of respondents work in small and medium sized firms, 26% in companies with one to nine employees, 39% in firms with 10 to 49, 15% in companies with 50 to 249, 14% in companies with 250 to 1000 and 6% in companies with over 1000 employees. Concerning the organizations' age, 16% are between 1 and 6 years old, 34% between 7 and 15 years, 25% between 16 and 29, almost 17% between 30 and 49 years and almost 8% have been in existence for more than 50 years. Concerning respondents' contract type, 68% said they have a permanent contract, 11% a contract for a stipulated period, almost 9% were temporary, 5% were freelancers and 9% reported another sort of contract. Lastly, respondents were asked about their qualification inside the firm, with almost 7% saying they were senior managers, 10% intermediary managers, almost 17% staff in charge, 21% highly qualified employees, approximately 25% qualified, 6% semi-qualified and 8% non-qualified. In addition, 3% said they were apprentices and 1% said they did not know.

In descriptive terms, for the employees, it is observed that the items in which they feel more in agreement in their workplaces are professional respect as workers and people (70%), followed by the existence of a good work environment (65%), as seen in Table 1 presented below. For 62% of respondents having the supervisors' support is essential. Approximately 37% denote the importance of having a work-life balance and 57% show that the organizations' support for skills development is essential. Approximately 80% of the workers feel they really contribute to the organization's productivity. Looking at the correlations matrix we can observe that the items most associated with the workers' sense of contribution to the organizations' productivity are professional respect, having a good work environment, and lastly supervisors' support.

Table 1. Descriptive Statistics and Correlation Matrix.

Variables	M	SD	Skewness	Kurtosis	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Feeling of contribution to productivity	0.8015564	0.3992165	−1.517	0.301	1.0000												
2. Supervisors' support	0.618677	0.4861848	−0.49	−1.767	0.2722 ***	1.0000											
3. Good work environment	0.6536965	0.4762548	−0.648	−1.586	0.2735 ***	0.3715 ***	1.0000										
4. Professional respect	0.6964981	0.460218	−0.857	−1.27	0.2869 ***	0.3878 ***	0.3911 ***	1.0000									
5. Work-life balance	0.3735409	0.4842151	0.524	−1.732	0.1724 ***	0.2999 ***	0.2662 ***	0.3085 ***	1.0000								
6. Skills' development	0.5680934	0.4958241	−0.276	−1.931	0.2161 ***	0.2777 ***	0.3064 ***	0.3299 ***	0.3079 ***	1.0000							
7. Female	1.515564	0.5002446	−0.062	−2.004	−0.0333	−0.0477	−0.0346	−0.0641	0.0001	0.0272	1.0000						
8. Age	2.745136	1.01798	0.371	−0.227	0.0624	−0.0038	0.0387	0.0759 *	−0.0042	0.0402	0.0824 *	1.0000					
9. Married	0.5603113	0.4968328	−0.244	−1.948	0.0310	−0.0095	0.0143	−0.0221	−0.0371	−0.0048	0.0197	0.4640 ***	1.0000				
10. Manager role	0.1770428	0.3820768	1.697	0.884	0.0774 *	0.1438 ***	0.1341 **	0.1177 ***	0.0738 *	0.1060 *	0.1028 *	0.1012 **	0.1131 *	1.0000			
11. College education	0.7256809	0.4466052	−1.015	−0.974	0.2079 ***	0.0919 **	0.1390 **	0.1063 *	0.1052 *	0.1505 ***	0.0235	−0.0726	0.0527	0.1481 ***	1.0000		
12. SME	0.8035019	0.3977365	−1.532	0.349	−0.0374	−0.0153	−0.0718	0.0037	0.0074	−0.0259	−0.0091	−0.2010 ***	−0.1421 ***	−0.0143	−0.0736 *	1.0000	
13. Company age	2.651751	1.172012	3.111	7.71	0.0103	−0.0214	−0.0628	−0.0265	−0.0486	−0.0245	0.0541	0.3258 ***	0.2320 ***	0.0030	−0.0116	−0.4105 ***	1.0000

Source: Own elaboration. Significance levels: * $p < 0.10$. ** $p < 0.05$. *** $p < 0.0$. SME: Small and Medium-sized Enterprises.

The variables presented above were subsequently used in estimation processes, considering two distinct models: (1) an Ordinary Least Squares (OLS) model; and (2) a Multinomial Logit model; in order to reveal the set of subjective and behavioral components of QWL that influence the workers' perception of contribution to productivity. The main reasons for using the two models are as follows: (i) estimation of the OLS model is justified by the dataset analyzed following normal distribution, considering a dependent variable represented in binary terms, which can determine the probability of the influence of a hypothetical set of independent variables arising from the literature review presented above; the dependent variable takes the value of 1, when the employee states they feel they contribute to productivity; and 0, otherwise; and (ii) estimation of the multinomial model can test a representation at level of the same dependent variable, which lets us, first, contrast the empirical evidence with Model 1, and secondly, determine the variability of the probability of influence of the same hypothetical set of independent variables, through comparison of the results between a baseline corresponding to: 'not contributing to productivity' (level 1); 'contributing to productivity to some extent' (level 2); and 'totally contributing to productivity' (level 3).

To do so, the log-odds for these two categories relative to the baseline are computed, and then the log-odds are considered as a linear function of the predictors. Several control variables were used, namely: gender; age; marital status; employee's role; employee's education; organization's sector; organization's size; organization's age; and employee's position in the organization. The operational model of analysis is as follows (Figure 1):

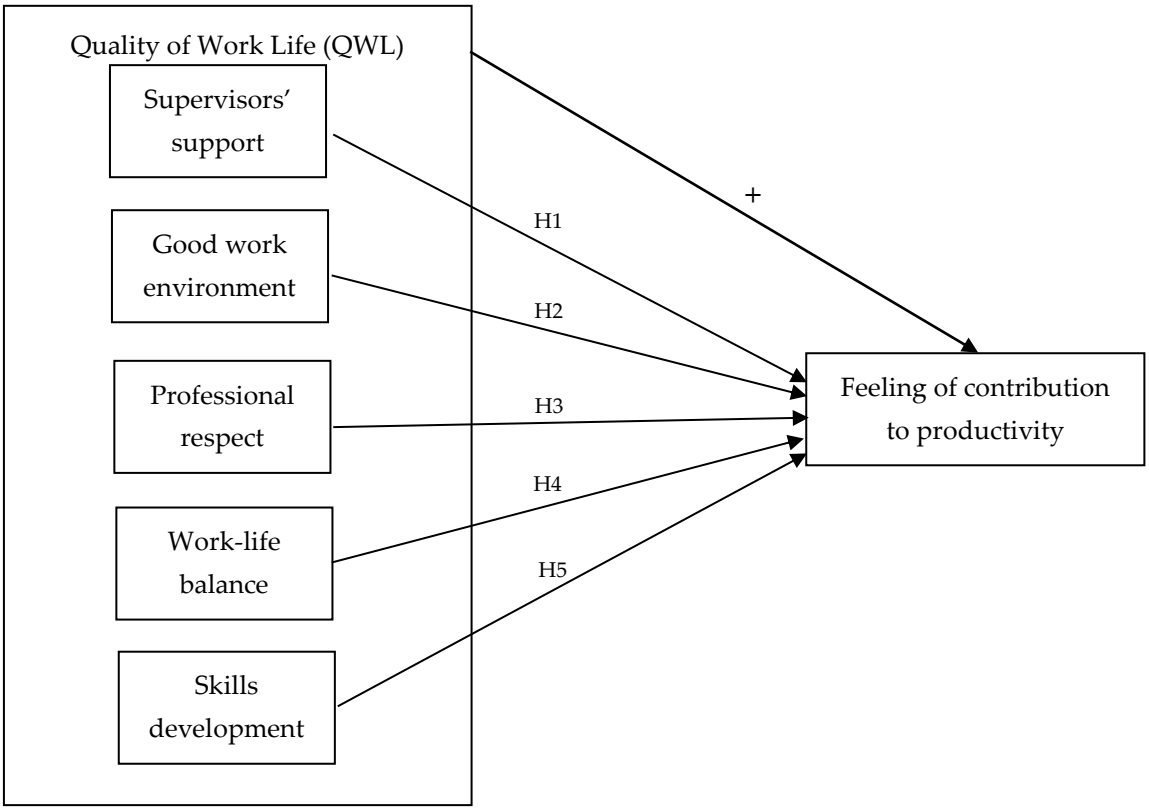

Figure 1. QWL and Feeling of Contribution to Productivity: Operational model of analysis (Source: Own elaboration).

Table 2 below presents more details and description of the set of variables.

Table 2. Variables description.

Variables	Description
Feeling of contribution to productivity	1 if the worker feels they contribute to the organization's productivity, 0 otherwise.
Scale of feeling contribution to organization's productivity	1 for workers feeling they don't contribute to organization's productivity; 2 for workers feeling they contribute to organization's productivity to some extent, and 3 for workers feeling they totally contribute to organization's productivity.
Supervisors' support	1 if the worker feels satisfied with supervisors' support/treatment, 0 otherwise.
Good work environment	1 if the worker feels satisfied with the work environment, 0 otherwise.
Professional respect	1 if the worker feels respected by the organization both as a professional and individual, 0 otherwise.
Work-life balance	1 if the worker feels the organization is concerned with work-life balance, 0 otherwise.
Skills development	1 if the worker feels the organization supports skills development, 0 otherwise.
Female	1 if female, 0 otherwise.
Age	1 for 20–25 years; 2 for 26–35 years; 3 for 36–45 years; 4 for 46–55 years; and 5 for ≥55 years.
Married	1 for being married, 0 otherwise.
Manager role	1 for occupying a managing role, 0 otherwise.
College education	1 for having college education, 0 otherwise.
SME	1 for being SME, 0 otherwise.
Company age	1 for 1 to 6 years; 2 for 7 to 15 years; 3 for 16 to 29 years; 4 for 30 to 49 years; and 5 for ≥50 years.

Source: Own elaboration.

4. Results and Discussion

Regarding the results of the OLS regression for the sample considered (see correspondent column of Model 1, in Table 3), which used as dependent variable the feeling of contribution to productivity, with the value of *1* when the worker declares they feel they contribute to productivity and 0 otherwise, the LR Chi^2 of 14.38 with a *p*-Value of 0.0000 indicates that the model as a whole is statistically significant.

As observed in Table 3 below, three statistically significant variables influence workers' sense of contribution to productivity, namely: (i) professional respect; (ii) having a good work environment; and (iii) feeling supervisors' support. Interestingly, work-life balance and the organization's skills development support do not have any significant influence on the feeling of contribution to the organizations' productivity.

Moreover, from the control variables tested in the first model, it should be noted that employees' college education level has a significant and positive effect on their feeling of contribution to productivity.

In Model 2, the likelihood ratio quotient of 22.06 with a *p*-Value of 0.0002 signals that the model as a whole is statistically significant. Here, a set of predictors related to collaborators' sense of contribution to productivity (computing a categorical variable with three levels: 1, not contributing to productivity; 2, contributing to productivity to some extent; and 3, totally contributing to productivity; are considered in the empirical application.

Regarding the sense of contributing to some extent to organizations' productivity, only work-life balance denotes a significant, although negative, influence. Moreover, the older the workers are the more likely they are to feel somehow productive to their organizations. Concerning level 3, representing the feeling of totally contributing to the organization's productivity, workers feeling respected by their

companies, sensing that their organizations make them feel confident and value their contribution affects in a positive and significant way the high level of feeling they contribute to firms' productivity. Workers who feel they are highly productive are also older and those occupying managerial roles and direction positions in their organizations.

Table 3. QWL: Subjective and behavioral components influencing employees' feeling of contribution to productivity.

Variables	**Model 1:**	**Model 2:**	
Dependent Variable: Contribution to Productivity	OLS Regression	Multinomial Logit	
		Baseline: Feeling of not contributing to productivity	
Independent variables:	Coef.	Coef. Feeling of contributing to productivity to some extent	Coef. Feeling of totally contributing to productivity
Supervisors' support	0.1112487 *** (0.0386135)	0.1387051 (0.2829922)	0.0169725 (0.313576)
Good work environment	0.1012274 ** (0.0396864)	−0.1571931 (0.2944245)	−0.3292686 (0.3255704)
Professional respect	0.1194258 *** (0.0417695)	0.2335013 (0.2996408)	0.5612954 * (0.3395112)
Work-life balance	0.0181309 (0.0371606)	−0.4871505 * (0.2743621)	−0.5201555 * (0.3044264)
Skills' development	0.0525111 (0.0367527)	0.2142189 (0.271979)	0.2460842 (0.3016579)
Female	−0.0188813 (0.0330991)	0.0149441 (0.2438254)	−0.2331886 (0.2705418)
Age	0.0220647 (0.0191218)	0.3310333 ** (0.1469402)	0.3456309 ** (0.1619994)
Married	−0.0007321 (0.0376591)	−0.2280585 (0.2797668)	−0.0901252 (0.309747)
Manager role	−0.0100354 (0.0443451)	0.4593606 (0.3697954)	0.6808159 * (0.3938579)
College education	0.1415679 *** (0.0379515)	0.0578064 (0.2788375)	−0.0239672 (0.3085947)
SME	0.0022576 (0.045563)	0.1645333 (0.336115)	0.0256681 (0.3730899)
Company age	0.0044527 (0.0160382)	0.0342415 (0.1197577)	−0.0841063 (0.1328729)
Obs.	514	514	
LR Chi^2	14.38	22.06	
Prob. > Chi^2	0.0000	0.0002	

Source: Own elaboration. Significance levels: * $p < 0.10$. ** $p < 0.05$. *** $p < 0.0$; Standard errors in brackets. LR Chi^2: Likelihood Ratio (LR) Chi-Square test; Prob. > Chi^2: The prob > chi2 statistic for the overall model is a test of the joint null hypothesis that all of the regression coefficients (other than the constant term) are zero.

Contrasting the two estimation processes, we conclude that the OLS model reveals most predictors explaining workers' feeling of contribution to productivity, by detecting positive and significant influences of 3 out of 6 subjective and behavioral components of QWL. Going deeper, it is important to crosscheck what predicts the collaborator's feeling of lack of contribution to productivity, in order to improve the management capacity of human capital, following a behavioral approach.

Bearing in mind the set of research hypotheses under examination, new insights arise concerning the subjective and behavioral components of QWL influencing employees' feeling of contribution to productivity.

Thus, model 1 gives support to H1a, as workers who feel they are supported and appreciated by their supervisors feel they contribute more to the organizations' productivity than others. These findings are in line with prior findings of [30], stressing the importance of workers being supported and appreciated for increased productivity.

Model 1 supports H2, as we detect a significant and positive influence of good workplace environments, by being safe and sanitary, on workers' feeling of productivity. Such results are aligned with prior studies which detected a positive association between job security, safety and well-being at the workplace and job productivity, satisfaction and motivation [37], and the existence of a safe work environment and its positive impact on productivity [1]. These results are aligned with prior literature, which found that by being involved in a socially supportive group inside the workplace, employees are more likely to contribute to organizational performance [31]. In the same line of reasoning, a study referred to previously, applied to the Croatian context [51], identified an important impact of co-operative working environments on QWL.

We found support for H3, as workers who feel respected as professionals (in Models 1 and 2) contribute more to organizations' productivity than others. In Model 1, our empirical findings reveal a positive and significant influence of workers being professionally respected on the sense of feeling productive. Regarding the findings of Model 2, this influence is also important but only for the group of workers who feel they contribute greatly to the organization's productivity. This corroborates the rationale of the model proposal found in [39], which outlined that the needs for psychological growth covering the different frameworks associated with professional valorization and respect (namely, skill variety, task identity and significance, autonomy and feedback) are connected with QWL and thus performance. Moreover, our results ratify the concluding remarks of previous scholars [11,40], who defended that employees' sense of pride and commitment, in relation to being valued as professionals, increases their contribution. These visions are also in agreement with previous empirical findings denoting a positive effect of the worker being considered and taken into consideration in the organizations' goals on performance [42].

Concerning H4, which states that workers who have the possibility to enjoy the adoption of work-life balance practices in their organizations, feel they contribute more to the organizations' productivity than others, no significant evidence is found in Model 1. Moreover, in Model 2 we detect a significant, although negative, effect of employees' feeling that the organization has a work-life balance vision on the feeling of contributing to productivity and so this hypothesis is rejected. This can be justified by the lack of work-life balance practices on the part of supervisors and the organization itself, as well as possible development of a negative emotion concerning the work-life balance allowance, which in certain organizational contexts could be interpreted as a mode of diminishing the potential leadership responsibilities given to target-workers.

The results are contrasting, but do not reject the previous findings in [52], which argued for a positive association between work-life balance and quality of work life, thus spurring productivity. In a similar vein, achieving a balance between private and professional life is expected to be positively associated with organizational commitment and, thus, with productivity at work [61]. In fact, the empirical findings obtained here not only do not contradict the previously identified positive association between work-life balance and QWL, but also shed some light on 'invisible ceiling' issues related with the gender leadership issue and supervisors' behavior within the organizational context, which need to be further explored in future research concerned with organizational productivity based on the individual behavior (of supervisors and workers) and subjective well-being influenced in the scope of the organizational context's boundaries.

We found no support for H5, stating that workers who feel their organizations invest in their careers and skills development, for example through continuous learning, the development of new

skills or supporting professional growth, contribute more to organizations' productivity than others. Interestingly, our findings do not seem to be related with prior work, for example, in [39], which pointed out an association between professional valorization (skill variety), QWL and performance, as well in [28], where positive argumentation was given to reinforcing investment in employees' training, to be able to achieve better performance levels in the future. This contrasting result could be justified by the productivity measure used, being a subjective measure, concerning the perception of being productive. These results also contrast with prior literature defending a positive association between organizational investment in workers' management and organizational performance [16], as well as paying attention to employee management systems, aligning the goals of the organization with career decisions, rewards, structured growth and thus impacting positively on workers and organizations' performance.

5. Conclusions

This study analyses, in an innovative way, the influence of subjective and behavioral components of QWL on organizational performance, measured through collaborators' feeling of contribution to the organization's productivity. The empirical findings show the importance of factors related with workers having their supervisors' support, integration in a good work environment and feeling respected both as professionals and as people.

One of the research challenges addressed here, in a pioneering way, is the use of a subjective measure of collaborators' commitment to organizational productivity, attempting to provide new implications for organizational management, taking into account components that were hitherto unexplored empirically, various subjective and behavioral components that require greater knowledge to address, in an alternative way, improved organizational performance and behavioral drivers of productivity, rather than relying exclusively on increasing collaborators' remuneration.

Adopting a more behavioral line of organizational management, and integrating the emerging literature on the QWL construct originally proposed in [7], this analysis contributes to the literature on QWL and organizational performance, bringing two axes of reasoning founded on new empirical evidence, namely: (1) identifying factors that can influence organizational performance, represented here by an alternative measure referring to the collaborator's feeling of contributing to the organization's productivity; and (2) proposing a new agenda for human capital managers, focusing on the importance of subjective and behavioral components of QWL, which can help to strengthen productivity in the organizational context, following a behavioral approach both at the company and individual level.

Regarding implications, the evidence obtained signals that human capital managers committed to reinforcing organizational productivity through changing the behavior of collaborators and the organization itself should seek to fulfill a new strategic action agenda with the following priorities: (1) fostering an organizational culture that values behavioral practices of supervisor respect for the collaborator (i.e., hierarchical subordinates) in the organizational context; (2) promoting positive emotions and feelings in collaborators that they are appreciated in the workplace; (3) ensuring that supervisors protect collaborators from hazardous conditions, to reduce feelings of uncertainty and risk; and (4) giving importance to the duties and tasks performed by collaborators.

Surprisingly, this study does not present additional evidence to the established view pointing towards the importance of having a work-life balance and companies' support for workers' skills development in the contribution to workers' productivity. This may be justified, on the one hand, by the content of the research question included in the original survey used in the current study that allows us to point out a hypothetically negative feeling concerning the leadership responsibilities given to target workers, without valuing in a proper way the required work-life balance. Nevertheless, there is still great room for improvement as regards promoting the subjective conditions tending to strengthen behaviors oriented towards stimulating organizational productivity, especially, addressing gender issues, balanced management of the trade-offs between personal and professional life; and leadership responsibilities, per gender role.

The main limitations of the analysis concern the impossibility of carrying out a study with a time dimension, which could determine hypothetical relationships of causality (or precedence) between subjective and behavioral components and organizational performance. Another limitation is in relation to the response variable representing organizational productivity being based on a subjective measure of the collaborator's perception of individual contribution to organizational productivity. Nevertheless, considering the difficulty in obtaining data of a subjective nature and the aims of this study, it seems acceptable to consider this alternative measure of the organization's non-economic performance, which requires future exploration through additional research.

In a related vein, this opens an avenue for tracing further research endeavors, expanding both the number of objective and subjective metrics, in order to gauge the hypothetical differences in the relationships established between QWL's components and organizational performance, "measured" in objective or subjective terms. This would imply the design of a new questionnaire targeted to assess the feelings of the leaders regarding the performance of workers, and, afterwards, it will be possible to produce a contrasting analysis.

For the future, more thorough study of the relationship between QWL and organizational productivity is suggested, by making a comparative analysis involving different profiles of organizational culture considering other contexts of organizational location, for example, in America, Asia, Europe, Africa and Australasia. In this line of analysis, it would also be interesting to pursue this topic considering different organizational and corporate governance contexts, for example, multinationals, family control, female management, management with ethnic diversity and management with values. Another avenue of future research would be the possibility, in the organizational context, of using new forms of organizational design and management able to change behavior in a subjective, inclusive and participatory way. It is necessary, therefore, to explore how design thinking, organizational gamification and co-creation can mobilize the collaborator to contribute effectively to improved organizational performance.

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Quality of Work Life and Contribution to Productivity: Assessing the Moderator Effects of Burnout Syndrome

João Leitão [1,2,3,4,*], Dina Pereira [2,3] and Ângela Gonçalves [2]

1 Faculty of Social and Human Sciences, Research Center in Business Sciences (NECE), University of Beira Interior, 6200-001 Covilhã, Portugal
2 Research Center in Business Sciences (NECE), University of Beira Interior, 6200-209 Covilhã, Portugal; dina@ubi.pt (D.P.); angela.goncalves@ubi.pt (Â.G.)
3 Centre for Management Studies of Instituto Superior Técnico (CEG-IST), University of Lisbon, 1049-001 Lisboa, Portugal
4 Instituto de Ciências Sociais (ICS), University of Lisbon, 1649-004 Lisboa, Portugal
* Correspondence: jleitao@ubi.pt

Abstract: This study is focused on assessing the effects of burnout as a moderator of the relationship between employees' quality of work life (QWL) and their perceptions of their contribution to the organization's productivity by integrating the QWL factors into the trichotomy of (de)motivators of productivity in the workplace. The empirical findings resulting from an OLS multiple regression, with interaction terms, applied to a survey administered at 514 employees in 6 European countries, point out two important insights: (i) QWL hygiene factors (e.g., safe work environment and occupational healthcare) positively and significantly influence the contribution to productivity; and (ii) burnout de-motivator factors (that is, low effectiveness, cynicism, and emotional exhaustion) significantly moderate the relationship between QWL and the contribution to productivity. Combining burnout with other QWL components, such as occupational health, safe work, and appropriate salary, new insights are provided concerning the restricting (i.e., low effectiveness and cynicism) and catalyzing (emotional exhaustion) burnout components of contribution to productivity. These findings are particularly relevant given the increased weight of burnout, mental disorders and absenteeism in the labor market, affecting individuals' quality of life and organizations' performance and costs.

Keywords: burnout; emotional exhaustion; low effectiveness; cynicism; quality of work life; productivity

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1. Introduction

The lack of quality of work life (QWL) is associated with higher levels of work-related occupational stress, anxiety and burnout, which lead to lower job performance and induces significant costs for organizations [1].

Recently, the World Health Organization (WHO) categorized burnout as a job-related phenomenon [2], characterized by chronic stress [3]. Burnout embraces three main dimensions, emotional exhaustion or energy reduction, the negative emotional state of cynicism and low professional effectiveness [2,4–10]. The costs of burnout are growing fast [8,11], affecting currently 13–25% of the working population [12].

Workers with a high level of emotional intelligence usually have reduced burnout levels [13] as these individuals are more able to deal with stress, which in turn could lead to a higher level of productivity [14]. Emotional regulation techniques can aid individuals to feel accomplished at work [15]. As a sense of low accomplishment is one of the dimensions of burnout, emotional regulation strategies could help to prevent this syndrome.

Such a sense of not being able to accomplish duties is associated with the lack of workers' health and wellbeing, which in turn can be caused by poor working conditions [16]. A related OECD working paper states that health is an important factor in the relationship

between work factors and productivity, and strong evidence was found of a negative relationship between job stress and productivity [17].

According to available data, as a whole, from 2018, productivity has been increasing since 1995 in virtually every EU country [18], although its pace growth has been slowing down. Increasing the productivity of individuals and organizations is among the essential objectives of the Europe 2020 strategy for growth, driven by international competitiveness concerns and the promotion of productivity, growth and sustainability [19], and more recently, with the reinforcement of quality of life through truly green and sustainable growth, as contained in the European Green Deal [20].

Following such a need to improve workers' productivity, the QWL requires further reinforcement in order to spur employees' motivation which is increasingly important in the context of digital transition observed in highly skilled and technologically advanced economies [21]. Adding to the previous statements, the QWL's improvement is also in line with the worldwide commitment for accomplishing the 17 sustainable development goals (SDGs), as defined by the United Nations.

As previously outlined by [15], besides emotional regulation techniques, there is a need for further research to extend knowledge about burnout components or (de)motivators and their role in accelerating individuals' personal commitment to organizations' performance, incorporating the still limited knowledge on the components of QWL as a cornerstone of organizational performance.

In this line of reasoning, the current study provides an innovative assessment of the effects of burnout as a moderator of the relationship between employees' QWL and their perceptions of their contribution to the organization's productivity, highlighting the integration of the QWL factors into the trichotomy of (de)motivators of productivity in the workplace. By doing so, it makes a two-fold contribution, namely: (i) testing the moderating effects of burnout on QWL, disaggregating the interaction effects by motivators and hygiene per component of QWL; and (ii) revealing the burnout components, as de-motivators, which restrict or catalyze the relationships between distinct components of QWL and employees' contribution to productivity.

This paper is structured as follows: first, a literature review and the hypotheses are presented, followed by the research methodology. Then the results are discussed and conclusions drawn, ending with the limitations and implications of the study.

2. Theoretical Background and Research Hypotheses

2.1. Quality of Work Life and Productivity: From the Roots into an Integrating Model

Recovering the roots of the guiding literature on job satisfaction originated in QWL, Herzberg proposed a model where the factors involved in attaining job satisfaction are different from the factors that prompt job dissatisfaction [22]. Herzberg asserts that the opposite of job satisfaction is not job dissatisfaction, but instead no job satisfaction [23].

This theory, known as Herzberg's two-factor theory or motivation-hygiene theory, proposes that motivation factors are intrinsic to the job while hygiene factors are extrinsic to the job. The motivators or growth factors are achievements, recognition, the work itself, responsibility and advancement, while the hygiene or dissatisfaction-avoidance factors are: company policy and administration, supervision, interpersonal relationships, working conditions, salary, status and security [22,23]. The results of Herzberg's work indicate that motivators are the cause of job satisfaction and hygiene factors the cause of unhappiness on the job [23]. This theory was the subject of many scientific studies, some supporting this theory [24–28], while others counter it [29–32].

Moreover, more recently, another theory arose, the trichotomy of motivator factors in the workplace [33], based upon Herzberg's theory [22] and also the theory of tourist motivation factors [34]. The trichotomy of motivator factors adds another factor to Herzberg's two-factor theory and identifies three factors involved in job satisfaction: motivators, hygiene factors and de-motivators. This theory identifies as motivators for job satisfaction the following factors: bonuses, promotion opportunities, personal development opportunities,

flextime, cafeteria benefits, recognizing merit and training paid by the employer [33]. As hygiene factors, Koziol et al. identify compensation, working hours, workload, interpersonal relations, friendly atmosphere at work, industrial safety, work content, company policy, responsibility and social scheme activities. For the final and added de-motivator factors, the following are described: mobbing by superiors/coworkers, stress at work, work exceeding employee's psychophysical potential and qualifications, short-term contracts, employer's continuous and close supervision and lack of possibility of changing status quo/making improvements [33]. The author assumes the motivation factors represent the stimulants, the hygiene factors represent the nominants, while the de-motivator factors represent the denominants [33]. In addition, the author considers that in order to make improvements to the motivation system, the de-motivators (denominants) should be eliminated, the hygiene factors (nominants) should be optimized, and lastly, the motivators (stimulants) should be maximized [33].

With the motivation of designing an integrating model of the QWL factors into the trichotomy of (de)motivators of productivity in the workplace, it should be stressed that albeit there is a vast amount of literature on the subject of QWL, many researchers agree that QWL is different from job satisfaction and that it deals with employees' wellbeing [35–39].

Hackman and Oldham proposed a model in which the needs of psychological growth (skill variety, task identity, task significance, autonomy and feedback) were connected to QWL [40].

Walton (1980) considered eight conceptual categories in QWL [41]: adequate and fair compensation; safe and healthy working conditions; immediate opportunity to use and develop human capacities; opportunity for continued growth and security; social integration in the work organization; constitutionalizing the work organization; work and the total life span; and the social relevance of work-life.

According to Sirgy et al. [40], QWL can be expressed by the satisfaction of a set of employee needs in relation to resources, activities and outcomes associated with their participation at the workplace [39].

Considering employee's personal experiences, Martel and Dupuis (2006) define QWL as corresponding to the conditions experienced in the dynamic pursuit of one's own hierarchically organized goals within work domains [42]. Thus, reducing the gap that separates the individual from these goals will have a positive impact on the individual's general quality of life, organizational performance, and consequently on the overall functioning of society.

QWL can have distinct meanings based on individual perceptions, varying according to age, position in industry and career stage [43]. In addition, it should be noted that good QWL enhances wellbeing and satisfaction in the workplace [44].

According to Mejbel, Almsafir, Siron, and Alnaser (2013), the most common drivers of QWL are reward, benefits, compensation, career development, communication, safety, security, management involvement, the cohesion of work and life, job satisfaction and employee motivation [45].

As these examples from the literature of reference reflect, QWL is a multi-dimensional construct and can be described as a favorable working environment that supports and promotes satisfaction by providing employees with job security, growth opportunities, promotion, compensation and recognition [46]. QWL is associated with health, wellbeing, job security, job satisfaction, work-life balance, motivation, productivity and competence development [44,46], and it encompasses four main components: safe work environment, occupational health care, appropriate working time, and appropriate salary [47]. A poor working environment (e.g., poor safety and health, work pressure and stress) can also affect QWL, although in a negative way [48]. In fact, the work environment has been consistently reported as the most influential factor of QWL [49]. This is also in line with the previous findings of Leitão, Pereira and Gonçalves (2019), who underlined the importance of factors related to workers having their supervisor's support, being integrated into a good work environment and feeling respected, acting as positive influencers of QWL [50].

It is suggested that organizations should provide employees with a more secure work environment so that they can perform at their best level [51]. For organizations, a good QWL has been regarded as an essential tool to attract and retain employees [52–54]. Furthermore, QWL is important for organizations to achieve growth and profitability, obtaining more efficient and effective outcomes from employees [55].

The core objective of QWL in an organization is to improve the employee's wellbeing and productivity [37,56]. An organization cannot get efficient and effective outcomes from its employees without QWL since the latter is important for employees and necessary for the organization to attain growth [55]. Good management of QWL makes the organization's employees healthier, more committed, working and producing more and better [57]. Other studies have revealed positive correlations between QWL and productivity [53,58–60].

Considering the above-mentioned literature, the following research hypothesis is formulated:

Hypothesis 1 (H1): *QWL's motivating factors have a positive relationship with the contribution to productivity.*

Hypothesis 1a (H1a): *Appropriate working time has a positive and significant effect on the contribution to productivity.*

Hypothesis 1b (H1b): *An appropriate salary has a positive and significant effect on the contribution to productivity.*

Hypothesis 2 (H2): *QWL's hygiene factors have a positive relationship with the contribution to productivity.*

Hypothesis 2a (H2a): *A safe work environment has a positive and significant effect on the contribution to productivity.*

Hypothesis 2b (H2b): *Occupational healthcare has a positive and significant effect on the contribution to productivity.*

2.2. Burnout and Organizational Stress

The term burnout first appeared in the pioneering study by Freudenberger in 1974 [61]. While working as a psychoanalyst, he described his own experience as a combination of feelings, exhaustion and fatigue, a lingering cold, headache and gastrointestinal disturbances, sleeplessness and shortness of breath. Despite being first mentioned almost half a century ago, burnout is still a problem and is increasingly discussed. As the discussion about burnout increases, so does the use of the word as a catchphrase, an expression that includes a variety of conditions and symptoms [62] and steers away from the original meaning and purpose.

Despite the pioneering concept being introduced by Freudenberger (1974), the earliest accepted definition of burnout was only widely spread by Maslach, Jackson and Leiter (1996), reconceptualizing burnout as the syndrome of reduced personal accomplishment, increased emotional exhaustion and increased depersonalization experienced by individuals working closely with people [63]. Concerning the origin of this type of syndrome, the burnout results from experiencing chronic stress at the workplace have not been dealt with correctly [3,64].

In 2019, the World Health Organization (WHO) updated the definition of burnout and re-characterized it as a job-related phenomenon instead of a health or mental disorder. Burnout is now defined by WHO (2019) as: "a syndrome conceptualized as resulting from chronic workplace stress that has not been successfully managed. It is characterized by three dimensions: feelings of energy depletion or exhaustion; increased mental distance from one's job, or feelings of negativism or cynicism related to one's job; and reduced

professional efficacy. Burn-out refers specifically to phenomena in the occupational context and should not be applied to describe experiences in other areas of life".

Job burnout can be differentiated in terms of (i) emotional exhaustion; (ii) depersonalization; and (iii) lack of personal accomplishment [4–10,65], and is found mostly in people who have social professions, such as teachers, doctors and social workers [64]. For example, in the USA, burnout is more common among physicians than among other workers [66].

Despite affecting professional life, burnout has also been said to affect personal life [4,5,65,66] and employees' general health by increasing the possibility of developing sleep illnesses, obesity, diabetes, increased cardiovascular risk, faster aging, fatigue, low self-esteem, anxiety and depression [11,67]. Burnout also has been associated with suicidal tendencies and substance abuse [8,11,61]. Nonetheless, the main symptoms associated with and observed in burnout patients are chronic fatigue, continuous exhaustion, concentration disturbances, memory lapses, disorganization, lack of drive, personality changes, anxiety, depression and a low sense of personal accomplishment [11,66–68]. Somatic symptoms also occur and can appear in the form of headaches, gastrointestinal disorders and cardiovascular disturbances (e.g., tachycardia, arrhythmia and hypertonia) [68–70]. In its turn, it has been reported that smoking could have a protective effect against burnout, justifying that the reason could be that smokers take more breaks [71].

Regarding the professional aspect, job burnout has been associated with absenteeism, decreased productivity, organizational commitment, motivation and satisfaction [3,5,10]; reduced physical and mental health and affecting the quality of work [72]. In fact, the level of satisfaction in the workplace is found to have a decisive influence on workers' health [73]. Lower levels of burnout are found in people with a greater interest in their jobs [72]. On the other hand, high levels of burnout were reported as possibly indicating a negative attitude towards work and oneself, lack of interest and lack of satisfaction with one's work [74]. Indeed, in countries with higher burnout levels, people do not feel happy, are not satisfied with their jobs and do not feel engaged at work [75]. Job burnout has been stated as having a possible adverse impact on nurses' performance, work satisfaction and QWL [76]. It also has been reported that job burnout is also present among academics, in particular those who belong to public universities [77]. On the one hand, a high QWL has been associated with greater productivity at the workplace [50]. On the other hand, work-related occupational stress, anxiety and burnout are related to lower job performance [78] and lead to significant costs for organizations [1]. In organizational contexts, the costs of burnout are growing fast [8,11], affecting 13–25% of the working population [12]. In addition, more burnout cases occur in countries where economic performance is lower, and higher levels of burnout are observed in countries with lower GDP and longer working hours [75].

Nowadays, the labor force is subject to increased strain due to the uncertainty, competitive climate and job insecurity that decreases wellbeing and can contribute to converting employee commitment into burnout [5,79,80].

Schaufeli (2018) suggests that burnout should not only be seen as an individual psychological state but also as a collective phenomenon with economic and sociocultural ramifications at the national level. To combat this, organizations have already started to recognize burnout as an organizational issue and are trying to promote teamwork and improve the sense of community in order to encourage commitment [8,11].

A highly stressful environment cultivates higher burnout, as staff stress is a positive predictor of burnout, as previously shown in the literature [2,3,64,81]. Occupational stress can have a negative impact on the worker's productivity [82].

Both emotional exhaustion and burnout are considered extreme forms of stress, and as the former suggests energy depletion [83], a decrease in productivity is expected [84]. Singh (2000) identified a negative impact of burnout on productivity, mainly in terms of work quality rather than quantity [85]. Wright and Bonett (1997) also reported a negative association between emotional exhaustion and productivity, the former being the primary dimension of burnout predicting job performance [86].

Seligman and Schulman (1986) analyzed the relationship between optimism/cynicism at work and productivity, reporting higher productivity among optimists than pessimists [87]. The same authors found that pessimists seem to leave their jobs twice as frequently as optimists.

Regarding the low personal accomplishment associated with burnout, Nayeri, Negarandeh, Vaismoradi, Ahmadi and Faghihzadeh [88] identified a positive and significant relationship between personal accomplishment and productivity. The authors also found that employees with low levels of personal accomplishment only achieved low to intermediate levels of productivity. Conversely, employees with high levels of personal accomplishment achieved high to very high levels of productivity. Considering the previous literature, the following hypotheses are derived:

Hypothesis 3 (H3): *A burnout's de-motivating factors moderate the relationship between the QWL's motivators and hygiene factors and the contribution to productivity.*

Hypothesis 3a (H3a): *Emotional exhaustion restricts the relationship between the QWL's motivators and hygiene factors and the contribution to productivity.*

Hypothesis 3b (H3b): *Feelings of cynicism restricts the relationship between the QWL's motivators and hygiene factors and the contribution to productivity.*

Hypothesis 3c (H3c): *A sense of being less effective restricts the relationship between the QWL's motivators and hygiene factors and the contribution to productivity.*

2.3. Design of the Operational Model of Analysis

The literature review reflects that QWL is associated with health, wellbeing, job security, job satisfaction, work–life balance, motivation, productivity and competence development [44,46], including four main aspects: safe work environment; occupational healthcare (the QWL's hygiene factors); appropriate working time; and appropriate salary [47] (the QWL's motivating factors); and revealing that burnout (the burnout's de-motivating factors) can be associated with: emotional exhaustion; depersonalization; and lack of personal accomplishment [4–10,65]. Considering the small number of studies on the moderating effect of burnout on QWL, the current study pays special attention to the moderator effects of burnout de-motivator factors in terms of the relationship between QWL and contribution to productivity. Figure 1 below, bearing in mind previous studies and the research hypotheses originating from the literature review, proposes an operational model of analysis.

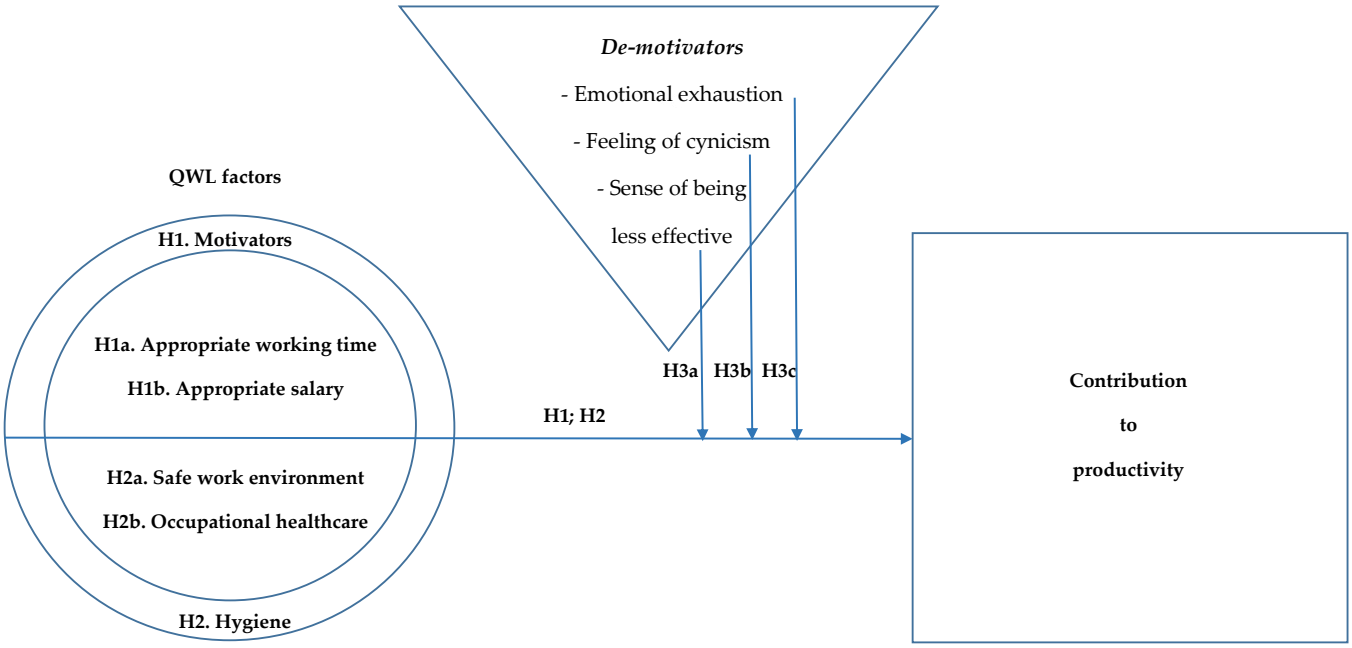

Figure 1. Integrating quality of work life (QWL) factors into the trichotomy of (de)motivators of productivity in the workplace: an operational model of analysis.

3. Methodology

3.1. Sample

The study comprehends the analysis of the responses to a survey funded on different questionnaires previously used to carry out related surveys on health and wellbeing in the workplace, including the pioneering measure on the quality of work life developed by Sirgy et al. [39] and the set of analytical tools surveyed and empirically operationalized by Leitão et al. [50].

The survey was conducted from April to July 2018. A total of twelve project partners originating from Italy, Bulgaria, Cyprus, Portugal, Greece and Spain participated in data collection by interviewing employees. The intention was not to interview company owners or general managers to avoid bias in the responses. A convenience sample based on a random selection procedure was used. In each organization, a contact person was identified to ensure completion of the questionnaire, which was afterward validated by the research team.

The questionnaires were applied through personal interviews to ensure a maximum response rate. The partners followed a set of instructions for selecting interviewees: 15 companies among micro, small and medium-sized firms (10% of interviewees for each category—EU definition of SME), plus five among large firms and public entities, involving two employees per organization and totaling 514 questionnaires.

This survey made it possible to identify several factors that are potential influencers of the desire of employees to contribute (or not) to organizational productivity (Leitão et al., [50]). Furthermore, it raised unexplored factors related to the stress and the physiological and psychosomatic condition of employees, as well as their linkages with the role played by environmental and health conditions at the workplace, in promoting wellbeing at the workplace as an organizational lever for increasing satisfaction, productivity and performance.

3.2. Measures and Preliminary Data Analysis

Table 1 below presents the sample characterization, showing that the respondents were distributed by gender as follows: 48% women; and 52% men. Regarding employee age: 9% are aged between 20 and 25; 34% between 26 and 35; 37% between 36 and 45; 14% between

46 and 55; and only 7% are older than 55. Concerning respondents' marital status, 35% are single, 59% are married, and almost 7% are in another situation. Regarding respondents' role in the organization, 18% say they occupy a managerial role, 67% a qualified role and 16% a non-qualified position. Regarding education, 51% have a university degree, 22% have a post-graduate degree, 19% completed secondary education, 7% completed 9 years at school, and only 1% completed 4 years. Concerning the sector of activity of the respondents' organizations, almost 2% belong to the primary sector, 14% the secondary, 77% the tertiary and 7% are from public organizations. Most respondents work in micro, small or medium-sized firms, 26% in microsized with 1 to 9 employees, 39% in small-sized with 10 to 49, 15% in medium-sized with 50 to 249, 14% in large companies with 250 to 1000 and only 6% in companies with over 1000 employees. Concerning the age of organizations, 16% are between 1 and 6 years old, 34% between 7 and 15, 25% between 16 and 29, almost 17% between 30 and 49 years and almost 8% have been in existence for more than 50 years. Concerning respondents' contract type, 68% say they have a permanent contract, 11% a contract for a stipulated period, almost 9% were temporary, 5% were freelancers, and 9% reported another type of contract. Finally, respondents were asked about their qualification inside the firm, with almost 7% identifying themselves as senior managers, 10% intermediary managers, almost 17% staff in charge, 21% highly qualified employees, approximately 25% qualified, 6% semi-qualified and 8% non-qualified. In addition, 3% answered they were apprentices, and 1% said they did not know.

Table 1. Sample characterization.

Variables	Type	Weight
Employee gender	Female	47.83
	Male	52.17
Employee age	20–25	8.61
	26–35	34.05
	36–45	36.99
	46–55	13.89
	55+	6.46
Employee marital status	Single	34.83
	Married/Union	58.66
	Other	6.52
Role in organization	Director/Manager	17.77
	Qualified	66.60
	Non-qualified worker	15.63
Employee education	4 years	0.78
	9 years	7.41
	12 years	19.10
	University education	50.49
	Post-graduate	22.22
Organization sector	Primary	1.96
	Secondary	14.29
	Tertiary	77.30
	Public	6.46
Organization size	Micro: 1 to 9	26.37
	Small: 10 to 49	39.06
	Medium: 50 to 249	15.23
	Large: 250 to 1000	13.87
	+Large: 1000+	5.47

Table 1. *Cont.*

Variables	Type	Weight
Organization age	1 to 6	16.41
	7 to 15	33.98
	16 to 29	25.00
	30 to 49	16.60
	+50	8.01
Employee contract type	Without time limit	67.77
	With time limit	11.13
	Temporary	8.79
	Freelancer	4.49
	Other	7.81
Employees' position inside an organization	Senior manager	7.25
	Intermediary manager	9.80
	Staff in charge	16.67
	Highly qualified	21.18
	Qualified	24.51
	Semi-qualified	8.24
	Non-qualified	8.63
	Apprentice	2.55
	Do not know	1.18

In this study, the dependent variable used is a contribution to productivity, as respondents were asked to what degree they feel they contribute to the organization's productivity. The independent variables used all regarding the different aspects of QWL, such as safe work environment, occupational healthcare, appropriate working time and appropriate salary. The variables used as moderators concern burnout: emotional exhaustion, cynicism and low effectiveness.

Table 2 below presents the descriptive statistics. It can be observed that 80% of respondents feel they contribute to their organization's productivity. The majority of respondents, 65%, feel that they have a safe work environment. Half the interviewees feel that their working time and salary are appropriate. It can also be observed that 37% of respondents reported emotional exhaustion, 20% reported cynicism, and 23% stated that they feel their effectiveness is low. In addition, the skewness and kurtosis statistics indicate a normal distribution of the variables studied. In addition, the variance inflation factors (VIF) do not indicate any potential problems of multicollinearity since they show a low average value of 2.39, which allows the subsequent ordinary least squares (OLS) regression analysis.

Table 2. Descriptive statistics and variance inflation factors.

Variable	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	VIF	1/VIF
(1) Contribution to productivity	514	0.8015564	0.3992165	−1.517	0.301	-	-
(2) Appropriate working time	514	0.5019455	0.5004833	−0.008	−2.008	2.08	0.481876
(3) Appropriate salary	514	0.5252918	0.4998464	−0.102	−1.997	1.98	0.506079
(4) Safe work environment	514	0.6536965	0.4762548	−0.648	−1.586	2.20	0.454185
(5) Occupational healthcare	514	0.4922179	0.5004265	0.031	−2.007	2.18	0.458808
(6) Emotional exhaustion	514	0.3715953	0.4837018	0.533	−1.723	5.73	0.174376
(7) Cynicism	514	0.2023346	0.4021317	1.486	0.210	5.34	0.187400
(8) Low effectiveness	514	0.2392996	0.4270716	1.226	−0.500	4.76	0.210019
(9) Female	514	0.4844358	0.5002446	0.062	−2.004	1.06	0.942902
(10) Married	514	0.5603113	0.4968328	−0.244	−1.948	1.11	0.902871
(11) Manager role	514	0.1770428	0.3820768	1.697	0.884	1.11	0.903050
(12) College education	514	0.7256809	0.4466052	−1.015	−0.974	1.08	0.927895
(13) Micro, small and medium-sized	514	0.8035019	0.3977365	−1.532	0.349	1.06	0.946222
(14) Contract without term	514	0.6750973	0.4687947	−0.750	−1.443	1.14	0.880920
					Mean VIF	2.39	

The pairwise correlations in Table 3 below reveal interesting associations between the contribution to productivity and three variables, that is, safe work environment, university education, and permanent contract, in a positive and significant way. On the other hand, a negative and significant association can be observed between the contribution to productivity and the feeling of low effectiveness. The safe work environment variable is negatively and significantly correlated with the variables of emotional exhaustion, cynicism and low effectiveness. Conversely, the safe work environment variable is positively and significantly associated with the variables of manager role, university education and permanent contract. The variable of occupational healthcare is significant and positively correlated with the variables of appropriate working time and appropriate salary. The appropriate working time variable is positively and significantly correlated with the appropriate salary variable and negatively and significantly correlated with the manager role. The appropriate salary variable is positively and significantly correlated with the female variable. Emotional exhaustion is positively and significantly correlated with cynicism and low effectiveness. Cynicism is positively and significantly correlated with low effectiveness and being female. Low effectiveness is positively and significantly correlated with being married.

3.3. Model Specification

The main reason for using OLS models is that the dataset analyzed follows a normal distribution, considering a dependent variable represented in binary terms, which allows determining the probability of the influence of a hypothetical set of independent variables arising from the literature review and the operational model of analysis proposed above. Therefore, the dependent variable takes the value of 1 when employees state they feel they contribute to productivity and 0 otherwise. Model 1 corresponds to the basic model specification. Models 2 to 4 represent the expanded model specifications, including interaction terms, to test the hypothetical moderator effects of various burnout components on QWL. Model 5 conjugates the 4 previous models' specifications. The OLS regression model takes the usual form of:

$$Yi = \beta 0 + \beta 1\ Xi1 + \beta 2\ Xi2 + \ldots + \beta k\ Xik + \varepsilon i \quad (1)$$

where: Yi takes the i's value on the outcome variable; β0 is the regression constant; Xij takes i's to score on the jth of p predictor variables in the model; j is the predictor j's partial regression weight, and εi is the error for case i.

Using matrix notation, Equation (1) can be represented as:

$$Y = X\beta 0 + \varepsilon \quad (2)$$

Y being an × 1 vector of outcome observations; X an × (p + 1) matrix of predictor variable values (with a column of ones for the regression constant); and ε is an × 1 vector of errors; where n is the sample size and p is the number of predictor variables. The p partial regression coefficients in β inform about each predictor variable's unique or partial relationship with the outcome variable.

Table 3. Correlation coefficient matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Contribution to productivity	1.0000													
(2) Appropriate working time nt	0.0312	1.0000												
(3) Appropriate salary	0.0447	0.2998 ***	1.0000											
(4) Safe work environment	0.2735 ***	0.0355	−0.0205	1.0000										
(5) Occupational healthcare	0.0801 *	0.2024 ***	0.1722 ***	−0.0277	1.0000									
(6) Emotional exhaustion	0.0091	−0.0151	0.0054	−0.1765 ***	−0.0404	1.0000								
(7) Cynicism	−0.0044	−0.0213	−0.0158	−0.1627 ***	−0.0115	0.3142 ***	1.0000							
(8) Low effectiveness	−0.1097 **	−0.0067	−0.0421	−0.2147 ***	−0.0141	0.1821 ***	0.2283 ***	1.0000						
(9) Female	0.0333	0.0001	0.0873 **	0.0346	−0.0044	0.0360	0.1126 **	0.0585	1.0000					
(10) Married	0.0310	0.0113	−0.0101	0.0143	0.0725	0.0566	0.0071	0.0834 *	−0.0197	1.0000				
(11) Manager role	0.0774 *	−0.0783 *	−0.0694	0.1341 ***	0.0021	0.0336	−0.0433	0.0027	−0.1028 **	0.1131 *	1.0000			
(12) University education	0.2079 ***	0.0416	0.0180	0.1390 ***	−0.0052	−0.0325	−0.0702	−0.0026	−0.0235	0.0527	0.1481 ***	1.0000		
(13) Micro, small and medium sized	−0.0374	−0.0128	0.0201	−0.0718	−0.0714	−0.0149	0.0297	0.0134	0.0091	−0.1421 **	−0.0143	−0.0736 *	1.0000	
(14) Contract without term	0.1235 ***	0.0816 *	0.0143	0.1761 ***	0.0100	0.0005	−0.0849 *	−0.0880 **	−0.0341	0.1889 ***	0.0715	0.1042	−0.1131 *	1.0000

Significance levels: * $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

4. Results

The results of the estimation process are presented in Table 4 below. Regarding the results of the first OLS regression (model 1), where the contribution to productivity was used as the dependent variable, we find that a safe work environment and occupational healthcare (i.e., QWL hygiene factors) positively and significantly influence the contribution to productivity, while low effectiveness (e.g., a burnout component) negatively influences the contribution to productivity. Moreover, the control variables used reveal that university education has a positive and significant influence on the contribution to productivity.

Concerning the analysis of model 2, where we studied the influence of burnout de-motivator factors, namely the emotional exhaustion on components of QWL related to the contribution to productivity, this confirms the previously identified positive and significant influence of both. Interestingly, when looking at the interaction between emotional exhaustion and appropriate salary (a QWL's motivator factor), the contribution to productivity increases. The same significant and positive sign is found concerning university education. QWL hygiene factors, safe work environment and occupational healthcare on the contribution to productivity. Once more, low effectiveness per se has a negative and significant influence on the contribution to productivity.

Looking at model 3, when assessing the influence of cynicism on the components of QWL hygiene factors, again, both a safe work environment and occupational healthcare have a significantly positive influence on the contribution to productivity. Cynicism shows a positive association with the dependent variable, whereas low effectiveness reveals a negative and significant association. Remarkably, cynicism combined with a safe work environment significantly restricts the contribution to productivity. Again, the same reported positive and significant association for university education is found.

Now observing model 4, which tests the influence of low effectiveness on QWL components in relation to the contribution to productivity, a safe work environment influences the contribution to productivity positively; again, the QWL hygiene factors showing an important effect. Moreover, from the control variables used, it can be seen that university education has a positive influence on the contribution to productivity.

Considering the last OLS model, model 5, where we considered the influence of both burnout de-motivator factors and QWL components on the contribution to productivity, the QWL hygiene factors, safe work environment and occupational healthcare influence the contribution to productivity positively. It is observed that the combinations of (i) emotional exhaustion and occupational health; (ii) cynicism and safe work environment; and (iii) low effectiveness and appropriate salary; restrict the contribution to productivity. On the other hand, having emotional exhaustion in combination with an appropriate salary is able to catalyze the contribution to productivity.

Table 4. Estimation results: basic and expanded models.

	Basic Model Specification	**Expanded Model Specifications (with Interaction Terms)**			
Dependent Variable: Contribution to Productivity	**Model 1**	**Model 2: Emotional Exhaustion × QWL**	**Model3: Cynicism × QWL**	**Model 4: Low Effectiveness × QWL**	**Model 5: Burnout × QWL**
Independent variables:					
Appropriate working time	−0.0106251 (0.0356739)	0.002724 (0.0450805)	0.0144145 (0.0402466)	0.0004014 (0.0415648)	0.015954 (0.0486371)
Appropriate salary	0.0248291 (0.0355056)	−0.0531801 (0.0443152)	−0.0046687 (0.0398339)	0.0458615 (0.0409572)	−0.0319938 (0.0475192)
Safe work environment	0.2026167 *** (0.0375959)	0.2264452 *** (0.0478003)	0.2552763 *** (0.0422751)	0.2266892 *** (0.043463)	0.2635709 *** (0.0513709)
Occupational healthcare	0.0689924 ** (0.0345356)	0.1043871 ** (0.0434402)	0.0638563 * (0.0384015)	0.0572153 (0.0397882)	0.0854087 ** (0.0463152)
Emotional exhaustion	0.0465404 (0.037038)	0.0371263 (0.0771303)	0.0538701 (0.0371588)	0.0426644 (0.0372002)	0.0096937 (0.0816304)
Cynicism	0.0495092 (0.0449866)	0.0441092 (0.0449138)	0.1513757* (0.0908087)	0.0562785 (0.0451581)	0.1416273 (0.0947152)
Low effectiveness	−0.0684219 * (0.0413764)	−0.0716486 * (0.0414406)	−0.0695572 * (0.0412559)	0.0237732 (0.0822762)	0.0110992 (0.0842447)
Emot_exhaus × App_work_time		−0.0335582 (0.072789)			−0.0033589 (0.0769073)
Emot_exhaus × Approp_salary		0.2158195 *** (0.0728621)			0.2129359 *** (0.0774649)
Emot_exhaus × Safe_work		−0.0578495 (0.0726563)			−0.0067044 (0.07659)
Emot_exhaus × Occup_health		−0.1050703 (0.0714138)			−0.129529 * (0.0755918)
Cynicism × App_Work_time			−0.1048213 (0.0867841)		−0.0921237 (0.0922984)
Cynicism × Appro_salary			0.1093108 (0.0864103)		0.0712437 (0.0918393)

Table 4. *Cont.*

	Basic Model Specification	Expanded Model Specifications (with Interaction Terms)			
Dependent Variable: Contribution to Productivity	**Model 1**	**Model 2: Emotional Exhaustion × QWL**	**Model3: Cynicism × QWL**	**Model 4: Low Effectiveness × QWL**	**Model 5: Burnout × QWL**
Cynicism × Safe_work			−0.2130826 ** (0.085264)		−0.1893905 ** (0.0900107)
Cynicism × Occup_health			0.0166369 (0.0860482)		0.037276 (0.0916919)
Low_effectiv × App_Work_time				−0.0493286 (0.0819525)	−0.0254765 (0.0835964)
Low_effectiv × Approp_salary				−0.1035448 (0.0832592)	−0.1828795 ** (0.0852819)
Low_effectiv × Safe_work				−0.0994873 (0.0819374)	−0.0561263 (0.0837742)
Low_effectiv × Occup_health				0.0750905 (0.0824151)	0.1080183 (0.0846726)
Female	0.0218044 (0.0339961)	0.0191741 (0.0338196)	0.0122917 (0.034039)	0.0207438 (0.0340773)	0.0093997 (0.0339436)
Married	0.0024119 (0.0349167)	0.0061544 (0.0348861)	0.0030183 (0.0348193)	−0.0003153 (0.0350419)	0.0025934 (0.0349261)
Manager role	0.0200969 (0.0452851)	0.0284628 (0.0450923)	0.0188389 (0.0451044)	0.0201053 (0.0457597)	0.0223733 (0.0454116)
University education	0.1534784 *** (0.0383223)	0.1526989 *** (0.0382553)	0.1447968 *** (0.0382664)	0.1539299 *** (0.0384025)	0.1469154 *** (0.0383266)
Micro, small and medium sized	0.0056381 (0.0427898)	−0.0016807 (0.042634)	0.0010696 (0.0426245)	0.0038388 (0.0428799)	−0.0062275 (0.0426168)
Permanent contract	0.0513097 (0.0372964)	0.052821 (0.0370996)	0.0537378 (0.0373525)	0.0505762 (0.037627)	0.0542539 (0.0374733)
No. of observations	514	514	514	514	514
R2 (adjusted)	0.1278 ***	0.1461 ***	0.1445 ***	0.1345 ***	0.1676 ***

Standard errors in brackets. Significance levels: * $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$.

5. Discussion

According to the results obtained, all OLS models (1–5) give support to H2, stating that the QWL's hygiene factors have a positive and significant effect on the contribution to productivity, and this is in line with previous literature [51], which states that a safer work environment will make employees perform at their best level, also in line with the previous findings of Kiriago and Bwisa (2013) and Leitão et al. (2019) [48,50], who found a negative correlation between a poor work environment and QWL. This agrees with previous work that considers health an important component of QWL [41,44,46]. Furthermore, as Herzberg's work shows, not having balanced hygiene factors causes no job satisfaction [48]. In addition, the results obtained are aligned with prior theories suggesting that the hygiene factors (i.e., nominants) should be optimized in order to achieve satisfaction on the job [59], being the latter associated with employees' sense of contribution to productivity. This is also aligned with previous works defending that QWL can be expressed through the satisfaction of a set of employee needs, which is associated with their participation, contribution at the workplace [29]. No significant direct effects related to hypothesis 1 were found.

According to the results obtained with model 1, the H2a and H2b cannot be rejected. Notably, regarding th Herzberg's hygiene factors, having a safe work environment and benefiting from occupational healthcare schemes is able to catalyze the contribution to productivity. The same support is found in models 2, 3 and 5. In model 4, it is found to support only for H2a.

The current study raised and tested a set of hypotheses around a burnout's de-motivator factors (that is, emotional exhaustion, cynicism, and sense of low effectiveness) and their moderator role on the relationship between the QWL's motivators and hygiene factors, and the contribution to productivity. In fact, it is found support for H3a (in models 2 and 5), H3b and H3c. (in models 3 and 5). Indeed, benefiting from an appropriate salary, schemes of occupational health (QWL's motivators) at work coupled with emotional exhaustion restricts the relationship between QWL and contribution to productivity (H3a), which is aligned with previous work [11,66–68,78,87]. Highly stressful working environments are associated with a higher burnout, being staff' stress a positive predictor of burnout, as prior studies already conveyed [2,3,64,81]. Both emotional exhaustion and burnout impact negatively on the worker's productivity [82], being extreme forms of stress, causing energy depletion [83], and thus slowing productivity [84–86]. The results now obtained ratify previous findings, connecting QWL's motivators and hygiene factors with emotional exhaustion (the primary dimension of burnout), pointing out a negative impact of burnout on productivity.

Moreover, the empirical evidence now obtained signals that cynicism, a form of pessimism, restricts the relationship between the QWL's motivators and hygiene factors, and the contribution to productivity, thus supporting H3b. Such results are in line with prior literature, which addressed the relationship between optimism/cynicism at work and productivity, concluding that optimist workers are more productive at work than pessimists [87]. In addition, cynic and pessimist workers are more absent than optimists are. The current study underpins a negative and significant effect of the burnout's de-motivator factor, cynicism, as well as its moderator role on the relationship between the QWL's hygiene factors (such as having a safe workplace) and the contribution to productivity (as found in models 3 and 5). Optimistic workers positively affect the effect of hygiene factors, such as safe work environments, on the sense of job productivity.

Taking as reference the results obtained in model 5, there is support for H3c, as there is evidence of a negative and significant effect of the burnout's de-motivator factor, low effectiveness of the workers, and its moderator role on the relationship between the QWL's motivators (such as having an appropriate salary), and the contribution to productivity. This is aligned with previous literature [87,88] that advocated a positive influence of personal accomplishment on productivity and suggesting that workers that feel low personal effectiveness, which this associated with burnout, are less productive on the job. The

empirical findings now obtained also unveils that low effectiveness, when combined with appropriate salary, restricts the contribution to productivity. These results highlight the importance of implementing a set of initiatives for fighting job-related burnout, as in terms of costs, it is estimated that it affects between 13 and 25% of the working population [8,11], influencing employees' performance and thus firms' productivity. From the current findings, it is also possible to provide lines of action, namely designing appropriate payment schemes, including benefits programs targeted to personal expenses cut for the employee or related persons, which in turn proved to have a role on the sense of job effectiveness and contribution to the firms' productivity.

Our findings also suggest that workers with higher qualifications (like having a university degree) are also more productive, also bearing in mind that almost 50% of our sample population is college-educated.

6. Conclusions

This study provides an integrating model of QWL factors into the trichotomy of (de)motivators of productivity in the workplace. To do so, the original Herzberg's motivators (workers' appropriate working time and appropriate salary) and hygiene factors (having a safe work environment and benefiting from occupation healthcare schemes) are integrated as QWL factors, as well as the moderating effects of three burnout factors, i.e., the de-motivators, namely, emotional exhaustion, cynicism and low effectiveness, in order to assess the moderator role of burnout on the relationship between the employee's QWL and perceptions of their contribution to the organization's productivity.

Taking as reference the results obtained through estimation of the complete expanded model specification (i.e., model 5), it is worth noting that concerning QWL's motivators and hygiene factors, such as having an appropriate salary, having a safe work environment and benefiting from occupational healthcare, are confirmed as positively influencing employees' contribution to productivity. Additionally, new light is shed on the role played by burnout factors, the so-called de-motivators, as a moderator of the relationship between QWL and contribution to productivity. On one hand, the coefficient associated with the interaction term of feeling emotional exhaustion and being appropriately paid denotes a catalyzing effect on the workers' contribution to productivity. This reveals a positive and significant effect of an appropriate salary on workers feeling burned out, which can act as a compensating catalyst of their contribution to the organization's productivity. On the other hand, the coefficient noticed on the interaction between emotional exhaustion and having occupational healthcare in the organization shows a negative and significant effect, which can restrict the positive relationship between QWL and contribution to productivity.

The interaction between workers feeling cynics and having a safe work environment also contribute significantly to restricting the relation between QWL and workers' sense of productivity. Another interesting point is that university education has a significant and positive influence on employees' contribution to productivity.

The empirical findings now obtained point out that workers are feeling low effectiveness restrict the relationship between the QWL's motivator factors (such as having an appropriate salary) and their contribution to productivity.

These findings are particularly relevant given the lack of scientific knowledge about the role played by burnout de-motivator factors in absenteeism in the labor market, affecting the relationship between QWL and productivity in organizations. The current findings contribute to advancing knowledge about the interaction between QWL and certain burnout components, which can catalyze or restrict the relationship between QWL and contribution to productivity, guiding the decision-making process and human capital management to foster organizational productivity through QWL, considering burnout levels. This study allows for both theoretical and practical implications in an innovative manner. In the first hand, in terms of theoretical implications, it integrates QWL factors, both motivators and hygiene, into the trichotomy of burnout de-motivators of productivity in the workplace. On the second hand, a set of practical implications can also be derived

to leaders and managers that are responsible for designing and implementing innovative occupational health programs in the workplace, for instance: (i) creating the conditions for spurring safe work environments; (ii) designing appropriate occupational healthcare schemes; (iii) creating appropriate salary compensations to balance the stressful working environments; (iv) working on safe job conditions to counterbalance more cynicism attitudes at work; and (v) compensating employees accordingly to promote more job effectiveness, favoring QWL and productivity in the workplace.

The main limitation of this study lies in the impossibility of carrying out a study with a time dimension that could evaluate hypothetical causality relationships between subjective and behavioral components and organizational productivity. Another limitation concerns the response variable representing productivity is based on a subjective measure of the employees' perception of contribution to productivity.

To expand this topic, deeper research is recommended with a more comprehensive study about the relationship between QWL, burnout, and contribution to productivity, considering different stress environments in the light of turbulent and fast-changing work ecosystems. This would mean working within the organizational context versus distance work (or working from home), contrasting innovative practices of human capital management, including organizational innovation, organizational polyvalence, long-distance project management, creativity labs, organizational hubs, work–life balance and wellness.

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Institutional Review Board Statement: Ethical review and approval were waived for the study on human participants in accordance with the European legislation and institutional requirements applicable in this study, which was not conducted in our originary Higher Education Institution. The study was funded in the scope of the previously referred R.E.NewAL. SKILLS project and the board governance structure of this project established a quality assurance, evaluation and monitoring framework, through which had created the R.E.NewAL. SKILLS Contents Quality Plan (REC-QP) to ensure defined and shared quality standards for the contents production, including the questionnaires for gathering data, as well as identifying key-roles among partner representatives and scores to be achieved by the contents produced. Such plan created a set of committees to ensure ethical procedures, quality control, efficiency and monitoring: a General Assembly, the ultimate decision-making body of the consortium and supervisory body for the execution of the project, coordinated by a representative of the Lead Partner (Coordinator of the General Assembly) acting as chairperson; and a Curriculum Committee (CC) made of RENewAL Contents Quality Managers (CQMs), selected by partner organizations among their staff, responsible for the quality control of R.E.NewAL. SKILLS contents, such as the survey questionnaire. The design of the questionnaire and methodology used to collect data was approved by the General Assembly, the partners and the CC, assuring that the methods of data collection, the conformity of the questionnaires and the subsequent anonymized treatment complied with ethical and quality standards, with published results not containing any entity identifying information. At last, the Education, Audiovisual and Culture Executive Agency (EACEA) approved the outputs of the R.E.NewAL. SKILLS and closed the project with success.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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sustainability

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Review

Public Administration and Values Oriented to Sustainability: A Systematic Approach to the Literature

Isabel Marques [1], João Leitão [2,3,4,5,*], Alba Carvalho [1] and Dina Pereira [3,4]

[1] Department of Management and Economics, University of Beira Interior (UBI), 6200-209 Covilhã, Portugal; isabel.marques@ubi.pt (I.M.); albakattarine@msn.com (A.C.)
[2] Faculty of Social and Human Sciences, NECE–Research Center in Business Sciences, University of Beira Interior, 6200-001 Covilhã, Portugal
[3] Research Center in Business Sciences (NECE), University of Beira Interior, 6200-209 Covilhã, Portugal; dina.pereira@tecnico.ulisboa.pt
[4] Centre for Management Studies of Instituto Superior Técnico (CEG-IST), University of Lisbon, 1049-001 Lisboa, Portugal
[5] Instituto de Ciências Sociais, ICS, University of Lisbon, 1600-189 Lisboa, Portugal
* Correspondence: jleitao@ubi.pt; Tel.: +351-275-319-853

Abstract: Values guide actions and judgements, form the basis of attitudinal and behavioral processes, and have an impact on leaders' decision-making, contributing to more sustainable performance. Through a bibliometric study and content analysis, 2038 articles were selected from Scopus, from the period 1994–2021, presenting global research tendencies on the subject of values, public administration, and sustainability. The results indicate that *Sustainability* is the most productive journal, the main research category is in social sciences, the most productive institution is the University of Queensland, the location with the most publications and research collaborations is the USA, and the authors with the greatest number of articles are Chung, from Chung-Ang University; García-Sánchez, from the University of Salamanca; and Pérez, from the University of Cantabria. Analysis of keywords shows that the most relevant are "sustainability", "CSR", "sustainable development", "innovation", and "leadership". Time analysis of keywords reveals a tendency for lines of research in the social and work area. The results also provide data about the framing of studies in sustainability pillars and the types of values referred to and indicate the main areas of public administration studied. Finally, a future research agenda is proposed.

Keywords: public administration; public sector; values; sustainability

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1. Introduction

The main motivation of this systematic literature review is related to the scarcity of literature reviews that deal with the problem of public administration and values oriented towards sustainability. In this vein, it is necessary to map political, cultural, ethical, moral, aesthetic, ecological, vital, spiritual, and religious values to understand the different ways in which organizational and individual values have been addressed in the literature, as well as the contributions of skills, managerial techniques, and moral competence having a behavioral effect, which allows for the achievement of a balanced exercise of sustainability. In this sense, the administration of public institutions requires the adoption of ethical principles and values oriented towards the effective and efficient use of public resources with the ultimate aim of contributing to increased social well-being. Ethics and values, although often used as synonyms, do not have the same meaning, with ethics being the mental process that comes into action when the individual is deciding between right and wrong, or assessing two rights, where the process of appropriate decision-making principles is established for when different values enter into conflict [1]. For the same authors [1], having values represents understanding the importance of ethical processes for decision-making; being ethical helps in choosing the correct values.

From an organizational perspective, ethics should be understood as a horizon of shared values, where organizational practices are directed and transformed simultaneously, creating an important ethical meaning [2]. In organizations, true values are noted in leaders' decisions, in the way people are rewarded and promoted, in the assessment methodology, and in corporate practices [3], and they can influence various aspects, such as employees' feelings towards the organization [4] and human well-being [5]. Bettinger [6] states that a robust corporate culture, where values are rooted in the organization, is one of the key factors contributing to long-term, sustained high performance, as values allow greater work engagement, and consequently, greater prosperity [7].

In this context, value-based management is a process of rooting values continuously at the heart of organizations in order to form a true culture of values. Dolan and Garcia [8] indicate that value-based management is a strategic management tool with the triple usefulness of simplifying, guiding, and developing employees' behavior. However, despite efforts to create value for these and other stakeholders, organizations have not managed to implement, fully and effectively, their sustainability policies [9].

The notion of values is especially appropriate in public service [10], considering that this should be permeated by values that benefit citizens collectively [11], covering aspects of integrity, legality, and participation related to good governance [12]. Recently, conflicts of values in the circumstance of the modernization of public services have been shown, particularly regarding the principles of reform concerning the paradigm of New Public Management (NPM), which aims to ensure greater efficiency and effectiveness of public services in countries belonging to the Organization for Economic Cooperation and Development (OECD) [13]. Public service is substantially different from the private sector, considering that rather than dealing with a market environment and with a limited number of stakeholders, public service relates to a political environment involving various individuals and external organizations [14]. In addition, government objectives and restrictions placed by political authorities ensure that private sector practices cannot be indiscriminately transferred, partly due to the different operational environment, which seems to have an impact on organizational culture and to be a challenge in public service.

Concerning public management specifically, although the subject is relevant, with a significant number of studies addressing organizational values, few studies focus on the dynamics inherent to the concept of values, allowing theoretical constructions and bibliographic measurements in the context of public management, which is also related to organizations' sustainability.

In this context of analysis, it is considered relevant to verify the typology of the values adopted in the administration of public institutions, which, combined with managers' technical skills and moral competence, can ensure the ultimate goal of sustainability.

This systematic approach contributes to the literature by mapping the main streams, areas, contributions, contributors, institutions, and locations associated with the topic of values attributed to sustainable public administration, providing a future research agenda grounded on the most important clusters found in the set of reference studies selected.

The current systematic literature review is organized as follows. Firstly, it provides an overview of the main literature streams and the conceptual framework in use. Secondly, it presents the materials and methods. Thirdly, the results and discussion are presented, based on bibliometric analysis and qualitative content analysis. Fourthly, the conclusion and avenues for future research are provided.

2. Literature Review and Conceptual Framework

2.1. Axiology and Organisational Values

Axiology concerns the study of values in a wide-ranging way, expanding their meaning and articulating economic, ethical, aesthetic, and logical questions that are traditionally considered separately. For Modin [15], Nietzsche is the father of axiology, although Lotze was the proposer. This is because Nietzsche, with his criticisms, sought to break down all the absolute values of logic (truth), morality (virtue), metaphysics (being) and religion

(God), pointing to their decadence and alienation. Secondly, he proposed the dynamism of the value of life, a life that accepts in itself all its expressions. For McArdle, Hurrell, and Muñoz Martinez [16], axiology allows an understanding of the influences of beliefs and values on life experiences, human actions, and perceptions.

Until the mid-1970s, research was formed of empirical studies, but these were limited by groups' own particular construction and the methods adopted, which did not allow systematic comparison between the studies made. Research carried out in 1973 [17] harmonized the relation between systematic research of the theory of values and established the connection between values and behavior, where by recognizing their values, individuals should predict their behavior. Other authors [18] consider values as being principles acting on behaviors, going far beyond specific situations and directing behaviors, ordering them according to their relevance. A more contemporary definition [19] summarizes values as lasting beliefs that serve as a reference for action and vary very little according to the circumstances. In turn, Schwartz [20], developing the theory of universal basic human values, presents the fundamental characteristics for values that form a system of priorities characterizing individuals and guiding actions. For this author [21], individual values differ from cultural ones, considering that the individual's axiological priorities are the result of shared culture and unique personal experience, whereas cultural values help society to mold contingencies to which people must adjust. Frunză [22] proposes that values can be used as resources to guide actions, situations, and states in organizations.

In recent decades, values have been defined as the classification of collective principles orienting action, or how a collective tries to act, forming a consensus that a social or organizational group judges to be relevant to achieve objectives and collective well-being [22]. Frunză [22] states that the idea of the relativization of values has spread in recent times, allowing the formation of new hierarchies of values considering individual or organizational needs. The author also mentions that the organization should be seen not just as a place of work, but also as part of employees' development and personal fulfilment.

2.2. Public Administration and Competing Values

Authors discuss that values between private and public organizations differ in practice, and this is an empirical question, considering that they are shown through attitudes, preferences, decision-making, and actions [23]. With globalization, public organizations have come under pressure to find a common governance system. The consequence of this is the increasing similarity between the values and principles of public administration worldwide [24]. Oldenhof, Postma, and Putters [25] conclude that public management is characterized by multiple conflicting values, such as impasses between efficiency and equity, efficiency and democratic legitimacy, and equity and freedom, among others. The study by Van der Wal, Graaf, and Lasthuizen [23] follows in this direction, finding that although public managers consider values such as legality, impartiality, and incorruptibility as the most important in the sector, many private sector values, such as expertise and effectiveness, are also indicated by these professionals. In this context, Villoria [26] points out that the managers of public organizations face four types of value conflicts: (i) between political and organizational values; (ii) between organizational and social values; (iii) between organizational and economic values; and (iv) between economic values themselves. These conflicts require of managers solid decision-making that is aware of the consequences, marked by technical skills but also by moral competence [27].

Renshaw, Parry, and Dickmann [28] point out that many studies address the term "organizational values" without a proper definition, probably due to the difficulty of conceptualizing it, bearing in mind that values are often positioned as constructs at the individual level [29]. However, it should be noted that organizational values are important components of the organizational culture [30] and principles that are responsible for the successful management of organizations [31]. Concerning individual values, these can be defined as the internalized beliefs held by individuals about the way they should

behave [32], according to their personal experiences [33], culture, and the social system where they are inserted [31,33].

Thus, it is also important to note that there is a tension between both types of values. Public employees are exposed to conflicting demands, which they must meet [34]. This conflict stems from the need to respond to citizens, align their decisions with the interests of co-workers [35], and adapt their preferences, functions, and identities to the organization in which they are located. At the same time, public institutions need to meet demands, presenting the best results and using fewer resources, and have the challenge of integrating these employees into the organization and its standards. This adjustment process between the parties corresponds to so-called organizational socialization [36].

Individuals who are part of public organizations are often frustrated with their restrictions and ambiguities [37] and with the organizational ownership of values in the public service [38]. Considering the importance of congruence between organizational and individual values, in terms of individuals' attitudes and behavior [39,40], to reach better individual performance [39–41] and to ensure the organization's success [41], the key role played by the leaders to encourage this alignment of values is considered fundamental. In this ambit, transformational leadership is a powerful a tool that can be used by managers to promote an oriented process for alignment and congruence of values in the public service [41,42].

Public organizations come under double pressure: on one hand, competitiveness and the need to improve their economic position, service provision, and efficiency, and on the other, pressure to maintain traditional, historical management practices [43]. Therefore, there is discussion about the set of values that should guide public administration [44], with the consensus being that there are multiple value systems that are often in conflict, such as the dualities, for example, between efficiency and effectiveness, or impartiality and legality. Public organizations present the need for "renewal" in both political and administrative aspects in order to obtain the best strategies for their institutions to achieve their objectives, providing society with efficient services [45]. To do so, organizational culture is one of the key points in understanding human actions [46].

In this context, Peng and Pandey [47] mention the importance of autonomy as a driver of individuals internalizing public organizational values, which is in the public interest as these tend to help them face the conflicts experienced by individuals concerning the complex decisions of the actions of public administration management. In the context of New Public Management (NPM), civil servants are expected to perform their roles, duties, and tasks differently in responding to citizens' needs and demands. This is reflected in a call for a normative change in the organizational culture of the public sector, which should be accompanied by a similar change in the team's vision, perceptions, and will to adapt to that culture. Therefore, the change in values, at both the macro-organizational and micro-personal level, should be aligned to create a harmonious functioning of modern bureaucracy [48]. For the authors, new policies will be successful only when the individual is comfortable with the process of value transformation and the new organizational culture. Those values portray the need to improve internal and external processes of effective management, strengthening the relationship with the public and developing strategic thinking directed at clearer and measurable objectives, in the same ways as private companies operate [48]. As for the hierarchical aspect, as occurs with people, organizations differ, not so much through having different values, but by the degree of importance given to each of them, indicating that values represent guidelines for the organization's life, influencing its members' behavior [49], with shared values having important functions in the organizational context.

Zhong, Bao, and Huang [43] say that the values of work in public organizations have been subject to considerable study in recent decades, mainly after NPM. Management based on values is considered an important tool for human resource management [50], as it guides employees' attitudes and influences their performance at work [51].

2.3. Public Value and Organizations' Sustainability

Following the UNESCO (United Nations Educational, Scientific, and Cultural Organization) vision, sustainable development is the comprehensive paradigm of the United Nations, described by the 1987 Brundtland Commission Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [52]. Sustainable development has four interconnected dimensions (i.e., society, environment, culture, and economy). Sustainability is a paradigm facing the future in which environmental, social, and economic considerations are balanced in the search for improving the quality of life, which is considered a long-term goal, while sustainable development refers to the various processes and paths to achieve it. In 2015, all member states of the United Nations adopted the Sustainable Development Goals containing 169 goals that countries seek to achieve by 2030. According to Clar et al. [53], the public sector faces some barriers to the adoption of policies that lead to sustainable development, such as lack of commitment, inadequate or unclear responsibilities, inadequate cooperation between political actors, insufficient financial and human resources, and lack of evidence or certainty in relation to global scenarios [53]. Promoting governance and providing better ways to link science to policymaking enables decisions to be based on good research that emphasizes trade-offs and multiple possibilities for action [54]. The dimensions of public value focus on organizational performance, presented as a benefit [55] and covering the dimensions of efficiency and effectiveness of public value and environmental sustainability, reflected in critical public value and understood positively by citizens in contexts of developing countries [56]. Some government projects have emerged to encourage public managers to embrace practices that arouse socio-environmental responsibility, while also approving responsible practices as a part of their long-term sustainability strategy [57]. Public administration is based on satisfying two needs: society demands creative, flexible treatments directed towards innovation, while economic tension and budget cuts force uses and models directed towards efficiency, competitiveness, and cost economy [58]. The new organizational system of public governance must integrate creativity, innovation, and flexibility to be able to achieve sustainability and public value.

Public value is related to a principle that must be continuous or a standard that must be met by public organizations when they regulate or provide their services, and it can be exteriorized through codes, ethics, norms, or principles [59]. Such values help organizational members to understand how they should act in that organization [60], serve as a link between civil servants' daily work and the general objectives of democratic governance [61], and are relevant for organizations, individuals, and societies. Attitudes and interpersonal interactions in organizational environments are affected by values and are seen as stimulating personal choices [62]. By taking with them their personal beliefs, choices, and actions into organizations, individuals count on them to make decisions [63], even if what forms the value(s) of public service differs from one country to another [64], considering that understanding the roles of values involves much questioning related to ethics in public administration [65]. For Hossain et al. [10], public service should serve the public interest as a way to ensure institutions' sustainability, and although some unethical and illegal practices persist, leading to public distrust, not all the behavior of civil servants is considered unethical, and some of this should be encouraged by stimulating practices to ensure such behavior is applied.

This reflection leads to the presentation of a conceptual structure (Figure 1, below) showing that different values, in both public administration and the sphere of private services, should be built and shared setting out from individuals, through the culture molded in organizations, and followed by top management and organizational members. Despite the existence of possible conflicts between those values, the behavioral effect arising from managers' technical competences and morals leads to organizations' social, economic, and environmental sustainability. The double bond "refers to the two feedback circuits that connect the observed effects of the action with strategies and values served by the strategies" ([66], p. 21). In this study, both organizational and individual values

are connected with technical skills at the level of competence of the managers who have a critical influence on the sustainability of public institutions. The combination of values, skills, and level of competence can stimulate new entrepreneurial practices that will lead to a sustainable pathway. Authentic leadership depends on the organizational context and an individual's positive psychological attitude, and it determines the self-awareness and self-regulated positive behavior of leaders and employees [67].

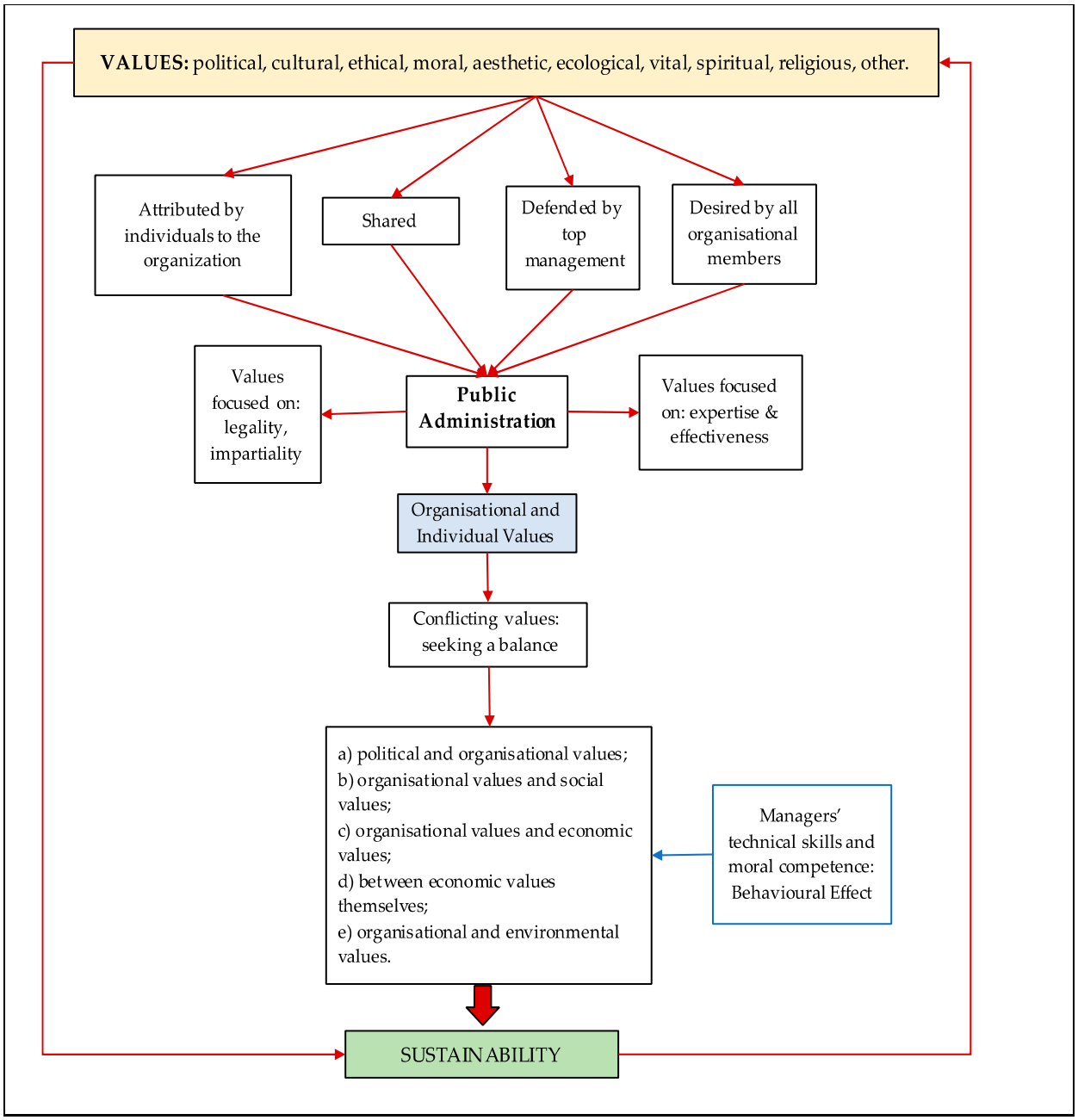

Figure 1. Conceptual structure of organizational values for institutions' sustainable reach. Source: Elaborated by the authors, adapted from Van der Wal, Graaf, and Lasthuizen [23]; Villoria [26]; and Ling, Wang, and Feng [27].

3. Materials and Methods

The research methods used were bibliometrics and content analysis of articles selected from the Scopus database (collected on October 8, 2020) due to its extent, reliability, and coverage [68]. The Scopus database was chosen due to its multidisciplinary nature and

large coverage. In addition, it is peer-reviewed, has daily updates, and has resources that assist the user in the searches carried out on the website, as well as creation lists for storing documents in the database during the search session, with structured searches by author and subject. The main advantages are: (i) inclusion of titles available in open access; (ii) wide coverage in terms of science and technology journals; (iii) tools for identifying authors; (iv) automatic generation of the h-index; (v) inclusion of more European content than Web of Science (WoS); and (vi) integration of more languages than English. An interesting feature is that although the Scopus database was not designed as a citation index, it includes citations from articles dating back to 1996.

From a number of options for choosing articles guiding the values of public administration, the key words of "public administration", "public sector", "values", and "sustainability" were used in the "All" box, adding to the search "and", which resulted in 9698 articles. Limiting the areas reduced this to 2038 articles, as presented in Figure 2.

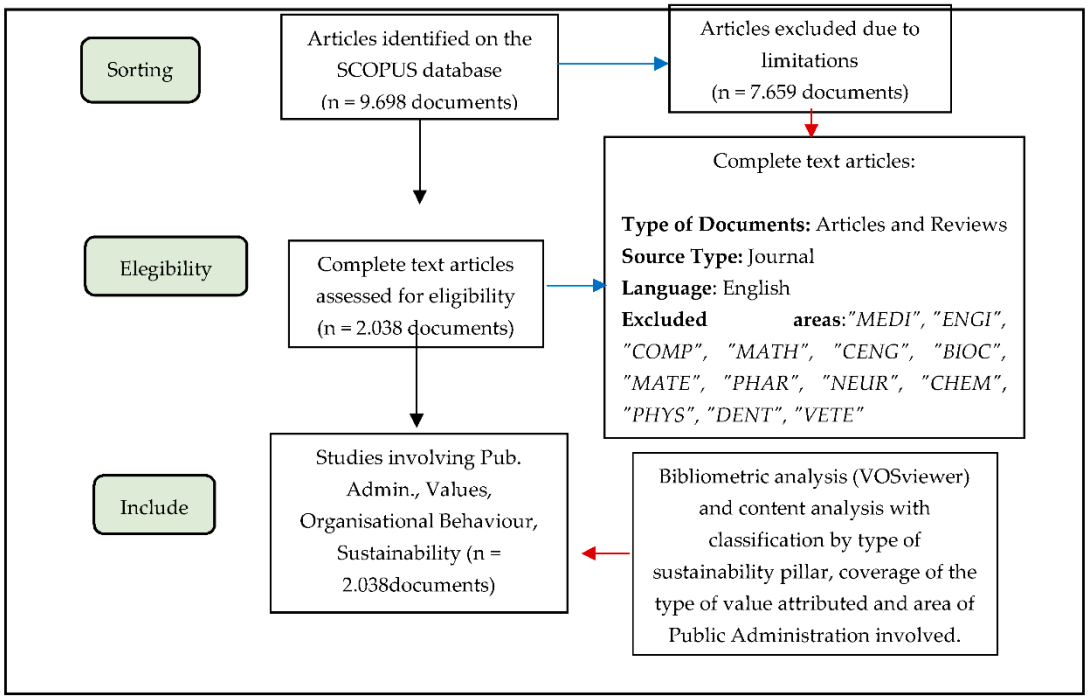

Figure 2. Method for selecting and including articles for analysis. Source: Own elaboration.

For the bibliometric analysis—which is the study of the measurement of scientific and technological progress and consists of quantitative assessment and analysis of comparisons of scientific activity, productivity, and progress [69]—VOSviewer (version 1.6.10., University of Leiden, Leiden, the Netherlands) was used to map and process the articles due to its reliability and suitability for bibliometric analyses. The relations between authors, institutions, and co-authors' locations were analyzed and interpreted based on the co-authorship of each study, and the relations between the keywords of all the documents was analyzed based on their co-occurrence [70]. Analysis of co-occurrence gives a graphic view of the interconnection of key terms in the documents [71]. Co-authorship analysis can reveal scientific collaboration and identify research groups [72].

For the qualitative stage, the data were studied using both an inductive and deductive method of content analysis [73,74]. The Abstract, Introduction and Results of the articles were read (i) to classify them as fitting one of the pillars of sustainability (environmental, economic, social) most associated with the subject of the article; (ii) to perform quantitative identification of the types of values found; and (iii) to identify associations between the values and sustainability pillars they are related to (political, ethical, ecological, moral, and others), (iv) the distribution of studies according to the major areas of public administration,

(v) the relation between the areas of public administration and the pillars of sustainability, and (vi) the relation between the areas of public administration with greatest emphasis and the values attributed to them. In this way, researchers, academics, managers, and others can benefit from the results arising from assessment in this area of research.

4. Results and Discussion

4.1. Bibliometric Analysis

4.1.1. Publications, Citations, and Areas of Research

Figure 3 shows the trend of evolution of publications on the topic studied. From the final selection (n = 2038), the articles were stratified according to the dates of publication, which cover the 1994–2020 period. From the total sum of 2038 articles identified, 1449 were published in the last 5 years, 2016 to 2020, which is 71.09% of all scientific production in these 28 years. This result reveals the growing interest and relevance of the topic.

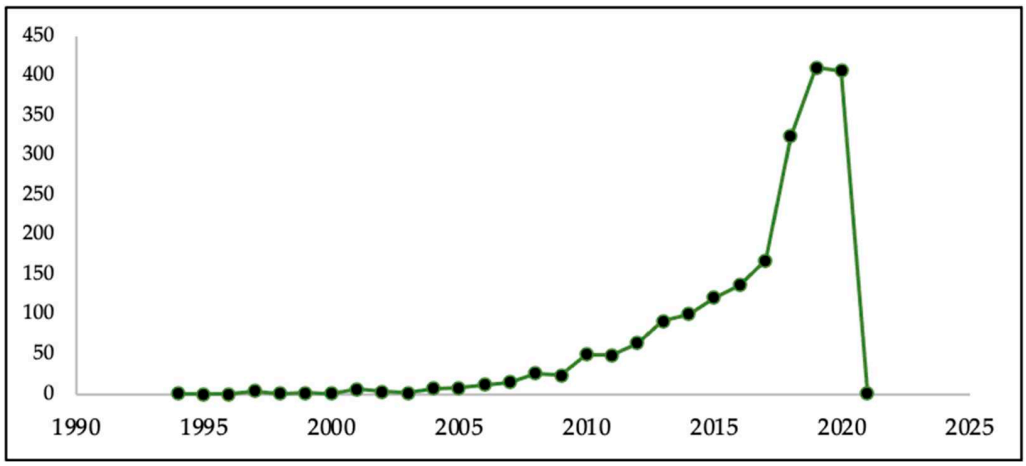

Figure 3. Number of articles included in the study, over 28 years. Source: Own elaboration.

Analyzing the evolution of citations (Figure 4), articles published before 2000, despite being few in number, had 13.758 citations, demonstrating that these articles have served as the basis to build scientific knowledge on the topic. In comparison, the most recent articles present a lower number of citations. This may be explained by the high number of articles, which has the effect of a greater distribution of citations among them.

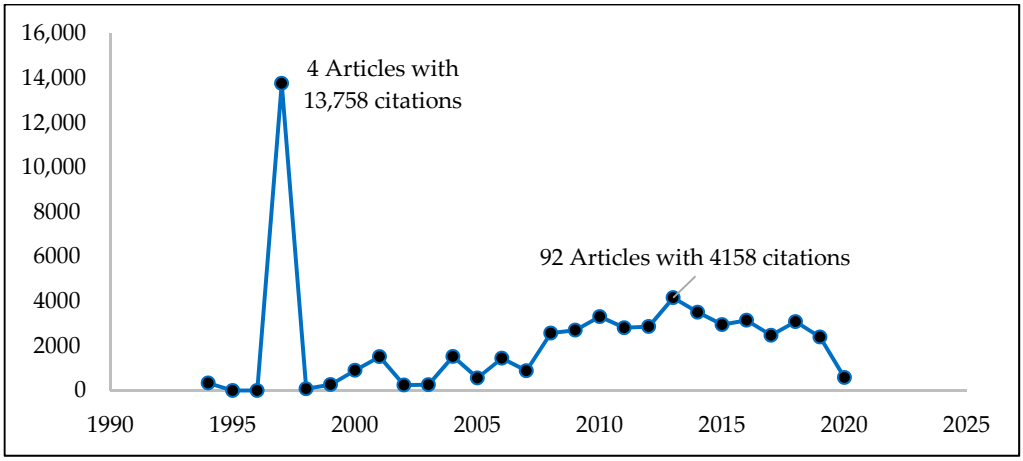

Figure 4. Evolution of the number of citations of articles per year. Source: Own elaboration.

According to the Scopus database, the journal clearly containing the most research in the area was *Sustainability Switzerland*, with 465 articles published (22.81% of the to-

tal), followed by *Journal of Business Ethics*, with 74 articles, and *Business Strategy and the Environment*, with 45 articles (Figure 5).

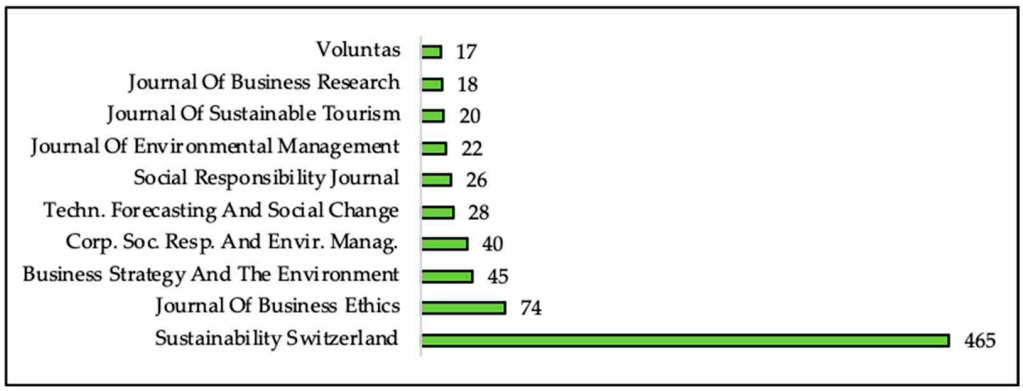

Figure 5. Main journals contributing to the theme. Source: Own elaboration.

The distribution of articles by area of research is presented in Figure 6. There is a concentration of articles in the areas of social sciences (58.97%), business management and accountability (51.07%), and environmental science (41.95%).

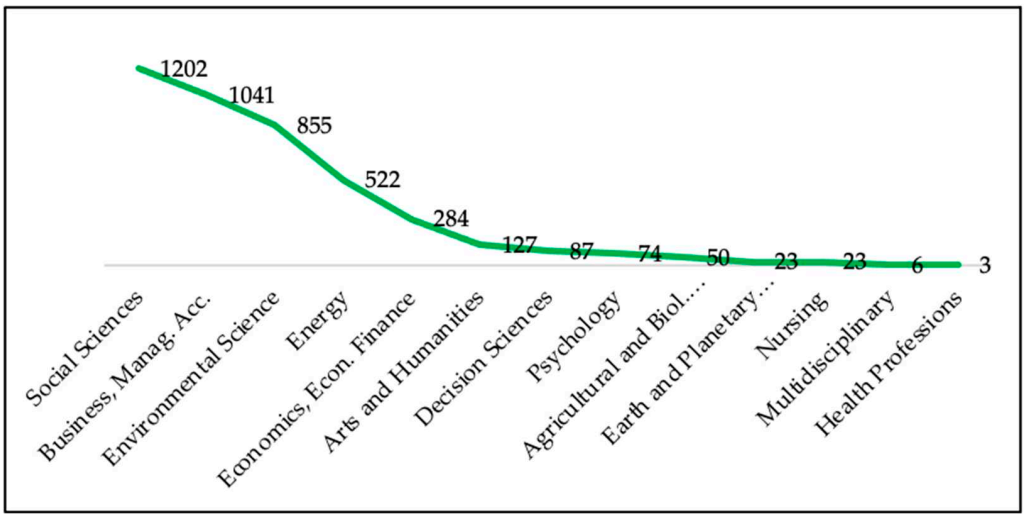

Figure 6. Main research areas. Source: Own elaboration.

According to the data extracted from Scopus, the most relevant articles in the area of social sciences address topics related to strategies for sustainability, educational administration, adaptation to environmental changes, tourism management, corporate sustainability, and other subjects. Regarding the area of business management and accountability, among the topics addressed are dynamic capabilities, strategic management, mindful consumption, corporate responsibility, and green supply chain management. Finally, in the area of environmental science, the most relevant articles include analysis of stakeholders, regional social-ecological systems, global climate change, and social license to operate.

4.1.2. Articles by Author, Institution, and Location

The 10 most productive authors on the subject of public administration and values oriented to sustainability were Chung, C.Y. (Chung-Ang University); García-Sánchez, I.M. (University of Salamanca); Pérez, A. (University of Cantabria); Barrutia, J.M. (University of the Basque Country); Echebarria, C. (University of the Basque Country); Gallego-Álvarez, I. (University of Salamanca); Gunasekaran, A. (California State University); Hickey, G.M.

(McGill University); Khan, M. (Abu Dhabi University); and López-Gamero, M.D. (University of Alicante). These results show a predominance of Spanish authors in studies on the subject (Table 1). In addition, Table 1 shows that these main authors published their most recent work in the last decade, confirming the current relevance of the topic. As for the keywords related to authors, a first group is related to organizations' social responsibility and their value and reputation, being formed by the words "corporate social responsibility (CSR)", "sustainable development", "corporate governance", "corporate and firm value", "stakeholders", "environmental management and policy", "reputation", and "reporting". A second group of words is related to local development and is formed of the words "local Agenda 21", "networking benefits", "local governments", and "sustainability". Finally, a third group, focusing on institutional characteristics and practices in public administration, is formed by the words "institutional theory", "sustainable supply chain", "big data", "dynamic capability", "innovation", "governance", and "public administration".

Table 1. Main authors and keywords.

Author	Affiliation	Location	First Article *	Last Article *	Nº of Publications *	Main Keywords
Chung, C.Y.	Chung-Ang University	Korea	2018	2020	6	CSR, corporate governance, sustainable development, corporate value, firm value
García-Sánchez, I.M.	University of Salamanca	Spain	2014	2020	6	Sustainable development, environmental policy, environmental management, CSR, stakeholder engagement
Pérez, A.	University of Cantabria	Spain	2015	2020	6	CSR, reporting, reputation, stakeholders
Barrutia, J.M.	University of the Basque Country	Spain	2011	2016	5	Local Agenda 21, networking benefits, local governments, sustainability
Echebarria, C.	University of the Basque Country	Spain	2011	2016	5	Local Agenda 21, networking benefits, local governments, sustainability
Gallego-Álvarez, I.	University of Salamanca	Spain	2012	2020	5	Environmental, CSR, sustainable development
Gunasekaran, A.	California State University	USA	2019	2020	5	Institutional theory, sustainable supply chain, big data, dynamic capability
Hickey, G.M.	McGill University	Canada	2013	2018	5	Innovation, governance, sustainable development, public administration
Khan, M.	Abu Dhabi University	United Arab Emirates	2018	2020	5	Analytical hierarchy process, sustainable development, social sustainability, Sustainability
López-Gamero, M.D.	University of Alicante	Spain	2008	2016	5	Competitiveness, environmental strategy, environmental management, hotels

Legend: * = in this research topic. Source: Own elaboration.

Figure 7 shows the network or map of cooperation between authors publishing on public administration and values oriented to sustainability, based on co-authorship. The color of each cluster refers to the group of authors in producing articles, while the size of the circle is interpreted according to the number of contributions made by the author. Here, authors are associated in seven clusters. Cluster 1 (red) presents the collaboration between Chen, X.; He, Q.; Jiang, Y.; Sial, M. S.; Zhang, I.; Zhang, S.; and Zhang, W. Cluster 2 (green) is formed by Abbas, L.; Chen, Y.; Gursoy, D.; Hu, X.; Wang, Y.; Wu, X.; and Zhang, Q. Cluster 3 (dark blue) presents the collaboration between Ariza-Montes, A.; Han, H.; Hernández Perlines, F.; Kim, I.; and Lee, S. Cluster 4 (yellow) is formed by Amin, A.; Liu,

Y.; Wu, J.; Yang, I.; and Zhang, D. Cluster 5 (purple) presents the collaboration between Nguyen, N.; Tsai, S. -B.; Wang, J.; and Xu, H. Cluster 6 (light blue) is formed by Lu, Y.; Xu, Y.; Zhang, H.; and Zhang, Y. Finally, cluster 7 (orange) is formed by Kim, H.; Kim, J.; and Sun, Y.

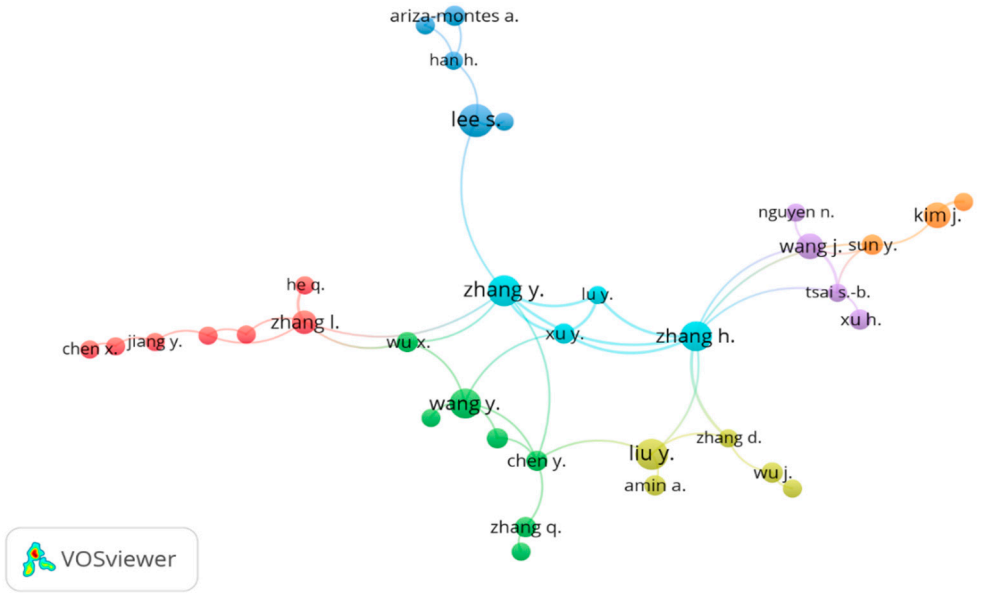

Figure 7. Cooperation network based on co-authorship between authors. Source: Own elaboration.

A predominance of Chinese authors is noted in cooperation networks. China has undergone various changes in its social system and administrative organizations, aiming to improve public service performance, following internationally accepted standards. This is a major challenge for the country, considering that traditionally its political system restricted citizens' participation [24].

Table 2 presents the 10 institutions that contributing most to scientific production on the subject studied. Standing out with 22 publications is the University of Queensland, located in Australia. It is followed by Hong Kong Polytechnic University, Wageningen University and Research, the University of Salamanca, the University of Granada, Bucharest Univ. Econ. Studies, Chung-Ang University, the University of Oxford, the University of Castilla-La Mancha, and the University of Waterloo. Therefore, of the 10 institutions contributing the most, three are Spanish.

The keywords related to the most prominent institution, the University of Queensland, were those related to the more social, non-profit-making aspect of organizations. In relation to the three Spanish universities, standing out are CSR, organizations' sustainable development, the hotel sector, and eco-innovation (Table 2).

The collaboration network between the main institutions publishing on public administration and values oriented to sustainability, based on co-authorship, is presented in Figure 8. Here, the colors represent the work groups publishing articles, while the size of each circle indicates the number of articles from each affiliation. Of the 4594 institutions, 159 of them present at least 2 articles, but they form 116 different clusters, with the biggest group consisting of only 5 connected institutions, namely Centrum Católica Graduate Business School, Pontifical Catholic University of Peru, Macau Polytechnic Institute, Macau University of Science and Technology, and Northeastern University. Given the high number of clusters formed, these results show a practically non-existent collaboration network between institutions, revealing scattered production of knowledge on this topic.

Table 2. Main institutions and keywords.

Institution	Location	N° of Publications *	Main Keywords
The University of Queensland	Australia	22	Social entrepreneurship, non-profit organizations, environmental management
Hong Kong Polytechnic University	China	19	Tourism workforce, CSR, environmental management
Wageningen University & Research	The Netherlands	17	Governance mechanisms, climate change adaptation, climate change decision
University of Salamanca	Spain	17	Environmental performance, stakeholder engagement, sustainability development, CSR
University of Granada	Spain	17	CSR, environmental strategies, sustainable development, information disclosure
Bucharest Univ. Econ. Studies	Romania	17	Sustainable business performance, investment decision, Business performance, sustainable entrepreneurship
Chung-Ang University	South Korea	15	Corporate value, CSR, firm value, corporate governance
University of Oxford	United Kingdom	15	Conflict resolution, GHG emissions reduction, Agenda 21, water–energy–food nexus
University of Castilla-La Mancha	Spain	14	Sustainable entrepreneurial orientation, family firms, hotel sector, eco-innovation
University of Waterloo	Canada	14	Agenda 21, stakeholders, tourism, visitor services, social network analysis

Legend: * = concerning this research topic. Source: Own elaboration.

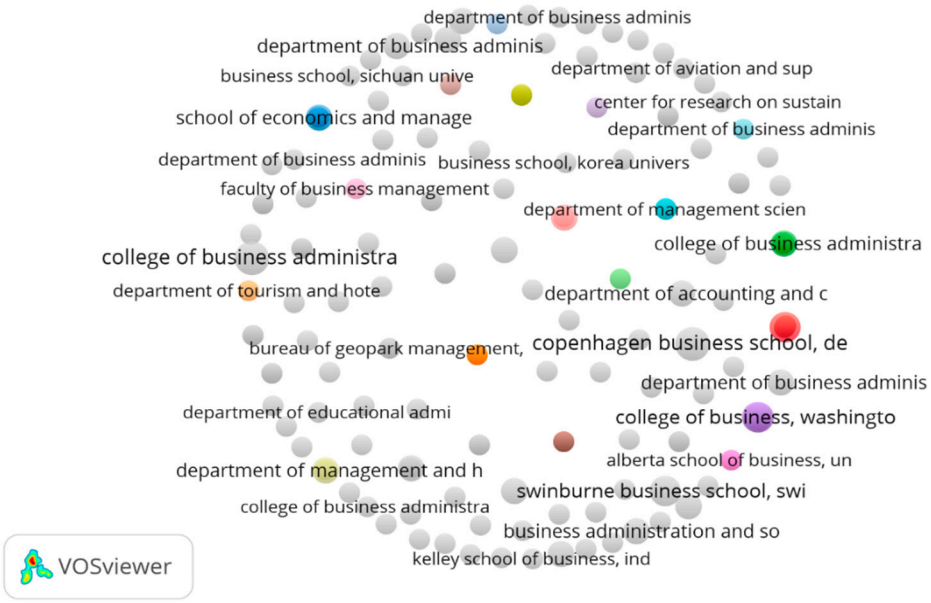

Figure 8. Network of cooperation between institutions based on co-authorship. Source: Own elaboration.

The total sample of articles originated in 116 different locations. The location with the greatest number of articles published on the subject is the USA (20.66%), followed by the United Kingdom (11.97%), Spain (10.2%), China (9.27%), Australia (8.04%), Canada (6.23%), Italy (6.08%) and South Korea (5.05%). The remaining locations do not exceed 5% of the number of articles.

The collaboration network between the main locations, considering co-authorship in the last 28 years, is presented in Figure 9. The colors represent the different clusters formed by groups of locations, while the size of the circle varies according to the number of items per location. In corresponding terms, the locations contributing to this area of research formed seven clusters.

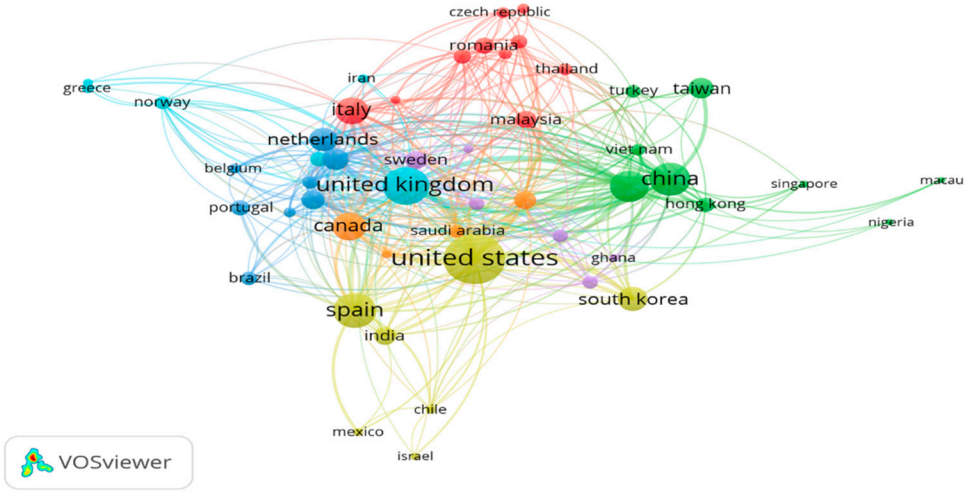

Figure 9. The network of cooperation considering the co-authors' locations. Source: Own elaboration.

The clusters are listed in Table 3, with these being named after the location with the largest number of articles.

Table 3. Locations Clusters.

Cluster Number *	Color	Cluster Name **	Locations
1	Red	Italy	Malaysia, Romania, Poland, South Africa, Thailand, Czech Republic, Indonesia, Slovakia, Lithuania
2	Green	China	Australia, Taiwan, Hong Kong, Turkey, Vietnam, Singapore, Macau, Nigeria
3	Dark blue	Netherlands	Germany, France, Portugal, Brazil, Switzerland, Austria, Belgium
4	Yellow	USA	Spain, South Korea, India, Chile, Mexico, Israel
5	Purple	Sweden	New Zealand, United Arab Emirates, Finland, Ghana, Ireland
6	Light blue	United Kingdom	Denmark, Norway, Greece, Iran, Cyprus
7	Orange	Canada	Pakistan, Saudi Arabia, Egypt

Legend: * = see in Figure 9; ** = main location; % = network percentage. Source: Own elaboration.

Cluster 1 (red) is the largest, with 10 locations, led by Italy in association with Malaysia, Romania, Poland, and others. In cluster 2 (green), China has the greatest number of articles, in collaboration with Australia, Taiwan, Hong Kong, and others. In dark blue, cluster 3 is led by the Netherlands, which has a collaboration network with locations such as Germany, France, Portugal, and Brazil. The United States stands out in cluster 4 (yellow) in collaboration with Spain, South Korea, India, and others. Cluster 5 (purple) is headed by Sweden, collaborating with New Zealand, United Arab Emirates, Finland, Ghana, and Ireland. In cluster 6, the location publishing most is the United Kingdom, in collaboration with Denmark, Norway, Greece, Iran, and Cyprus. Finally, cluster 7 is led by Canada, collaborating with Pakistan, Saudi Arabia, and Egypt.

4.1.3. Keyword Analysis

Figure 10 shows the keyword network for public administration and values oriented to sustainability, based on co-occurrence. The main keywords used in the articles were "sustainability", "CSR", "sustainable development", "innovation" and "leadership". Five main groups of keywords were detected through co-occurrence analysis of the articles published on this subject.

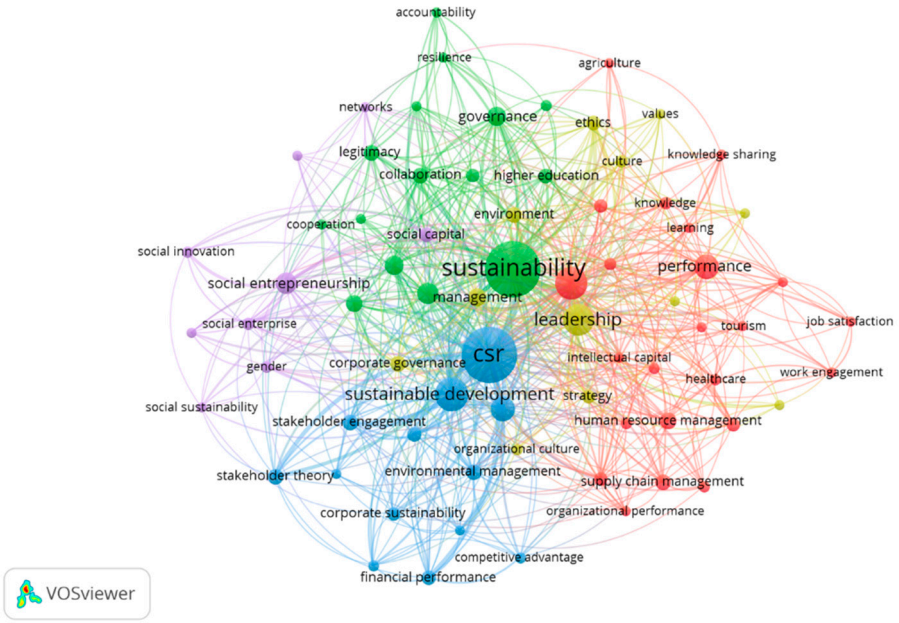

Figure 10. Network of keywords based on co-occurrence. Source: Own elaboration.

Cluster 1 (red) is the largest, grouping 31.94% of the keywords analyzed. The main keyword, due to its greater number of co-occurrences, is "innovation", associated with the words "performance", "human resource management", "supply chain management", "climate change", "transformational leadership", "small and medium enterprises—SMES", "entrepreneurial orientation", "knowledge", "competitiveness", "developing countries", "healthcare", "structural equation modelling", "hospitality", "intellectual capital", "job satisfaction", "organizational performance", "tourism", "agriculture", "knowledge management", "knowledge sharing", "learning", and "work engagement".

Cluster 2 (green) presents 20.83% of the keywords. The keyword with the greatest number of co-occurrences is "sustainability", associated with "entrepreneurship", "stakeholders", "governance", "social responsibility", "collaboration", "legitimacy", "higher education", "trust", "participation", "business ethics", "resilience", "accountability", "cooperation", and "firm performance". Cluster 3 (blue) groups 18.06% of the keywords analyzed. The main keyword is "CSR", associated with the words "sustainable development", "institutional theory", "environmental management", "stakeholder theory", "stakeholder engagement", "financial performance", "environmental policy", "corporate sustainability", "competitive advantage", "environmental performance", "performance measurement", and "sustainability reporting". Cluster 4 (yellow) presents 16.67% of the keywords. The word standing out is "leadership", associated with "management", "corporate governance", "environment", "ethics", "strategy", "culture", "organizational culture", "local government", "values", "implementation", and "total quality management". Finally, cluster 5 (purple) has the smallest number of keywords, presenting 12.5% of the total. The keyword with the greatest number of co-occurrences is "social entrepreneurship", associated with "social capital", "social enterprise", "social innovation", "gender", "business performance", "networks", "education", and "social sustainability". Table 4 presents the main keywords associated with the five clusters, named after the keyword with the most co-occurrences. It is worth pointing out the significant presence of organizational aspects and characteristics in the main keywords.

Table 4. Clusters of keywords.

Cluster Number *	Color	Cluster Name **	Main Keywords
1	Red	Innovation	Performance, human resource management, supply chain management, climate change, transformational leadership
2	Green	Sustainability	Entrepreneurship, stakeholders, governance, social responsibility, collaboration
3	Blue	CSR	Sustainable development, institutional theory, environmental management, stakeholder theory, stakeholder engagement
4	Yellow	Leadership	Management, corporate governance, ethics, strategy, culture
5	Purple	Social entrepreneurship	Social capital, social enterprise, social innovation, gender, business performance

Legend: * = see in Figure 10; ** = main keyword. Source: Own elaboration.

These results show that innovation in the public sector is associated with both internal and external stimuli/factors [75]. In this sector, organizational factors influence the sustainability of governance and impact decision-making [76]. Moreover, CSR practice is positively associated with greater engagement by stakeholders, such as employees [77], and increased trust among service users [78]. Leadership and ethical culture are associated with better financial performance in organizations [79]. Finally, social entrepreneurship and social firms allow greater social innovation, maximizing social interests and adding social values [80].

Figure 11 presents the evolution of each keyword cluster. This diagram shows the pioneering keywords, when they first appeared, and their influence over the 28 years analyzed.

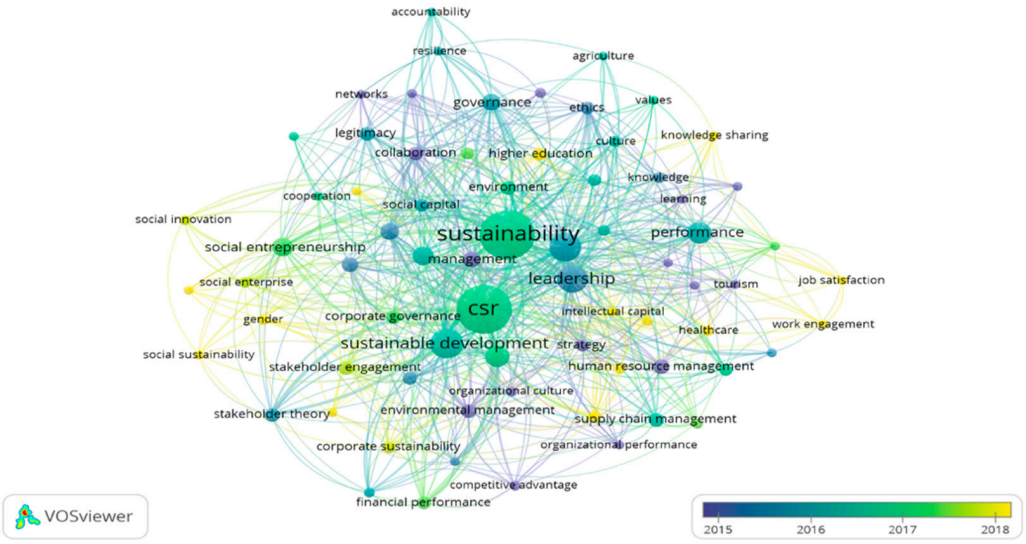

Figure 11. Evolution of the network of keywords based on co-occurrence. Source: Own elaboration.

The most influential keywords are seen to emerge in 2016 and 2017, where "sustainability" and "CSR" stand out. The words emerging more recently, in 2017 and 2018, show the recent interest in the social area, such as gender issues, social innovation, and social sustainability, and employee-related aspects such as engagement and work satisfaction.

4.2. Qualitative Content Analysis

Examination of the 2038 articles reveals a growing trend of studies on values, public administration, and sustainability (Figure 12). The last 10 years (2011–2020) represent 91.95% of all articles. In this period, 833 (40.87%) are set in the social context and address various issues, such as human resource management [81,82], organizational culture [79,83], social entrepreneurship [84,85], knowledge management [86], social learning [87], health

care [88,89], social responsibility [77], education [90–93], and others. Around 26.7% of studies address the economic dimension in this period, highlighting the topics of performance [93–95], innovation [96,97], entrepreneurship [98], competitiveness [99,100], supply chains [101–103], and others. In the last decade, the environmental dimension (24.48%) reflects topics such as water management [104], sustainable policies [105–107], adaptation to climate change [108–110], eco-tourism [111,112], environmental responsibility [113,114], sustainable development [115–117], and the circular economy [118,119].

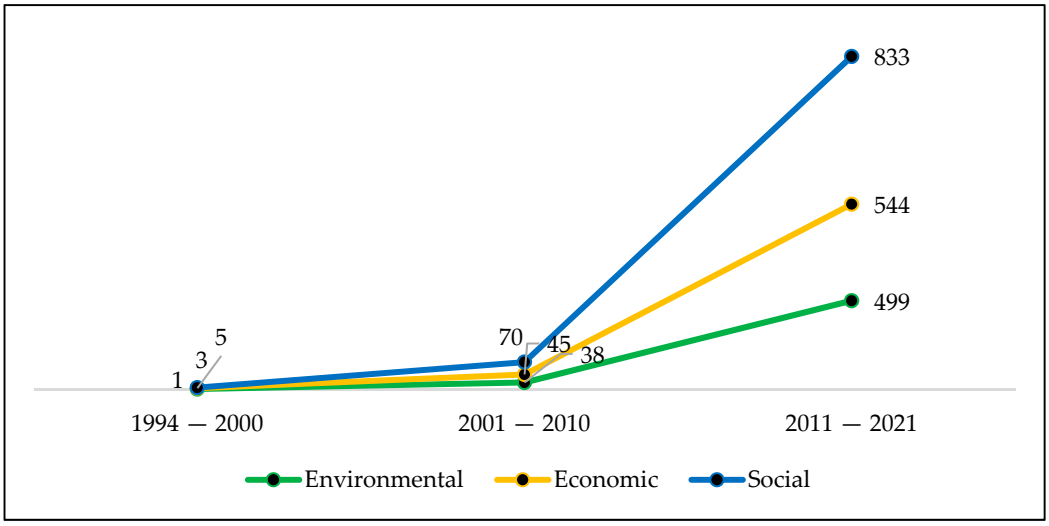

Figure 12. Quantity of articles distributed by decade and by type of sustainability pillar. Source: Own elaboration.

Figure 13 shows, for the total studies, the representative percentages of the types of values found in the literature review. Political values are shown in attitudes, regarding the preferences of a social group or society as a whole [120], and are most expressive, with 38.42% of studies. These are followed by cultural values (26.35%), where the individual's need to understand the values of their culture is fundamental to being able to assimilate it, become part of it, and transform it, in this way forming social learning [121]. Ethical values are defined as a set of values that guide human behavior in relation to other people in society [122], and are indicated in 18.55% of articles, followed by ecological, moral, and other values with 8.64%, 4.76%, and 3.29%, respectively.

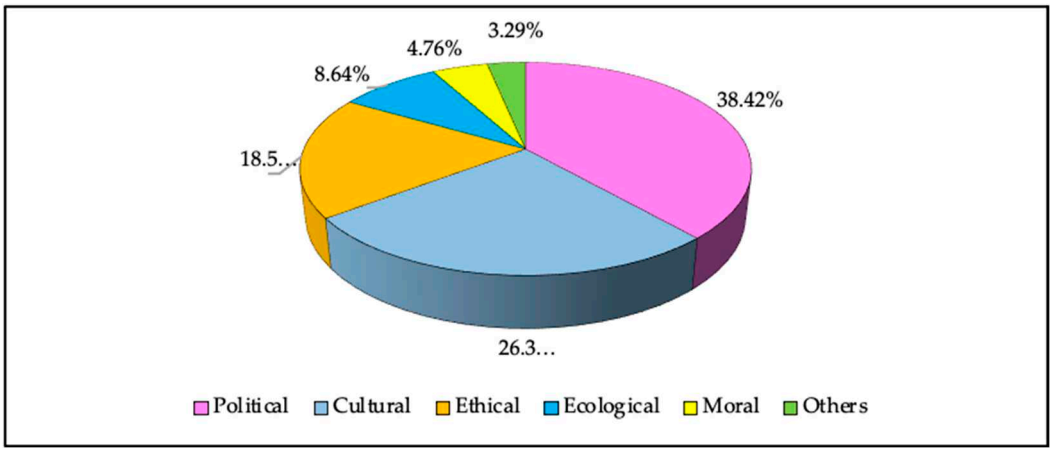

Figure 13. Percentage of studies by type of value. Source: Own elaboration.

The distribution of studies according to the dimensions of sustainability and the types of values is presented in Figure 14. In the social context, of the 906 articles, the

cultural value is the most expressive, with 35.43%. Political values are strongly represented in the economic and environmental dimensions with 53.37% and 39.96%, respectively. Many political decisions, whether economic, environmental, or social, are essentially choices between competing values, such as impartiality and legality, on one hand, and efficiency and effectiveness, on the other, and are seen in situations such as promoting equal opportunities. These decisions can result in conflicts between values such as efficiency, justice, equality, diversity, and merit [48].

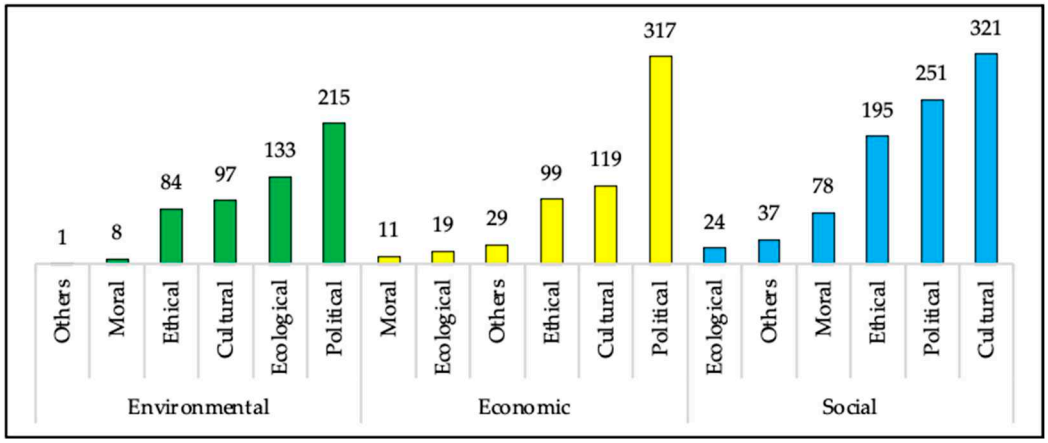

Figure 14. Number of studies according to sustainability pillar and type of value. Source: Own elaboration.

Concerning the major areas of public administration, Figure 15 shows the distribution of articles analyzed in this study. A relevant number of articles focus on the economy (29.34%). This is due to the relevance of the economy for sustainability, considering the organization of society and the volume and speed at which natural resources should be used [123]. Public management's participation in environmental actions has a fundamental role in ensuring a decent, sustainable future for all. In the last decade, studies addressing actions and reflections in legislating, implementing, and controlling public actions have increased (13.05%), showing their importance [124]. Sustainable social development (11.48% of studies) refers to a number of actions that aim to improve the population's quality of life, with less social inequality, assured rights, and access to services (principally education and health) giving people full access to citizenship.

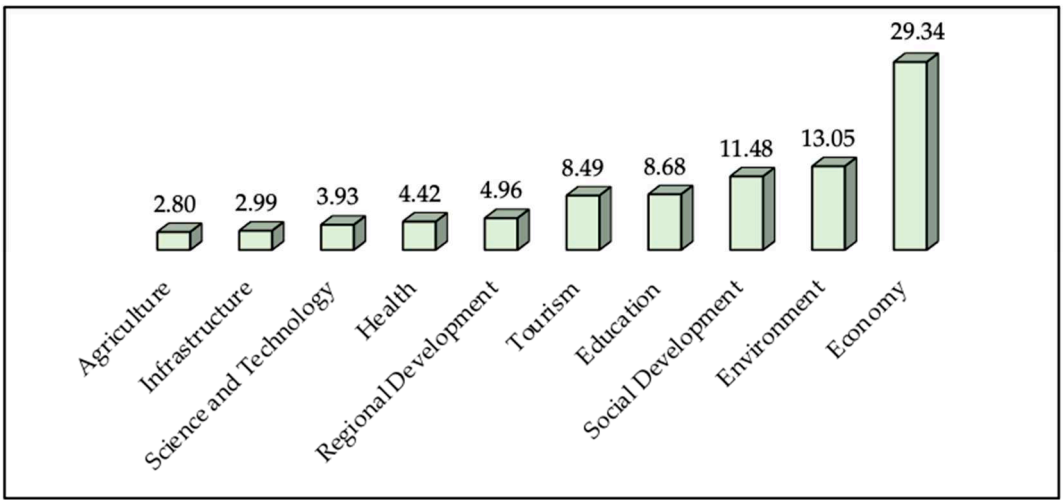

Figure 15. Percentage of studies distributed by area of public administration. Source: Own elaboration.

The pillars of sustainability and their relation to major areas of public administration, shown in Figure 16 and representing 71.05% of studies (1448), reveal authors' concerns regarding the economic context, as they aim to form a balance between the expanding population, social equity, and environmental conservation (343 articles). Academics are debating two different economic streams, and opinions diverge regarding the environment between the environmental or neo-classic economy, which addresses the environmental question from the point of view of pollution and natural resources, and the ecological economy, based on laws of thermodynamics and seeking to value ecological resources based on the net energy flows of ecosystems (entropy) [125,126].

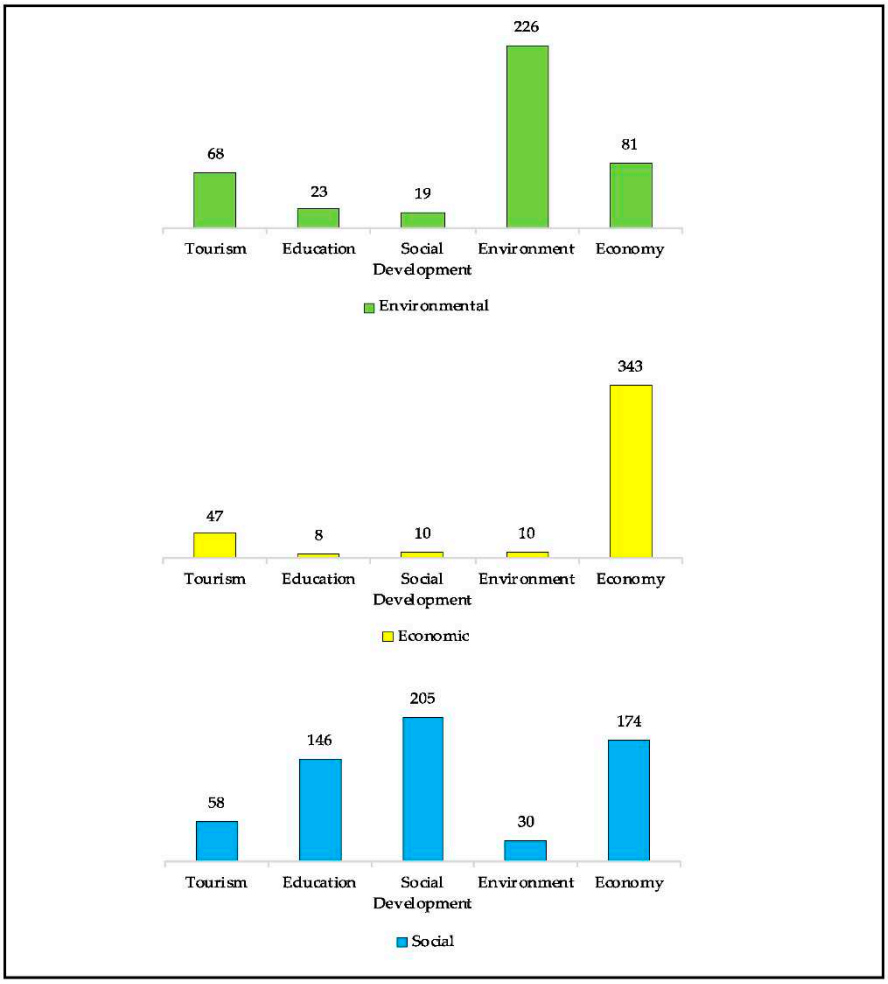

Figure 16. Relationship between sustainability pillars and the distribution of studies in major areas of public administration. Source: Own elaboration.

Then again, other researchers [127,128] have relevantly addressed the environmental dimension and reflections on the environment (226 articles), where the importance of natural resources for the continuity of life on Earth indicates that the economy and the environment act systemically and can be represented in the form of values, with these values being biological, ecological, and economic [129].

The relation between the social dimension and social development (205 studies) belongs to public administration's concern about social responsibility [130,131]. In the area of education, worthy of mention are studies focusing on educational policies [70,132], higher education [133,134], leadership [135], and knowledge transfer [136,137]. Research on the tourism sector and the environmental dimension has increased in the last decade and portrays authors' concern about environmentally responsible behavior [138,139], business behavior [140,141], and more.

Based on the areas of public administration that were most mentioned in this study (71.05% of all articles), their relation to the main types of values was analyzed (Figure 17). Standing out are: (i) political, cultural, and ethical values in the area of the economy; (ii) political and ecological values in the environment; (iii) political, ethical, and cultural values in social development; (iv) cultural, ethical, and political values in education; and (v) cultural, ecological, and political values in tourism.

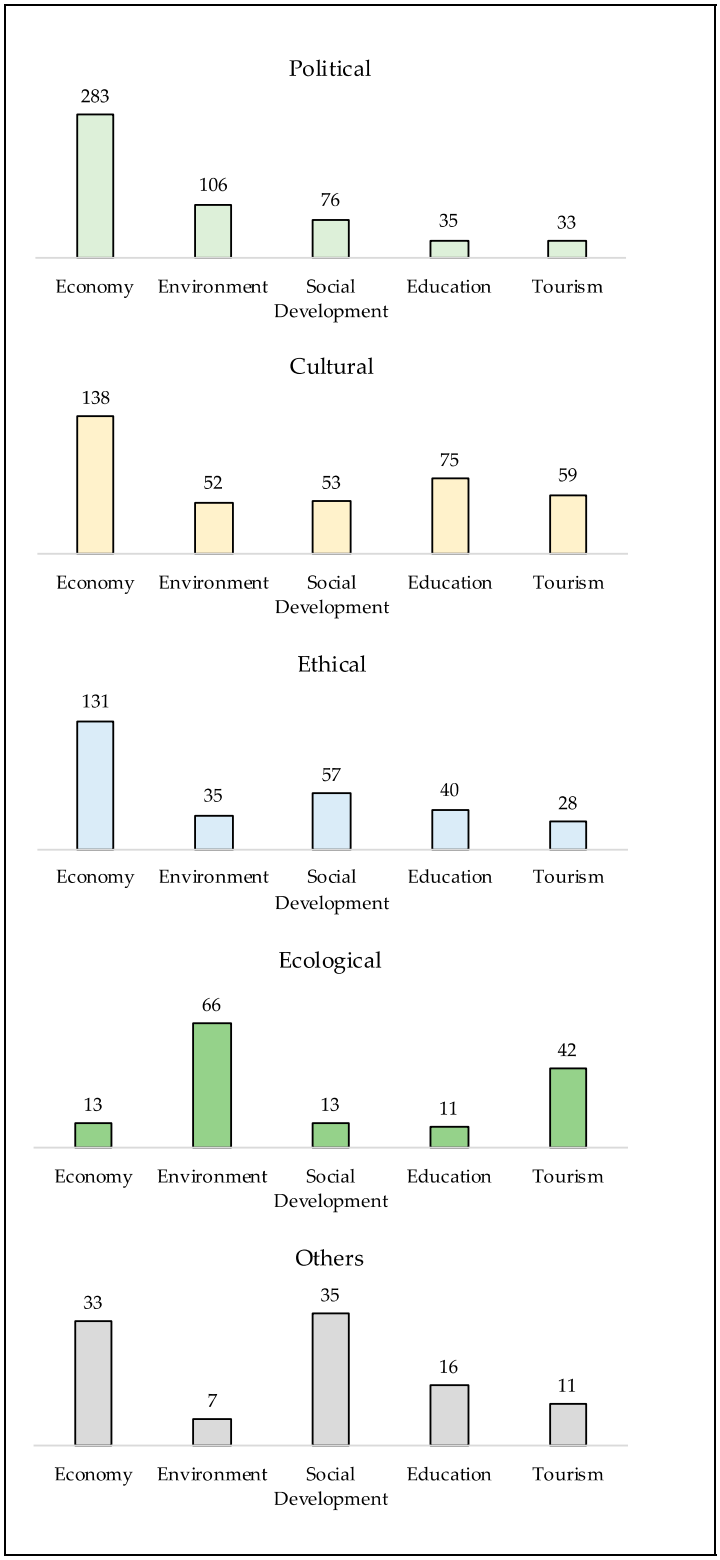

Figure 17. Areas of public administration and the number of studies classified according to the values. Source: Own elaboration.

Although the largest number of studies focuses on the economy, there is an undeniable growth of academic interest in environmental and social development matters. There is a strong influence of political values (533 articles), appearing in all areas of public administration and showing how important the role of public managers is in forming public policies. Also relevant are cultural and ethical values, which in fact support political values by directing good decision-making. No less importantly, ecological values have been gaining prominence among researchers, which connects to the belief in increasing human awareness concerning the conservation and sustainable use of natural resources.

The analysis of literature reviews, addressing the topic contained in the present study, means different approaches can be listed. Cowell, Downe, and Morgan [142] present the results of a survey that examined the impacts of an ethics regulation program introduced in England in 2000, which was aimed at improving the conduct of elected councilors. The ethical structure contributed to improved behavior, but the impacts were uneven across councils, reflecting broader contextual conditions—that is, managerial, political, and social.

Atkinson [143] explores the roots of environmental policy through a review and application of political literature, advocating that the government is responsible for protecting the environment in the face of rapid industrial growth. However, the inefficiency and misunderstanding of the political process, confused by a multitude of actors and interests and often inadequate resources, threaten the possibility of ensuring sustainability.

Ogunyemi and Laguda [144] develop a thematic review of the literature on ethics, governance, and sustainable practices with regard to engagement and development of the workforce. The same authors verify that existing research on ethics, governance, and sustainability in relation to workforce management can be categorized into five themes adapted from the categorization of ethical constructs in the work of Tucker et al. [145] on codes of conduct. These five themes are integrity, equality, economic efficiency and equivalence, distributive and contributory justice, and environmental concern.

The public value of e-government was the subject of a study by Twizeyimana and Andersson [146], in order to investigate the current state and what value e-government should produce. Six values, sometimes overlapping, were found: improved public services, improved administrative efficiency, open government capabilities, better ethical behavior and professionalism, greater confidence and security in the government, and better social value and well-being. These six dimensions of public value were subsequently generalized into three overarching, and also overlapping, dimensions of public value: improved public services, improved administration, and improved social value.

In relation to the current state of research on values, public administration, the public sector, and sustainability, it is worth noting that there is still limited knowledge on the adoption and coexistence of different organizational and individual values in public administration, associated with managers' level of competence, in order to foster sustainability.

5. Conclusions

Aiming to analyze the main trends of global research into the values attributed to sustainable public administration, in the period from 1994 to 2021, bibliometric and content analysis of 2038 articles obtained from the Scopus database was carried out. The most productive areas, authors, institutions, and locations were identified in publications on the subject of this research. The number of scientific articles per year in the period has increased significantly in the last decade, which saw the publication of a total of 1874 articles, representing 91.95% of all contributions on this issue. The most productive journals were *Sustainability Switzerland*, *Journal of Business Ethics*, and *Business Strategy and the Environment*.

The main categories identified as having the most articles published were the areas of social sciences, business management and accountability, and environmental science. As for the 10 authors with the most articles published, six are Spanish, but the top three are Chung, C.Y., from Chung-Ang University in South Korea; García-Sánchez, I.M, from the University of Salamanca in Spain; and Pérez, A., from the University of Cantabria, also in

Spain. Among the keywords associated with these authors, the most prominent are "CSR", "sustainable development", "corporate and firm value", "environmental management", "reporting", "reputation", and "stakeholders". This demonstrates a research focus on organizations' social responsibility and social development, environmental management, and the consequent influence of these on reputation and organizations' value in the eyes of their stakeholders. Analysis of co-authorship revealed that Chinese authors predominate in research collaboration networks.

The institutions with the greatest number of articles on the subject studied are the University of Queensland and Hong Kong Polytechnic University, while the main keywords associated with them are "social entrepreneurship", "non-profit organizations", "environmental management", "tourism workforce", and "CSR". Nevertheless, co-citation analysis revealed practically no research collaboration networks involving the institutions producing knowledge on this subject.

The locations contributing most to research are the United States, the United Kingdom, and Spain. The keyword analysis shows that the most relevant, due to the greater number of co-occurrences, are "sustainability", "CSR", "sustainable development", "innovation", and "leadership". Evolution over time shows a recent trend of research lines related to the social sphere, such as gender issues, social innovation, and social sustainability, and aspects related to employees, such as engagement and satisfaction at work.

As an answer to the core research question of this SLR, the typology of values adopted in the administration of public institutions appears grouped, in decreasing order of predominance, according to the components of the sustainability pillars, namely: (1) the social pillar (44.43% of studies), with cultural (1st), political (2nd), and ethical (3rd) values; (2) the economic pillar (29.13% of studies), presenting political (1st), cultural (2nd), and ethical (3rd) values; and (3) the environmental pillar (26.39% of studies), with political (1st), ecological (2nd), and cultural (3rd) values. These results reveal a predominance of political values in two of the three pillars that constitute sustainability.

The findings of this SLR contribute to filling an important gap by associating different types of organizational and individual values in the context of public administration, outlining the critical influence of managers on the sustainability of public administration. Through all the results presented, this SLR sheds light on a new descriptive and multidimensional structure, which contributes to advancing current understanding of public value, integrating different approaches, and the overlap between these values and the pillars of sustainability. For practical purposes, this multidimensional structure can be used by governments to evaluate the performance of initiatives supported by values through government policies and actions that can be used to evaluate the public value produced.

One of the limitations of this SLR is the exclusive use of the Scopus database. In future investigations, this gap could be addressed by crossing references and more comprehensive search mechanisms, including results from books, book chapters, and conference proceedings. Furthermore, the use of cluster analysis allows identification of significant concentration patterns, but this is dependent on the previous selection of search terms which, in the present SLR, had to be limited to key concepts, previously used in studies on management with public administration values, in order to ensure a dimension of the sample of selected publications that would guarantee significant results.

Although bibliometrics has some limitations because it is a form of quantitative analysis, the insertion of the qualitative analysis of the articles contributes to expanding future research trends. Concerning the future research agenda, emphasis is placed on the need to expand investigations in different areas of public administration with a focus on political and ecological values (environmental dimension). A suggestion is to carry out studies addressing the different ways in which public administration can respond to a challenging and highly uncertain political and economic context, through adopting political and cultural values (economic dimension), as well as cultural, political, and ethical values that can be adopted in the areas of education, culture, and health (among others), which can expand the scope of the areas of public administration (social dimension). In

addition, there is a need to develop studies that address perceptions about the effectiveness of policies implemented and on the evolution of sectoral systems, which can help to provide implications to ensure the sustainability of public institutions. There is also a need for research on the values attributed to sustainable public administration and studies to verify if there are differences in the impact of the three dimensions of sustainability on the reputation and value of public organizations according to different stakeholders.

Lastly, the current systematic approach of the literature not only provides an up-to-date exercise of the state of art on managing public administration institutions with values, but also opens avenues to enrich strategic orientation and governance, engaging both external and internal stakeholders, in order to build a true culture and commitment to the common good, well-being, and sustainable progress of all nations.

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Bridging Intellectual Capital, Sustainable Development and Quality of Life in Higher Education Institutions

Eugénia de Matos Pedro *, João Leitão and Helena Alves

Faculty of Human and Social Sciences, NECE–Research Center in Business Sciences, University of Beira Interior, 6200-001 Covilhã, Portugal; jleitao@ubi.pt (J.L.); halves@ubi.pt (H.A.)

* Correspondence: eugenia@ubi.pt

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Abstract: This paper analyses the relationship between the intellectual capital of higher education institutions (HEIs) and their sustainable development practices, and assesses whether higher education institutions' sustainable development practices are related to their stakeholders' quality of life. Using a structural equation model, two model specifications are estimated, gathering primary data from a convenience sample composed of 738 full-time students and 587 teachers/researchers at seven Portuguese higher education institutions. The findings reveal that intellectual capital influences sustainable development practices directly and positively, whereas sustainable development practices influence students' quality of life in a significant way, although the same is not verified for teachers/researchers. These findings provide insightful implications for policy-making and intellectual capital management for practices in higher education institutions; firstly, by showing that the sustainable development concept is associated with HEIs' practices of economic, environmental, social and organisational sustainability; secondly, by concluding that public Portuguese HEIs need to improve the social dimension of their sustainable development practices, and here there may be room for improvement in the institution through better and more proficient social engagement that is more directed to the challenges of sustainability and social change; and thirdly, by showing that the inclusion of better sustainable practices has repercussions on the quality of life of all stakeholders.

Keywords: higher education institutions; intellectual capital; performance; quality of life; sustainable development

1. Introduction

The different ways in which organisations, cities, regions and countries manage and introduce intellectual capital (IC) practices have been found to be a decisive factor, not only for their reputation, competitiveness and wealth, but also in raising their sustainability, focusing on citizens' quality of life (QoL) and contributing to a more sustainable and balanced society [1]. Despite the remaining gap and lack of information in the literature about how intellectual capital and sustainability influence each other from the practitioners' perspective, researchers' theoretical perspectives have shown how IC and sustainability are closely related [2]. For example, it was revealed that a country's knowledge assets and intangible assets have significant implications for its future value, inasmuch as they represent a source of skills and competences considered essential for national economic growth, the development of human capital and promotion of QoL [3]. Adding to the previous statements, knowledge, creativity and innovation have become the main factors stimulating social and economic development, reinforcing the role of IC in generating sustainable growth and development [4].

IC plays an important role in determining regional competitiveness, being even more important in regard to sustainable regional competitiveness, and it is assumed that the most important intellectual

resources are those that contribute to the creation of a competitive advantage and so result in an improved economic situation of a region [5]. For example, Dal Mas [6] demonstrated the relationship between IC and sustainability from a practitioner's point of view, supporting the interlink between IC and sustainable regional competitiveness. In addition, it increases society's awareness of sustainability, defines a region's legal and institutional environment, expresses relationships between the various stakeholders and, as a whole, creates the basis for forming sustainable competitive advantage. According to Malhotra [7], the intangible assets of a country have significant implications for the future national value, because they represent a source of the skills and competences considered essential to national economic growth, human development and QoL.

Higher education institutions (HEIs) are also part of this premise, as they are experiencing the challenges of sustainability, which is increasingly recognised as an essential driver for the development of sustainable societies [8], and also contributing to the QoL of their stakeholders and the populations where they are located [9]. Several challenges have been faced by HEIs, namely regarding budget reductions, which imply the implementation of efficiency and cost reduction logics, as well as adopting new community welfare promotion practices to improve their own quality of academic life (QAL). In this way, HEIs reinforce the attractiveness and retention of human and financial resources, which will positively contribute to the sustainability of these institutions. HEIs have shown a growing commitment to sustainable development (SD) through their mission statements, support and agreements, as well as through the effective implementation of the initiatives and practices of SD [10]. In recent years, some studies have been carried out regarding HEIs' involvement in the implementation of SD practices, e.g., [10–12]. These practices are linked to different dimensions (e.g., economic, environmental, social and organisational) and are integrated into the main activities of HEIs, namely teaching, research, operations, social commitments and culture [10].

Bearing in mind the publication by UNESCO [13] for education institutions, including HEIs, it is recommended that all their processes should be based on sustainability principles. In specific terms, for SD practices in HEIs to be more effective, according to UNESCO, the institution as a whole has to be transformed. Such a whole-institution approach aims at mainstreaming sustainability into all aspects of the education institution, which involves rethinking the curriculum, campus operations, organizational activities, culture, student participation, leadership and management, community relationships and research [14].

In the literature, the concepts of sustainability and SD are commonly considered interchangeable, and sometimes as equivalent, e.g., [15,16]. This study, in the same line as stated in [17], assumes that sustainability is a principle, while SD relates to a social process involving choices and decisions towards sustainability. In other words, SD is the means to achieve sustainability, which is the final, long-term objective [16]. Therefore, HEIs have a fundamental role to perform in implementing and leading SD initiatives through the institutions' internal policies and practices.

Following this line of research, having as a vision the whole-institution approach mentioned above, the objective of this study is to fill this research gap in the perceptions of the stakeholders of Portuguese HEIs in relation to their SD practices, and, in turn, investigate how these practices can contribute to these stakeholders' QoL. Regarding HEIs' IC, there is still room and a need to understand how the management of IC can be articulated according to the existing SD practices in these institutions, so that the latter can function as mechanisms to identify existing gaps in HEIs' strategic reports and plans to be filled in the short and long-term.

Considering the above and the stakeholders' perspective, this study aims to fulfil the following objectives: (i) ascertain whether there is a direct, positive and significant relationship between HEIs' IC and their SD practices; and (ii) check whether HEIs' SD practices are directly, positively and significantly related to their stakeholders' QoL, thereby shedding light on a new perspective of the ongoing research on IC.

Considering the importance of IC, and having found no studies so far relating HEIs' IC with their own SD practices and QoL, considering stakeholders' perception, this study proposes to analyse

SD practices, through economic, social, environmental and organizational dimensions, and the QoL of HEIs' stakeholders (students, teachers/researchers) through: (i) students' quality of academic life (QAL); and (ii) through the quality of work life (QWL) of teachers/researchers. This approach is of interest to both the scientific community and to HEI managers, as it is an innovative and relevant subject, never before studied, and may lead to better results for students and greater motivation among their collaborators.

To fulfil these aims, there is, first, a brief overview of the evolution of the literature; firstly, on IC in HEIs and the relationship with SD practices, and secondly on the relationship between SD practices in HEIs and QoL. Then, two models are presented and tested through quantitative analysis, gathering primary data from students and teachers/researchers at seven Portuguese HEIs, using a structural equation model (SEM) and the partial least-squares (PLS) method in order to verify the robustness of those relationships. Finally, the conclusions, implications and limitations of the study are elaborated.

2. Intellectual Capital of HEIs and Sustainable Development Practices

As entities involved in the creation and spread of knowledge, HEIs have been taking on a more entrepreneurial role, involving networking and international collaboration, and are increasingly more articulated in regard to critical issues of sustainability and social change, as stated by [18]. These authors highlight the fact of this idea being in line with the perspective of the fourth stage of IC, i.e., the creation of knowledge focused on the ecosystem. Studies related to this stage defend a change in approach to understanding the drivers of wealth creation, based on a balance of intellectual and financial measures, in order to create a more holistic vision of the national innovation capacity and the renewal of society and politics [19].

Therefore, monitoring IC is a way of measuring and controlling intangible and fundamental elements for these organisations [7], at the same time as ensuring SD. Similarly, the management of IC and its importance in HEIs are examples of issues studied by various authors, e.g., [20], as well as the association between HEIs' IC and sustainability [7], and how SD can be integrated into HEIs' practices [21].

Many HEIs have begun to incorporate SD practices into their systems and a variety of sustainability assessment tools have been developed to support HEIs in systematically measuring, auditing, benchmarking, and communicating SD efforts to their stakeholders [22]. As an example, it may refer to the Association for the Advancement of Sustainability in Higher Education (AASHE), which began in 2006. AASHE empowers higher education faculties, administrators, staff and students to be effective change agents and drivers of sustainability innovation [23]. This association developed the Sustainability Tracking, Assessment and Rating System (STARS), which is a framework for colleges and universities for measuring their own sustainability and it is the product of an extensive stakeholder engagement process. This approach fits also with the key elements for whole-institution approaches mentioned by UNESCO [13], as it allows the HEI, together with its stakeholders (e.g., teachers/researchers and students), to jointly develop the vision and strategic plan to implement SD practices in the whole institution.

However, despite the role played by HEIs in promoting SD being recognised as essential, e.g., [24,25], with examples of SD practices in different dimensions (e.g., environmental, economic, social and organisational) worldwide and integrated in HEIs' main activities (e.g., education, research, operations, social involvement and governance/culture) [26], some articles, e.g., [10,21,27] have pointed out that SD practices vary considerably from one HEI to another, and as for results found for SD practices implemented in Portuguese HEIs specifically, this is still at an early stage.

The potential impacts on HEIs' SD are based on practices related to economic growth, changes in social and business practices, social cohesion, contributions to climate change, sustainable human behaviours and urban development [22]. The most explored dimensions related to SD, in the HEI context, are environmental, social/cultural, economic and organisational/educational/political. These dimensions are integrated into activities related to teaching, research, campus operations, community

actions, assessment and the drawing up of reports [10]. Some authors identify three fundamental dimensions of SD: economic, social, and environmental [11,28]. However, it is increasingly common to find other dimensions, such as organisational, e.g., [29,30] and cultural, e.g., [29,30]. In the specific case of HEIs, the following dimensions were proposed in regard to the implementation of SD practices: environmental, economic, social/cultural, and organisational/educational/political, e.g., [10,24,31]. This study considers that SD practices operate in the following four dimensions: economic, social, environmental, and organisational.

In the same vein of [10], the economic dimension of SD involves practices of economic viability and considers economic needs (e.g., concern about economic performance, plans and actions to improve energy efficiency, and budgeting for practices that promote sustainable development). The social/cultural dimension concerns the actions of an organisation's human resources or the surrounding community (e.g., policies to promote equality and diversity, developing and participating in recreational, cultural or sporting activities, concerns and initiatives regarding social inclusion and scientific initiatives directed towards the outside community). The environmental dimension proposes including environmental concerns and practices in the institution's strategy (e.g., constructing sustainable buildings on campus, separating waste and sending it for recycling and equipment to generate renewable energy). Finally, the organisational dimension concerns how institutions mould their behaviour and values, and how the different stakeholders perceive and if they are satisfied with approaches and objectives related to sustainable development (e.g., declarations and statements on the HEI's views and formal documents on values, strategy, transparency in governance and ethical commitments).

Some authors highlight the importance of stakeholders' perceptions in research related to HEIs' SD, e.g., [12,32]. The discussion on sustainability is based on stakeholder theory [17]. Stakeholder theory aims to analyse the relationship between an organization and the economic and social actors (individually or collectively) that affect, are affected by, and have interests in the procedural and substantive aspects of corporate activities. The management principles of stakeholder theory are reflected in the new model of HEIs' governance through the presence of different internal and external stakeholders in the various management organs [33]. In addition, the stakeholder satisfaction affects organisations' competitiveness and image, with stakeholders' needs and expectations affecting the organisation's management system [34]. The same author concluded that a wide understanding and incorporation of these needs in the management system can contribute to achieving the objectives proposed and increasing stakeholders' QoL.

HEIs' IC can be one of the key elements in promoting SD [7], and in its generalized expression, the SD concept represents an evolutionary coordination of various concerns linked to well-being, such as social, cultural, economic and environmental concerns [35]. Furthermore, these authors emphasize that sustainable behaviour is conceived as actions that contribute to the QoL of current and future generations. HEIs' IC is identified in various studies as a composite of human capital, structural capital and relational capital, e.g., [36,37]. This capital approach differentiates from the one presented in the scope of the theory of capital developed by Pierre Bourdieu, since the latter considers other types of capital, such as economic capital, cultural capital, social capital and symbolic capital [38]. In this scope, it deserves to be outlined that, in the case of social capital, Bourdieu [38] refers to networks as a form of social capital, but also incorporates the nature of culture and how it is reproduced and transformed, as well as how it connects to social stratification and the reproduction and exercise of power, which is connected with the mode of how human capital evolves in the scope of social systems, as a heritage and a reproductive mechanism of social stratification. In this study, HEIs' IC stems from the triad of capitals; human, structural, and relational, having as reference the studies of [36,37].

In the HEI context, human capital is the sum of explicit and tacit knowledge held by all the human resources existing in the institution (teaching, research and development, management, directing and administrative staff in all services), acquired through both formal and non-formal education and the training processes included in their activities [20,39,40]. According to the vision expressed

in [41], human capital can play an important role in SD practices, through the intermediation between the various stakeholders and regional actors, through the demonstration of good practices such as developing management activities, strategic planning, construction projects, minimizing waste and practices of energy efficiency and sustainability, and responsible purchasing programmes, and through good, environmentally-friendly initiatives with an impact on the campus. Leaders can offer incentives to recognise and reward staff for becoming involved in groups leading SD in the academic and regional community. Notably, [10] concluded that, in general, Portuguese HEIs value and stimulate professional and personal development (e.g., vocational training, academic training), in order to ensure the adoption of good practices within the institution.

Additionally, in the HEI context, structural capital includes all explicit knowledge interrelated with the internal processes of the promotion, communication, and management of scientific and technical knowledge in the organisation, which spans both organisational aspects (operating environments derived from the interactions between research management and the organisation of processes, organisational routines, corporate culture and values, and internal procedures, within the scope of quality and information systems, among others), and technological aspects (technological resources available in the university, such as bibliographic and documentary resources, archives, technical developments, patents, licenses, software, and databases, among others) [39,42]. For example, in [43], the structural capital was related to the SD practices towards the improvement of some organisational processes and practices, such as structural improvements based on new technologies (databases, intellectual property) and organizational culture based on the management of environmental sustainability practices. However, in [10], it was stressed that, until now, in Portuguese HEIs the focus has been on processes related to the separation of waste and its forwarding for recycling and plans to reduce the production of waste (e.g., paper, plastic, metal, oils, batteries), so as to ensure SD.

Concerning relational capital in the HEI context, this reflects the extensive collection of economic, political and institutional relationships that have been built up and maintained between HEIs and their non-academic partners (companies, non-governmental organisations, local government and society in general), as well as the perceptions others hold of the institution in terms of its image, attractiveness, trustworthiness and security, among others [40,42].

Relational capital is the connector between the HEI and its various stakeholders, partners, firms, institutions, etc. In [44], the importance of relational capital for SD was revealed, in that it stimulates people's participative and cooperative capacity and makes them responsible for community development, through promotion and interaction between people, structures and institutions, sustained by mutual trust, tolerance and cooperation, as well as mutual respect, civility and participation. Initiatives related to SD in education, research, operations and the outside community help HEIs to respond to various challenges, attracting resources, lowering costs, promoting more effective management and tackling new challenges in society [45]. All this will also contribute to a more positive image of the HEI, attracting more students, promoting quality and excellence, and thereby contributing to the HEI's internationalization.

Considering the above, the following research hypothesis is formulated:

Hypothesis 1 (H1). *HEIs' IC has a positive and significant influence on the institution's sustainable development practices.*

3. Sustainable Development Practices and Quality of Life

The idea that economic development must be sustainable implies recognising the basic idea that natural resources are scarce and limited, therefore accepting that different socio-economic activities must be restrained [46]. However, according to the same authors, the concept extends ideologically to the cultural and social relations involved in SD processes, including those affecting social well-being and QoL.

The concept of sustainability emphasizes the idea of human behaviours that allow individuals in the present and future to satisfy their needs without exceeding nature's capacity to recover the resources extracted from it [47,48]. These human behaviours involve psychological tendencies and behaviours that show concern about conditions in the physical environment and the completeness of the social environment [46].

In turn, QoL covers a number of indicators portraying various environmental, social, economic and subjective factors [49]. Therefore, a better QoL can be achieved in societies that enjoy a well preserved and constructed natural environment, as well as good governance and good levels of physical health, economy and subjective well-being, as highlighted by [46]. The same authors conclude that, consequently, the interactions between human beings and their physical and social environment should create high levels of satisfaction with these factors, besides well-being and happiness, if these interactions are pro-sustainable—that is, if they are committed with aspects concerning sustainability issues in their daily lives, such as shared value, social welfare and environmentally friendly practices. Furthermore, Moser [50] claimed that a pro-sustainable relationship with the social and physical environment results in satisfying humans' needs and conserving that same environment. Taking care of the environment, conserving and preserving it, is a commitment that all organizations will be urged to make in the short term because it raises the QoL of individuals in the workplace (microenvironment) and those who inhabit the global space (macroenvironment) [51]. SD practices imply the improvement of QoL through satisfaction with many aspects of life, such as education, justice, community participation and recreation [52]. Thus, environmental, cultural and economic factors can interfere with the degree of satisfaction with life, especially if biological needs, safety aspects, social aspects, and psychological aspects have been minimally affected [53].

HEIs contribute to SD through their teaching, research, extension and management practices [54]. Following the statements of [55], a sustainable HEI is one that values the quality of teaching, implements practices aimed at improving the quality of academic life (QAL) and is concerned about managing the use of natural resources. Therefore, in the perspective expressed in [56], HEIs should integrate the principles and practices of sustainability, as that vision and institutional orientation is revealed to be important in undertaking a necessary process of awareness among the academic community and to help decision-making, planning and operational processes.

The psychology of sustainability and SD [57] looks at sustainability not only in terms of the ecological and socio-economic environment, but also in terms of improving everyone's QoL, as mentioned in [58]. In this line of thought, the same authors highlighted that it is essential to analyse the quality of working life (QWL), as professional activity plays a fundamental role in determining employees' physical and mental health and well-being. Similarly, in [59] it was claimed that SD can only materialize in work environments that promote employees' well-being.

As an indicator of well-being, QoL is, today, also an extremely important factor [9], as in its wider sense it involves the components of individuals' lives related to their financial situation, health, interaction with the environment, social relations, affective life, leisure, satisfaction with life and other aspects. QoL is a concept that has inspired much research in the last few decades and had a strong influence on social and political trends applied to various fields, such as urban and regional planning, health promotion and also in social and economic investigation [60].

The literature available in this field can be divided into two types of studies: (i) the studies that consider QoL as a set of purely economic factors (GDP per capita, cost of living, employment, scale economies, etc.), determinants of the growth, decline and competitiveness of organisations [61]; and (ii) as a set of non-economic factors, as a subject of research in the quality of academic life of students (QAL) (satisfaction with services, emotions felt in campus, etc.), e.g., [62–68], or as a factor for assessing quality of work life (needs for satisfaction in a physical and emotional line) (QWL) [69–73].

Some studies demonstrate the relationship between HEIs' IC and SD [7,22,74], and between HEIs' IC and QoL [9,75], but after checking some recent literature reviews regarding IC [19] and searching

the most renowned databases (e.g., Web of Science and Scopus), there were no studies which aimed to simultaneously analyse IC, SD and QoL in HEIs, considering their stakeholders' perceptions.

The SD practices can be related to QoL. For example, the social dimension of SD in the HEI context is associated with the quality of work and the quality of life in the academic community [10]; SD in HEIs is a type of development that ensures individuals' QoL through the conservation and preservation of the environment [54]. For example, in [50] it is stated that problems related to noise and environmental pollution are frequently mentioned by individuals as threats to their QoL [76]. If HEIs promote SD practices on campus, such as noise reduction, diminishing the use of paper and recycling campaigns by providing containers for this purpose, they can contribute to greater satisfaction among students.

Recent years have witnessed an exponential increase in the number of studies on QoL in educational environments in relation to the different individuals and groups therein [63,67,68,77–79], more specifically in the areas of students' QAL, e.g., [64–68] and the QWL of teachers and researchers [70,71]. QAL can be assessed in terms of feelings of global satisfaction with the student's experience of life at university [80]. QAL concerns the degree of need for satisfaction and the experiences that create positive emotions in the context of university life experienced by students [81]. Furthermore, the QAL corresponds to a sub-domain of QoL in general, expressed through the satisfaction revealed with the domain of university life [63,80]. These same authors conceptualized QAL as students' general feeling of satisfaction with the experience of university life through the presence of positive sentiments and the absence of negative ones.

QAL has also been measured as a composite of cognitive assessment, i.e., satisfaction of needs in life in the HEI, and affective assessment, referring to positive and negative affective experiences occurring throughout the period of studies at the HEI [64–68] This study adopts the view proposed in [80] regarding QAL, for whom this is defined according to the global feelings of satisfaction a student experiences in relation to university life. As QAL is measured through the determinants of satisfaction with HEI life [68], these SD practices are expected to contribute positively to students' QAL.

According to some studies, SD has a relationship with QoL [46], and with QAL [10]. If QAL measures students' QoL in the HEI context, then QAL can supposedly be affected by HEIs' SD practices. As mentioned, no studies are known to relate HEIs' sustainable development to students' QAL. For greater understanding of this connection, the following research hypothesis is formulated:

Hypothesis 2 (H2). *Sustainable development practices in HEIs have a positive and significant influence on students' QAL.*

QWL considers the organisational environment according to a wide range of needs for staff well-being at the workplace [69,82]. QWL has a multi-layered, dynamic structure covering different concepts such as safety at work, reward systems, workflows, opportunities for educational and work development, and participation in decision-making processes [70].

In [69], it was stated that QWL describes human resources' satisfaction of seven principal needs, namely health and safety, economic and family, social, esteem, self-updating, knowledge and aesthetic needs. However, in [80], these measures were conceptualized for updating QWL in terms of satisfaction composed of two sets of needs. Firstly, we have the composite of satisfaction of lower order needs, which includes satisfaction of health and safety needs, as well as satisfaction with economic and family needs. Secondly, we consider the composite of higher order needs, which includes satisfaction of social, esteem, self-updating, knowledge and aesthetic needs. These authors argued that the examination of the relative effectiveness of higher and lower order needs helps to prioritize the satisfaction of workers' needs. This method was also validated in [71].

QWL has been studied and defined by various authors e.g., [69,80,83,84]. However, the present study focuses specifically on HEIs, using the definition proposed in [85] for conceptualizing QWL—that is, the staff's satisfaction with a variety of needs through resources, activities and results arising from participation in the workplace; and for measures of QWL, the updated needs proposed

by the first authors were stated in [86]. Various studies in the field of QWL dealt with HEI teachers/researchers [70,71,73], but so far no studies are known to have dealt with the relationship between sustainable development practices in HEIs and the QWL of teachers/researchers, and so this is an innovative approach with potential interest for both researchers and HEI managers.

As already stated, SD affects QoL [46]. For example, recycling paper and other office material can make people feel that they are contributing to improving the state of the planet, and, as such, feel prouder of the place they work in, i.e., greater satisfaction and, therefore, a better QWL. A similar feeling is hoped for when the HEI contributes proactively to the balanced development of society through actions of social responsibility. A widely used definition of social responsibility for SD is that of the World Business Council [87], according to which corporate social responsibility is organisations' continued commitment to behave ethically and contribute to economic development, improving the QoL of the workforce and their families, as well as that of the local community and society in general. For example, in [88], the social dimension of SD was positioned as a motivational factor for the staff working in the organisation. Therefore, teachers and researchers' involvement in actions to help the community will make them feel better and consequently have a better QWL.

If QWL is people's response or affective reaction to the organisational system [89] and measures teachers and researchers' QoL in the HEI context, then QWL can supposedly be affected by HEIs' sustainable development. To deepen the understanding of this connection, the following research hypothesis is considered:

Hypothesis 3 (H3). *Sustainable development practices in HEIs have a positive and significant influence on the QWL of teachers and researchers.*

Considering the literature review and the research hypotheses formulated, two models of analysis are proposed in Figure 1. Model 1 is concerned with students' perceptions, and Model 2 relates to teachers and researchers' perceptions.

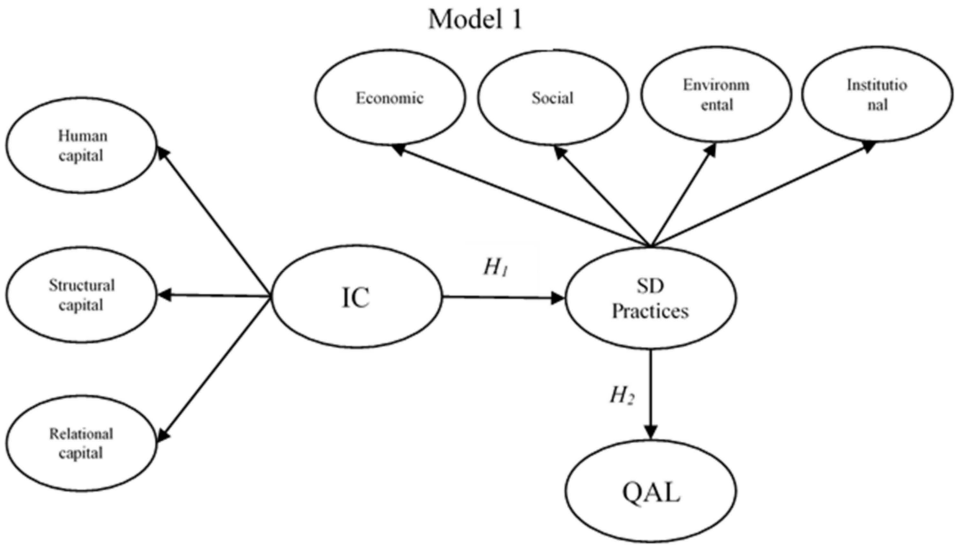

Figure 1. *Cont.*

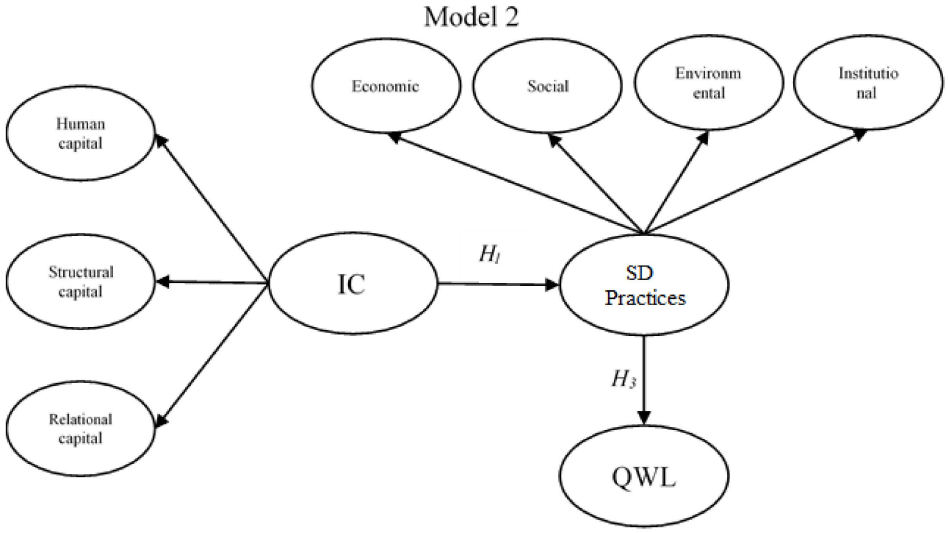

Figure 1. Influence of higher education institutions' (HEIs) intellectual capital (IC) on their own sustainable development practices and on students' quality of academic life (QAL) and teachers/researchers' quality of working life (QWL). Source: Own elaboration.

4. Research Methodology

With the motivation of accomplishing the objectives, this study was analytical and correlational, because it sought to explore the variables and the relationships between them, and it was cross-sectional because the samples were taken in a single period. The purpose of the study was descriptive because it aimed to discriminate the determining factors possibly associated with the phenomenon under study [90]. Through a quantitative, objectivist and, therefore, deductive approach, this research was supported by models built on results and previous research, with quantitative indicators collected through a questionnaire.

4.1. Unit of Analysis

The subject of study corresponded to the entirety of the diverse internal and external stakeholders of Portuguese State HEIs. Based on [91], students and teachers/researchers were selected for this study, given their importance and relevance for the study objectives. The selection of this population was justified as it ensured a diversified sample with the representation of one HEI per region NUTS II level (The Nomenclature of Territorial Units for Statistics (NUTS) is developed by Eurostat, and employed in Portugal for statistical purposes (https://ec.europa.eu/eurostat) and considered the entirety of these seven HEIs as a suitable laboratory to test the effects of IC on QAL and QWL. Due to limitations, in terms of data access, the sample's design incorporated seven HEIs, for the total number of seven NUTS II regions in Portugal, in order to ensure the total geographical coverture of Portugal, including five regions from continental Portugal: North, Centre, Metropolitan area of Lisbon, Alentejo, and Algarve, and also two autonomous regions: Madeira and Azores.

The Portuguese higher education system (public and private) is a binary system, where we can find the university education that is oriented towards the supply of solid scientific formation, joining efforts and competences of teaching and research units and the polytechnic education that is concentrated especially on applied sciences, vocational training and advanced, professionally-oriented technical training. In the current study, the decision was taken to focus on public university education, since they correspond to the dominant share of institutions providing higher education and research services in Portugal; this option facilitated the comparative analysis and representativeness of the results.

4.2. Instrument for Data Collection and Variables

Quantitative data were collected through a Questionnaire A, for students, and a Questionnaire B, for teachers/researchers, resorting to structured, closed questions. A seven-point Likert scale was used for the answers. This scale seems to be the most correct in this study as the respondents build acceptance levels according to their experiences and social influences, giving the opportunity to give clear answers instead of neutral or ambiguous answers. This type of scale has already been used in similar studies related to IC, e.g., [20], QAL, e.g., [68], and QWL, e.g., [71].

Both questionnaires were pre-tested to ensure that all the questions were understood and accepted in the same way by all respondents. Subsequently, some of the items of both questionnaires were adapted to improve comprehension.

4.2.1. Variables for IC

IC was measured considering the dominant triad formed of human capital (HC), structural capital (SC) and relational capital (RC), in line with the multidimensional analysis suggested in [19]. To determine the type of IC indicators, the methodological design proposed in [92] was followed. The 32 key indicators used for IC are presented in Supplementary Materials Annex 2.

4.2.2. Variables for Sustainable Development

The variables to measure the SD practices in HEIs are based on the study developed in [10]. The dimensions used are economic, environmental, social and organisational (see Supplementary Materials Annex 2).

4.2.3. Variables for QAL

Concerning QAL, as mentioned in the literature review, previous studies such as [64,65,68] were the cornerstones.

For the cognitive component, the scale proposed in [64,65] was adopted; and for the affective component, the criterion adopted in [64,65] was used, resorting to the scale proposed in [93]. Both criteria (cognitive component, affective component) have already been used and validated in previous studies, such as [67,68] (see Supplementary Materials Annex 2).

4.2.4. Variables for QWL

As for QWL, several studies were considered, e.g., [69,71,80], incorporating the correspondent adjustments (see Supplementary Materials Annex 2).

4.3. Sample and Data Collection Procedure

The definitive sample was collected between November 2017 and February 2018, in two phases. In the first phase, the questionnaires were sent by e-mail to seven Portuguese HEIs (see Table 1), via the Communication and Image Department at the University of Beira Interior. This e-mail, containing a link to the questionnaire, explained the purpose of the study, ensuring that participation was voluntary, anonymous and confidential.

In the second phase, as the first phase did not result in a representative sample, some paper questionnaires were administered in the classroom. The potential bias of students' non-response was assessed through *t*-tests, with no significant differences being observed between the two groups.

The participants in this study were 749 students and 587 teachers/researchers, having eliminated eleven student questionnaires as they were not correctly completed. The final sample comprised 738 students and 587 teachers/researchers (Supplementary Materials Annex 3 shows the sample characterisation with distribution of respondent students and teachers/researchers by HEI, area of study, gender and age group).

Table 1. HEIs, geographical area of location, weight by HEI, total of students (S) and teachers/researchers (T/R) samples.

HEIs	Region	Weight HEIs (%)		Total Sample Collected		Optimum Sample Size *	
	(NUTS II)	S	T/R	S	T/R	S	T/R
ISCTE-Instituto U. Lisboa	Metropolitan Area of Lisbon	16.67	13.1	118	77	109	70
U Açores	Autonomous Region of Açores	5.29	6.6	48	39	35	30
U. Algarve	Algarve	14.61	10.7	98	64	96	64
U. Beira Interior	Centre	12.86	17.6	132	105	84	105
U. Évora	Alentejo	12.16	13.8	88	82	80	83
U. Madeira	Autonomous Region of Madeira	5.27	6,8	35	41	35	41
U. Minho	North	33.14	31.4	219	179	217	173
Total		100	100	738	587	656	566

Legend: S = Students; T/R = Teachers/Researchers. * The optimal sample size to be collected at each participating HEI was determined for a confidence level of 99% and considering a sampling error of 5%, as proposed by [94]. Source: Own elaboration.

5. Presentation and Discussion of the Results

Prior to the analysis of the evidence provided by Model 1 and Model 2, the descriptive statistics of the variables studied were contemplated, as well as the distribution of the mean values in relation to students and teachers/researchers, which was found to be quite homogeneous in both models. The correlational relation between the control variables was also analysed. The results, presented in Table 2, show that the distribution of the mean values is quite homogeneous and all the correlations are statistically significant ($p < 0.01$), with values below or very close to 0.750, not indicating potential problems of autocorrelation.

Table 2. Descriptive statistics and correlation between variables Model 1 and Model 2.

Model 1	Human Capital	Structural Capital	Relational Capital	Economic	Environmental	Social	Organisational	QAL
Human capital	1							
Structural capital	0.716 **	1						
Relational capital	0.729 **	0.835 **	1					
Economic	0.584 **	0.731 **	0.731 **	1				
Environmental	0.560 **	0.618 **	0.651 **	0.627 **	1			
Social	0.492 **	0.594 **	0.582 **	0.650 **	0.591 **	1		
Organisational	0.694 **	0.742 **	0.804 **	0.697 **	0.690 **	0.572 **	1	
QAL	0.586 **	0.532 **	0.577 **	0.444 **	0.468 **	0.407 **	0.609 **	1
Average	4.836	4.752	4.905	4.634	5.240	4.890	5.119	4.836
Variance	0.560	0.962	1.005	1.145	1.430	1.542	1.470	0.560
Model 2	**Human Capital**	**Structural Capital**	**Relational Capital**	**Economic**	**Environmental**	**Social**	**Organisational**	**QWL**
Human capital	1							
Structural capital	0.736 **	1						
Relational capital	0.688 **	0.824 **	1					
Economic	0.652 **	0.737 **	0.796 **	1				
Environmental	0.473 **	0.619 **	0.698 **	0.678 **	1			
Social	0.435 **	0.545 **	0.603 **	0.582 **	0.528 **	1		
Organisational	0.422 **	0.569 **	0.586 **	0.610 **	0.582 **	0.565 **	1	
QAL	0.349 **	0.391 **	0.391 **	0.398 **	0.404 **	0.228 **	0.284 **	1
Average	4.256	4.187	4.450	4.802	5.040	4.600	4.377	4.736
Variance	0.705	0.995	0.931	1.133	1.782	2.036	1.321	0.929

** The correlation is significant at the level of 0.01 (2 extremities). Source: Own elaboration.

The data were analysed using a selected specification of a structural equation model (SEM), using the partial least squares (PLS) method, SEM–PLS. Considering the statement presented by Hair et al. [95], the PLS assumes no distribution to the data and is relatively robust against distribution deviations. However, the same authors stated that researchers should still examine PLS–SEM results carefully when distributions deviate substantially from normal. In accordance with this, absolute

skewness and/or kurtosis values of greater than one are indicative of non-normal data. Taking into account what was mentioned by Hair el al. [95], in this case, regarding skewness and kurtosis statistics, they do not provide evidence of a non-normal distribution. In both models, the kurtosis and skewness values of the indicators are within the acceptable range of −1 and +1. The only exception is the ORG indicator, in M1, which has a skewness of −1.113 and a kurtosis of 1.365, and thus exhibits a slight degree of non-normality. However, as the degree of skewness and kurtosis is not severe and because ORG is one of four indicators measuring the (reflexive) SD construct, this deviation from normality is not considered a problem and the indicator is retained.

The variance inflation factor (VIF) was also used to diagnose collinearity, and it was found that the variance value of each indicator is no higher than 2.7, signalling no potential multicollinearity issues.

5.1. Model Estimation

According to the procedures defined in [95], SEM–PLS is used mainly to develop theories in exploratory studies focusing on explaining the variance in dependent variables when examining the model. SmartPLS (v 3.2.7) software [96] was used to estimate the parameters, using bootstrapping of 5000 samples to obtain their significance [95].

The PLS model was assessed in three stages: (i) assessment of the global model was determined; (ii) the reliability/validity of the measurement model was checked; and (iii) the meaning of the paths (relations between constructs) within the structural model was assessed [97].

The initial measurement model of this study denotes reflexive characteristics (see Supplementary Materials Annex 2), containing two multidimensional constructs (second-order constructs) and nine latent variables (first-order constructs) that cannot be observed or measured directly, and can only be inferred through their observable variables, i.e., the forty-five indicators (see Supplementary Materials Annex 1).

After determining the values and adjusting the constructs of QAL and QWL, considering the literature review, the two models proposed were analysed. As in both models there is a second-order construct, this analysis will follow a two-step approach as recommended by [98], that is: (i) treatment of M1 and M2 only with the first-order constructs (models M1a and M2a); and (ii) treatment of the models incorporating the aggregate scores as an indicator of the second-order constructs (Models M1b and M2b).

Stage 1: Treatment of Models M1a and M2a. In this stage, the global model and measurement model will be analysed.

Assessment of the global model requires the use of quality adjustment measures. After estimating the two models (M1a and M2a) using SmartPls [96], it was found necessary to adjust both models, since the values presented did not agree with recommendations in the literature of reference. It was found adequate to drop the indicators with the smallest loading values that were detracting from the result. The models were estimated until the standardized root mean square residual (SRMR) value in both models reached the cut-off value of >0.08 [99]. Regarding M1a, the indicators of HC3, HC5, HC6, HC7, HC8, HC9, SC7, RC2, RC3 and RC8 were withdrawn; and from M2a the indicators of HC1, HC3, HC4, HC5, HC7, HC8, HC9, HC10, SC1, SC2, SC3, SC7, SC8, SC10, RC1, RC2, RC3 and RC4 were withdrawn. Figure 2 shows the final M1a and M2a models.

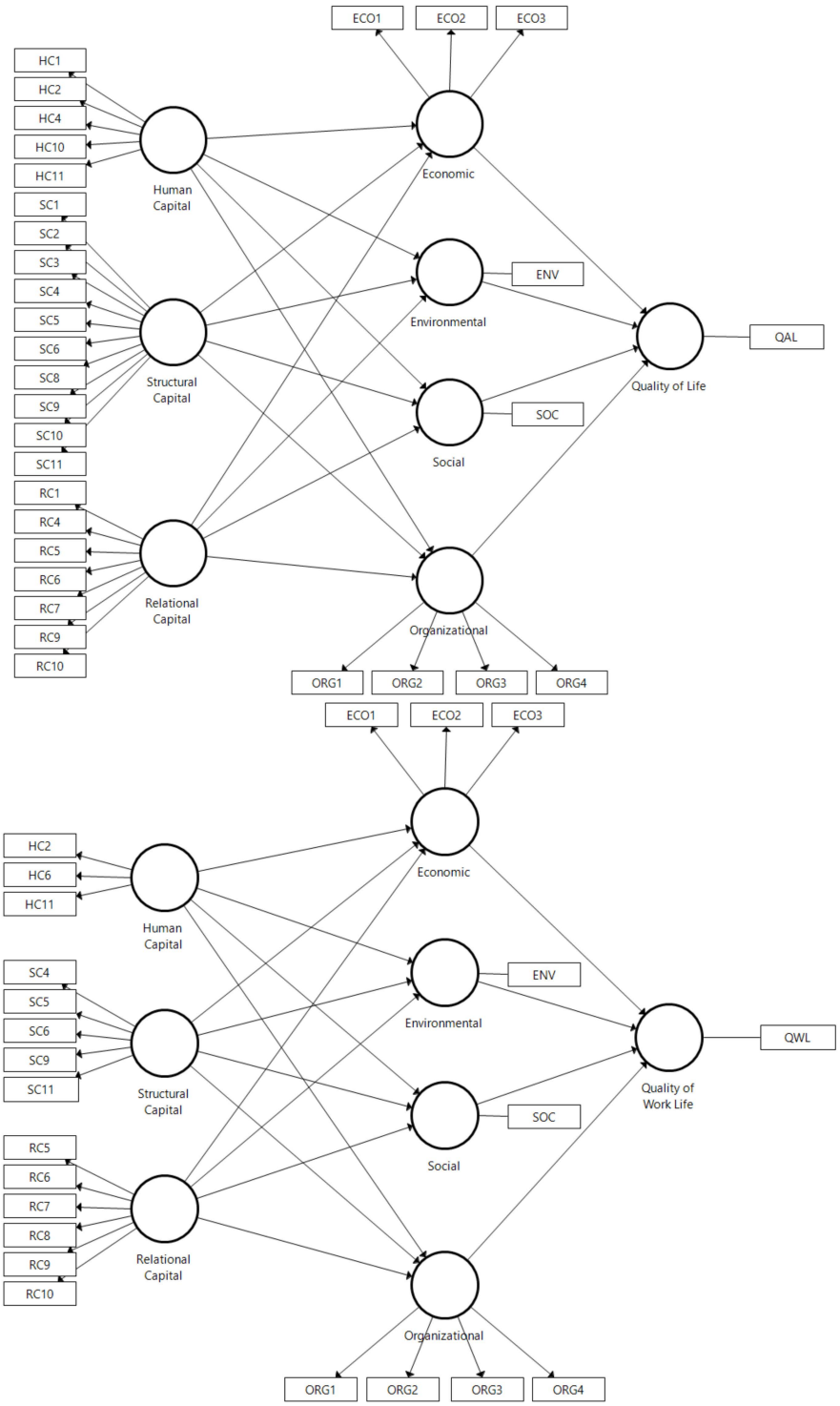

Figure 2. Models M1a and M2a adjusted only with the first-order constructs relations. Source: Own elaboration.

As observed in Table 3, the original SRMR value in both models was <0.08 [99] and all the deviations were insignificant because 95% of the bootstrap quantile (HI95) of the value of the three measures were greater than the original values [97].

Table 3. Quality of adjustment (estimated model and saturated model).

Fit Measures	Original Value		HI95	
	M1a	M2a	M1a	M2a
SRMR	0.059	0.069	0.064	0.077
dULS	1.866	1.444	2.171	1.790
dG	0.630	0.825	0.703	0.893

Legend: *SRMR*: Standardized root mean square residual; *dULS*: unweighted least squares discrepancy; *dG*: geodesic discrepancy. Source: Own elaboration.

In the assessment of the measurement model, only the reflexive indicators will be analysed, because the models do not have formative indicators. All the measures have as reference the recent studies of [100,101].

In the analysis of reflexive indicators, consideration should be given to: (i) reflexive indicator loadings; (ii) internal consistency reliability; (iii) convergent validity; and (iv) assessment of discriminant validity.

Regarding the loading values (see Table 4) of M1a and M2a, all the indicators are seen to present values above 0.70, as recommended, except for one indicator from M2a. However, as this indicator is close to 0.70, we decided to retain it, in agreement with the recommendation present in [102,103] by considering that it is necessary in the model.

Table 4 also presents the results of the analysis of internal consistency reliability, as well as the Cronbach alpha value. Interpretation of the coefficients of these analyses should also not present values under 0.70 (or 0.60 in exploratory research). All the variables also satisfy the requirements of the Dijkstra–Henseler indicator (ρA) (*rho_A*), since the values obtained by calculating the indicator are above the reference of 0.70.

The assessment of convergent validity is through the average variance extracted (AVE), which must be equal to or above 0.50. The result, presented in the same table, shows that the AVE value agrees with the literature of reference, i.e., above 0.5.

The discriminant validity is better detected through the calculation of the heterotrait–monotrait (HTMT) ratio, which for conceptually similar constructs must be HTMT < 0.90, and, for conceptually different constructs, HTMT < 0.85. Table 5 confirms that the result of this last analysis also agrees with the authors' recommendation, except for two values in both models that are very close to 0.90. In addition to these guidelines, to complement this result, researchers can formally test whether the HTMT value is significantly lower than unity (1) using bootstrapping, and in both cases Table 6 confirms that the result of this last analysis also agrees with these authors' recommendations, i.e., no interval has the value of one.

Table 4. Analysis of the measuring model (loadings, internal consistency and reliability, Dijkstra–Henseler indicator, composite reliability and average variance extracted (AVE) of models M1a and M2a.

M1a						*M2a*					
Variable/ Indicator	Loading	Cronb. Alpha	Rho_A	pc	AVE	Variable/ Indicator	Loading	Cronb. Alpha	Rho_A	Pc	AVE
HC		0.815	0.830	0.870	0.573	HC		0.727	0.734	0.848	0.654
HC1	0.742					HC2	0.869				
HC2	0.729					HC6	0.679				
HC4	0.733					HC11	0.863				
HC10	0.820					SC		0.852	0.855	0.895	0.631
HC11	0.757					SC11	0.747				
SC		0.910	0.912	0.925	0.554	SC4	0.821				
RC1	0.781					SC5	0.834				
RC10	0.774					SC6	0.854				
RC4	0.720					SC9	0.705				
RC5	0.801					RC		0.862	0.867	0.897	0.591
RC6	0.791					RC10	0.799				
RC7	0.801					RC5	0.814				
RC9	0.804					RC6	0.771				

Table 4. *Cont.*

	M1a						*M2a*				
Variable/ Indicator	**Loading**	**Cronb. Alpha**	**Rho_A**	**pc**	**AVE**	**Variable/ Indicator**	**Loading**	**Cronb. Alpha**	**Rho_A**	**Pc**	**AVE**
RC		0.894	0.896	0.917	0.612	RC7	0.755				
RC1	0.729					RC8	0.703				
RC2	0.701					RC9	0.768				
RC3	0.780					ECO		0.760	0.807	0.861	0.674
RC4	0.702					ECO1	0.797				
RC5	0.735					ECO2	0.894				
RC6	0.760					ECO3	0.767				
RC7	0.745					ENV	1.000				
RC8	0.810					SOC	1.000	1.000	1.000	1.000	1.000
RC9	0.749					ORG					
RC10	0.724					ORG1	0.864				
ECO		0.820	0.838	0.892	0.734	ORG2	0.841				
ECO1	0.882					ORG3	0.884				
ECO2	0.885					ORG4	0.805				
ECO3	0.801					QWL	1.000	1.000	1.000	1.000	1.000
ENV	1.000	1.000	1.000	1.000	1.000						
SOC	1.000	1.000	1.000	1.000	1.000						
ORG	0.921	0.922	0.944	0.808	0.921						
ORG1	0.908										
ORG2	0.907										
ORG3	0.897										
ORG4	0.883										
QAL	1.000	1.000	1.000	1.000	1.000						

Source: Own elaboration.

Table 5. Heterotrait–monotrait (HTMT) ratio of models M1a and M2a.

M1a	**HC**	**SC**	**RC**	**ECO**	**ENV**	**SOC**	**ORG**	**QAL**
HC								
SC	0.905							
RC	0.854	0.925						
ECO	0.776	0.844	0.852					
ENV	0.555	0.652	0.685	0.694				
SOC	0.526	0.870	0.608	0.720	0.591			
ORG	0.715	0.814	0.623	0.801	0.719	0.597		
QAL	0.238	0.263	0.280	0.186	0.220	0.168	0.300	
M2a	**HC**	**SC**	**RC**	**ECO**	**ENV**	**SOC**	**ORG**	**QAL**
HC								
SC	0.901							
RC	0.888	0.906						
ECO	0.565	0.676	0.689					
ENV	0.672	0.709	0.738	0.673				
SOC	0.559	0.563	0.640	0.652	0.527			
ORG	0.818	0.835	0.883	0.754	0.731	0.626		
QWL	0.059	0.065	0.093	0.068	0.116	0.033	0.092	

Source: Own elaboration.

Table 6. Heterotrait–monotrait (HTMT) ratio of models M1a and M2a using bootstrapping.

Variables M1a	Original Sample (O)	Sample Mean (M)	2.5%	97.5%	Original Sample (O)	Sample Mean (M)	Bias	2.5%	97.5%
HC -> ECO	0.103	0.105	0.018	0.197	0.103	0.105	0.002	0.016	0.195
HC -> ENV	−0.039	−0.040	−0.139	0.061	−0.039	−0.040	−0.001	−0.139	0.061
HC -> SOC	−0.009	−0.008	−0.114	0.098	−0.009	−0.008	0.000	−0.114	0.098
HC -> ORG	0.000	0.000	−0.080	0.076	0.000	0.000	0.000	−0.081	0.075
SC -> ECO	0.341	0.342	0.229	0.450	0.341	0.342	0.001	0.227	0.447
Structural Capital -> Environmental	0.306	0.307	0.177	0.434	0.306	0.307	0.001	0.173	0.430
Structural Capital -> Organisational	0.292	0.293	0.179	0.410	0.292	0.293	0.001	0.177	0.406
Structural Capital -> Social	0.379	0.380	0.232	0.521	0.379	0.380	0.001	0.227	0.518
Relational Capital -> Economic	0.374	0.372	0.269	0.476	0.374	0.372	−0.002	0.274	0.480
Relational Capital -> Environmental	0.422	0.421	0.303	0.541	0.422	0.421	−0.001	0.305	0.542
Relational Capital -> Organizational	0.548	0.547	0.442	0.650	0.548	0.547	−0.001	0.444	0.650
Relational Capital -> Social	0.266	0.265	0.132	0.396	0.266	0.265	−0.001	0.134	0.399
ECO -> QAL	−0.081	−0.080	−0.208	0.052	−0.081	−0.080	0.001	−0.211	0.049
ENV -> QAL	0.056	0.056	−0.039	0.152	0.056	0.056	0.000	−0.039	0.152
SOC -> QAL	0.017	0.018	−0.072	0.106	0.017	0.018	0.001	−0.074	0.104
ORG -> QAL	0.297	0.297	0.184	0.408	0.297	0.297	0.000	0.184	0.407
Variables M2a	**Original Sample (O)**	**Sample Mean (M)**	**2.5%**	**97.5%**	**Original Sample (O)**	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Economic -> Quality of Work Life	−0.005	−0.005	−0.102	0.094	−0.005	−0.005	0.000	−0.103	0.093
Environmental -> Quality of Work Life	0.120	0.120	0.015	0.226	0.120	0.120	0.000	0.016	0.226
Human Capital -> Economic	−0.122	−0.121	−0.227	−0.020	−0.122	−0.121	0.001	−0.229	−0.022
Human Capital -> Environmental	0.038	0.039	−0.061	0.140	0.038	0.039	0.001	−0.061	0.138
Human Capital -> Organizational	0.090	0.091	−0.002	0.184	0.090	0.091	0.001	−0.003	0.182
Human Capital -> Social	0.066	0.067	−0.053	0.188	0.066	0.067	0.001	−0.055	0.186
Organisational -> Quality of Work Life	0.034	0.034	−0.084	0.152	0.034	0.034	0.000	−0.084	0.152
Relational Capital -> Economic	0.379	0.380	0.270	0.489	0.379	0.380	0.001	0.267	0.486
Relational Capital -> Environmental	0.461	0.462	0.372	0.547	0.461	0.462	0.001	0.370	0.546
Relational Capital -> Organisational	0.522	0.522	0.438	0.599	0.522	0.522	0.000	0.434	0.596
Relational Capital -> Social	0.471	0.469	0.355	0.572	0.471	0.469	−0.001	0.358	0.574
Social –> Quality of Work Life	−0.047	−0.047	−0.158	0.066	−0.047	−0.047	0.001	−0.160	0.065
Structural Capital -> Economic	0.360	0.360	0.240	0.477	0.360	0.360	0.000	0.239	0.476
Structural Capital -> Environmental	0.266	0.265	0.156	0.370	0.266	0.265	−0.002	0.158	0.371
Structural Capital -> Organisational	0.241	0.241	0.139	0.345	0.241	0.241	0.000	0.140	0.345
Structural Capital -> Social	0.100	0.100	−0.024	0.228	0.100	0.100	0.001	−0.025	0.227

Source: Own elaboration.

Stage 2: Treatment of Models M1b and M2b. As the proposed model adopts a different nomological structure, as suggested in [98] after calculating the results of the first order model (Models M1a and M2a), the measurement model of the second order models needs to be tested (Models M1b and M2b). The second order constructs (intellectual capital and sustainable development) incorporate the respective score of the first order dimension produced by SmartPLS [96]. After this stage, the structural model can be estimated [103].

For the measurement model, the procedure is exactly as in Stage 1. Analysis of Table 7 confirms that all the values are within the established parameters (>0.70) or very close to that value. The same table presents the results of the analysis of internal consistency and reliability, as well as Cronbach's alpha and AVE values. According to the literature of reference mentioned in Stage 1, all the values are within normality.

As for the heterotrait–monotrait (HTMT) ratio, the values are also within normality (see Tables 8 and 9).

Table 7. Measuring model (loadings, internal consistency and reliability, Dijkstra-Henseler indicator, composite reliability and AVE) of models M1b and M2b.

M1b						M2b					
Variable/ Indicator	**Loading**	**Cronb. Alpha**	**Rho_A**	**pc**	**AVE**	**Variable/ Indicator**	**Loading**	**Cronb. Alpha**	**Rho_A**	**Pc**	**AVE**
IC		0.889	0.896	0.931	0.818	IC		0.879	0.890	0.925	0.805
HC	0.879					HC	0.876				
SC	0.926					SC	0.917				
RC	0.908					RC	0.897				
SD		0.858	0.870	0.903	0.700	SD		0.848	0.866	0.897	0.686
ECO	0.859					ECO	0.812				
ENV	0.823					ENV	0.853				
SOC	0.796					SOC	0.768				
ORG	0.869					ORG	0.876				
QAL	1.000	1.000	1.000	1.000	1.000	QAL	1.000	1.000	1.000	1.000	1.000

Source: Own elaboration.

Table 8. Heterotrait–monotrait (HTMT) ratio of models M1b and M2b.

M1b	**IC**	**SD**	**QWL**	**M2b**	**IC**	**SD**	**QWL**
IC				IC			
SD	0.887			SD	0.881		
QWL	0.282	0.259		QWL	0.070	0.100	

Source: Own elaboration.

Table 9. Heterotrait–monotrait (HTMT) ratio of models M1b and M2b using bootstrapping.

Variables M2a	**Original Sample (O)**	**Sample Mean (M)**	**2.5%**	**97.5%**	**Original Sample (O)**	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
IC -> SD	0.786	0.786	0.752	0.817	0.786	0.786	0.000	0.750	0.816
SD -> QAL	0.245	0.246	0.175	0.315	0.245	0.246	0.001	0.172	0.312
Variables M2b	**Original Sample (O)**	**Sample Mean (M)**	**2.5%**	**97.5%**	**Original Sample (O)**	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
IC -> SD	0.779	0.779	0.753	0.803	0.779	0.779	0.001	0.751	0.802
SD -> QWL	0.097	0.097	0.032	0.160	0.097	0.097	0.000	0.031	0.159

Source: Own elaboration.

With no formative indicators to analyse, the structural model is assessed below.

5.2. Assessment of the Structural Model

Primary assessment of the structural model is carried out considering two assessment criteria, namely the determination coefficient statistic (R^2), which measures the degree of model adjustment, and the statistical significances of the path coefficients [100,101]. As analysing structural equations through the PLS method consists of maximizing the value of the explained variance of the endogenous latent variables, the R^2 value of the constructs should present a high value [100,101].

Regarding the estimation of the effect size (f^2), according to [104] the reference values are: $0.02 \leq f^2 < 0.15$: small effect; $0.15 \leq f^2 < 0.35$: moderate effect; $f^2 \geq 0.35$: large effect.

The Stone–Geisser (Q^2) test is used as a criterion to measure the predictive relevance of the reflexive dependent constructs [105]. As in f^2, values of 0.02, 0.15 and 0.35 indicate that an exogenous construction has small, moderate or large predictive relevance in a given endogenous construction.

Analysing the values presented in Table 10, the results confirm that the structural model of both models presents acceptable predictive relevance (R^2) for SD and weak for QAL and QWL, and that the values, also presented in this table for f^2 and Q^2, are in accordance with the above-mentioned criteria.

Table 10. Determination coefficient (R^2), estimate of the size effects (f^2), and predictive relevance (Q^2) of models M1b and M2b.

Variables	R^2		f^2		Q^2	
	M1b	**M2b**	**M1b**	**M2b**	**M1b**	**M2b**
IC			1.617 ***	1.541 ***		
SD	0.618	0.606	0.064 **	0.009 *	0.403 ***	0.388 ***
QAL/QWL	0.060	0.009			0.054 *	0.008 *

Legend: * $0.02 \leq f^2/Q^2 < 0.15$: small. ** $0.15 \leq f^2/Q^2 < 0.35$: moderate *** $f^2/Q^2 \geq 0.35$: large. Source: Own elaboration.

Concerning the robustness of the path coefficients, the reference value is above 0.2 [103,106]. The observation of Table 11 reveals that all the coefficients present a value above 0.2, meaning that there is robustness in the relationships tested, except for SD -> QWAL ($p = 0.097$). Considering the estimated values of the coefficients and corresponding t values, there is good adjustment of the data used to estimate the model and test the hypotheses studied, in terms of structural relations. The final models are presented in Figure 3.

Table 11. Robustness of the coefficients and level of significance of the structural relations of models M1b and M2b.

Structural Relations	Estimated Value		Sample Mean		Standard Deviation		t-Value	
	M1b	**M2b**	**M1b**	**M2b**	**M1b**	**M2b**	**M1b**	**M2b**
H_1: IC -> SD	0.786 †	0.779 †	0.786	0.779	0.017	0.015	47.328 ***	51.124 ***
H_2/H_3: SD -> QAL/QWAL	0.245 †	0.097	0.246	0.097	0.036	0.039	6.804 ***	2.473 **

Legend: † = Robustness of the coefficient because the value obtained is above 0.2. ** = level of significance 5% (>1.96) *** = level of significance 1% (≥2.58). Source: Own elaboration.

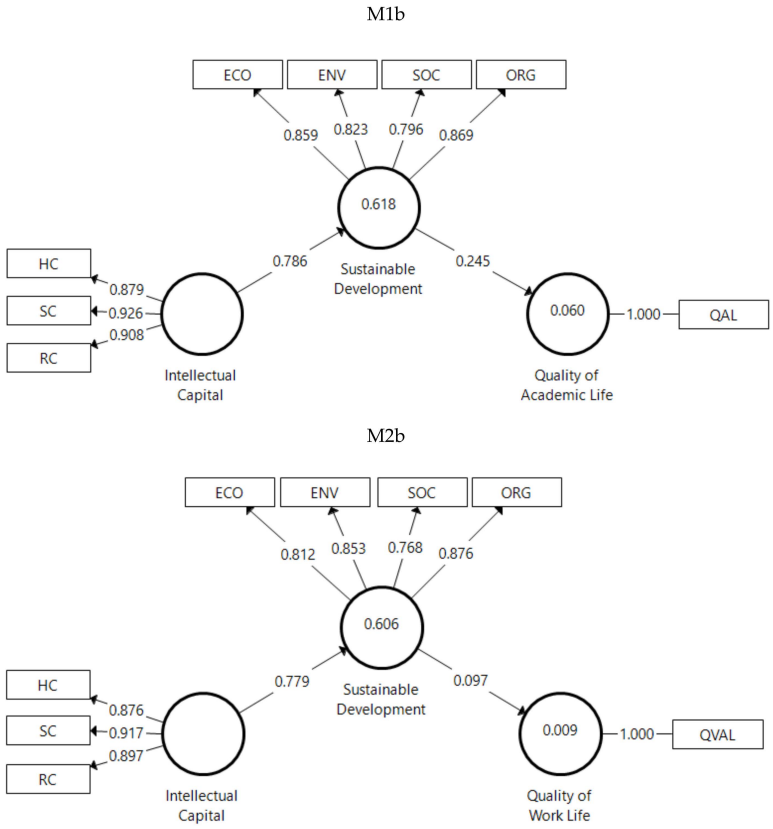

Figure 3. Complete final structural models of M1b and M2b, and the respective weights and loadings. Source: Own elaboration.

5.3. Contrasting Literature and Empirical Findings

Regarding hypothesis 1, HEIs' IC has a direct and positive influence on HEIs' SD practices, and so this hypothesis is not rejected in either model (M1: 0.786; and M2: 0.779). Indeed, HEIs' IC is found to promote SD through the different dimensions of sustainability studied (economic, environmental, social and organisational), which is in line with the global idea proposed in [8] that HEIs are agents of change for sustainability, being associated with the pressing challenges society faces related to accelerated environmental changes, the shortage of resources, increased inequality and injustice, as well as rapid technological change and social change. These results are also in line with other studies [24,25] that recognised HEIs' IC as essential in promoting SD, with examples of SD practices in environmental, economic, social and organisational dimensions being integrated into activities related to education, research, operations, social involvement and governance/culture worldwide [26].

Concerning the dimensions of IC, these are very balanced, finding a higher value in both models for SC (M1: 0.926; and M2: 0.917). The perception of SC, linked essentially to physical structures and the campus, seems to be the one both students and teachers/researchers give most importance to. This result coincides with those of other authors, e.g., [107], for whom SC is the most important part of IC because it serves as a vehicle to convert staff's personal knowledge into value. In addition, HC has the lowest value (M1: 0.879 and M2: 0.876). This difference, and also considering that the HC indicators presented the greatest problems in the models, with some of them being withdrawn, can mean that neither students nor teachers/researchers may be sufficiently well informed about their HEI's human resource system, and there may be inefficient management of these resources if it does not reveal their importance and staff's competences for the institution's good functioning.

As for the dimensions of SD, these results are in line with the state of the art, e.g., [10,22], which shows that the SD concept is associated equally with HEIs' practices of economic, environmental, social and organisational sustainability. Strangely, the social dimension, for both students and teachers/researchers, is the least robust one (M1: 0.796 and M2: 0.768), although positive and quite significant. Recovering [10], which found that Portuguese HEIs are mainly engaged in the social dimension of SD practices, contradicts the result obtained here somewhat, inasmuch as this study was made considering the perception of students and teachers/researchers. Perhaps HEIs are not sending out the right image in relation to the social dimension and/or respondents are giving greater importance to the other dimensions. This fact may be associated with the SD practices still in phases closely linked to planning, as previously advocated in [45].

Regarding hypothesis 2, according to which SD practices in HEIs have a direct and positive influence on students' QAL, this was not rejected either (M1b: 0.245). There is evidence for the presence of SD practices in HEIs that interact in students' lives, inasmuch as they are perceived by the latter and are part of their concerns. As mentioned by [46], sustainable behaviours contribute to quality of life in more instances than expected and students' perceptions of the dimensions associated with SD practices are very important for them to feel secure in both the present and future. These results strengthen the idea that SD practices are related to QAL, through the satisfaction with the experiences that create positive emotions in the context of university life experienced by students [62–68]. These satisfaction can be observed, as mentioned by [50], through several improvements in the campus environment (noise reduction, less use of paper, recycling campaigns, etc.), and in this way HEIs can contribute to greater satisfaction among students.

Concerning the result found for hypothesis 3, HEIs' SD practices have a direct and positive influence on the QWL of teachers/researchers. Despite this influence being positive and significant, for a 5% level reason the associated hypothesis is rejected. This result partially contradicts some authors, e.g., [46], who argued that SD affects QoL. Bearing in mind that QWL is a more specific construct, related to needs for satisfaction in the workplace, and not in a general way, this analogy must be done carefully because more evidence found in the HEI work context is needed.

The difference found between hypothesis 2 and hypothesis 3 sheds new light on the interesting fact that young people are more aware of, and perhaps more concerned about, matters related

to sustainability, and consequently about the future, compared to what is found in teachers' and researchers' perceptions. Therefore, the formers' perception of what is done in relation to SD in their HEI is revealed to be greater.

All in all, the results now obtained can be applied to the practice by HEIs managers through more visible sustainable efforts, building bridges within HEIs between IC, SD and QoL that will lead stakeholders to recognise the institution's sustainability efforts. For this they need, as mentioned in [23], to generate new ideas, to engage the HEIs' human resources in sustainability, promoting a better QoL, to create a baseline for continuous improvement, to inform strategic planning and budgeting, to integrate sustainability into the curriculum, to make real progress towards sustainability, and to be part of a global community involved in sustainability purposes.

6. Concluding Remarks and Future Research

This paper focuses on the influence of HEIs' IC (HC, SC, RC) on HEIs' SD, and on the influence of HEIs' SD on stakeholders' QoL (QAL of students and QWL of teachers/researchers), formulating three hypotheses for test purposes. To respond to the proposed objectives, after determining the state-of-the-art, a quantitative analysis was performed by collecting primary data and using a structural equation model and the PLS method. SEM–PLS supported two of the three previously formulated hypotheses.

The results obtained are important contributions to the literature on IC through the ratification of new evidences for theory, as they confirm empirically that, firstly, a positive and significant relationship exists between HEIs' IC and HEIs' SD, and secondly, a positive and significant relationship exists between HEIs' SD and students' QAL. Regarding the influence of HEIs' SD on teachers/researchers' QWL, no empirical evidence was found of a robust relationship between these two constructs, suggesting there may be other variables that are not being considered and which could possibly change this result, and so new, more thorough research in this field is suggested. Therefore, this type of relationship, never before studied, opens new theoretical horizons and new perspectives for further study and research in this area. The results indicate that IC (HC, SC and RC) has a positive and significant influence on HEIs' (economic, environmental, social and organisational) SD, since hypothesis 1 was not rejected in either model. That is, through the perception that students and teachers/researchers have of the IC and SD of their HEI, it is concluded that IC is directly and positively related to that institution's SD. These results are consistent with previous evidence [7]. HEIs should approach their IC as a whole, since all dimensions are revealed to be important. However, attention is drawn to the fact that HC is the one where there may be more room for improvement, since it had least weight in IC. Considering the results obtained in this study, for IC to produce an even greater impact on SD, HEIs should create and implement strategies towards continuous improvement of their human resources, as by devoting more attention to their human resources they can have greater empowerment and thereby influence HEIs' SD even more. This conclusion ratifies [108], which stated that human capital is an indicator of value creation that can be used to help formulate organisational strategy, provide a basis for evaluation and allocate some resources in the HEI context.

The results of this study are also in line with the previous concluding remarks found in [10], who revealed that Portuguese HEIs are beginning to give relevance to all the dimensions of SD and include them in their strategic plans, communication strategies and various policies. Nevertheless, it stands out that the social dimension has the lowest value (M1: 0.796 and M2: 0.768), and there may be room for a better positioning of HEIs through better and more proficient social engagement, as mentioned in [10], oriented towards the increasingly urgent challenges of sustainability, associated with rapid change and increased complexity and social unrest.

As for the relationship between HEIs' sustainability and QoL, there is evidence of its existence, supported by finding a positive and significant relationship between HEIs' SD and QAL. It is, therefore, underlined that HEIs have a fundamental role in promoting SD and their leaders' efforts are vital in achieving the goals associated with SD. HEIs must recognise their importance and responsibility,

not only in terms of pro-sustainability education but also by including measures of SD that have repercussions for the QoL of their stakeholders and that of the region's population and the country. As demonstrated in several studies, notably in the Spanish context, e.g., [31], it is important to develop policy statements, in order to increase sustainability practices in Portuguese HEIs [10].

HEIs should pay attention to how they manage their IC, creating value not only for the institution itself through the contribution to SD but also creating value for the QoL of their students and teachers/researchers, developing these points that may possibly be more connected to the latter's QWL. In addition, the efforts of HEI leaders should focus on achieving SD goals, and the actions promoted by these institutions should be in line with the perceptions of all their stakeholders.

Referred to as an implication, given the importance of transforming the education institution as a whole, the priority action areas undergo transformations at the level of information, because more and better information should be given about what happens in SD practices in HEIs, providing information which is accessible to all. However, and from the results obtained, perception is seen to be different depending on the stakeholder, and so SD practices should be monitored on a regular basis and the reports should be provided in such a way that everyone understands their content, using simple and accessible language. As noted by UNESCO [13], education institutions are encouraged to implement sustainability strategies and plans with institution-wide approaches, taking into account some key elements such as inter-institutional networks that facilitate mutual support, such as peer-to-peer learning on a whole-institution scale, and increase the visibility of the approach to promote it as a role model for change and adaptation.

This study also provides practical implications for stakeholders: (i) HEIs must satisfy students' needs and emotions, fostering QAL through a better engagement in sustainability activities, by integrating sustainability into the academic curriculum, and by giving more information at a higher quality about what is happening within the HEI concerning SD; and (ii) HEIs must develop some support infrastructures that allow managers to track which sustainability satisfaction needs (QWL) teachers/researchers may have, so that institutions can develop strategies leading to SD while enhancing human resources' satisfaction needs within the employer institution. For example, those needs may be related to social responsibility, and so can be addressed through the greater dissemination of the activities that the institution develops and/or intends to develop, and through specific educational training, that can contribute to both personal enrichment and a greater competence in knowledge transfer to their peers and/or students.

Regarding the limitations of this study, firstly the fact that various indicators from the initial model were eliminated, especially concerning HC, and this elimination may have limited our results. However, despite this, the final model presented very significant and conclusive results, allowing for very useful conclusions to be drawn and the non-rejection of two research hypotheses.

Secondly, the sample was confined to Portuguese HEIs and, therefore, these results cannot be generalized to HEIs in other countries.

Another aspect associated to the representativeness is the fact that the sample is related only to public university education. As Portugal has public and private HEIs and a binary system, as mentioned before, it would be worthwhile to have selected private HEIs and the polytechnic institutions. Therefore, representativeness is limited, and the results of the study cannot be generalized to the entire Portuguese higher education system. Nevertheless, based on the Portuguese public university education system, the sample was representative of the reality under study, since each institution was located in a different region at the NUTS II level.

Thirdly, HEI stakeholders were represented by only students and teachers/researchers. However, in studies made in other HEIs, the top management and/or leadership are almost always the ones surveyed.

As mentioned, the difference in the results found for QAL and QWL is a serious, sustained warning based on new empirical evidence, that young people are more aware of issues related to sustainability than teachers and researchers, since the former denote an high level of perception concerning sustainability issues, due to previous engagement in education programmes, which raised

their social consciousness on the need for change and addressing sustainability issues associated with climate change, social inequality and common well-being, which they tend to value as change mechanisms that can contribute to improving their quality of life, including the academic context and society as a whole. Here, the age factor may have some relevance, in that young people have been found to show greater concern about sustainability and the future of the planet. Nevertheless, the role attributable to pro-sustainability education from an early age can no longer be ignored, including the economic, social, environmental and organisational dimensions, as this can make all the difference in the inter-related cycles of learning and performance throughout life.

With this final motivation, a window of opportunity opens to make future comparative studies based on the age factor and pro-sustainability education factor, since we believe that both can be determinant for the development of successful SD practices, in the HEI context in particular, and society in general. Future research avenues can be explored by developing studies focusing especially on HC, aiming to test disaggregated measures and indicators of this critical asset. Adding to this, cross-country comparisons are suggested in light of the whole-institution approach, in order to assess the role played by "organisational inertia", in terms of potential resistance to change involving the adoption of a whole-institution sustainability vision and the implementation of SD practices at the institutional level. It would be also of interest to deepen the scarce knowledge on IC in HEIs by contrasting the perceptions of the governance board and the students concerning the different activities of this type of knowledge institution, which play a significant role in educating proactive citizens regarding sustainable development and quality of life, with a clear vision of social impact.

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HEI Efficiency and Quality of Life: Seeding the Pro-Sustainability Efficiency

Eugénia de Matos Pedro [1,*], João Leitão [1,2,3] and Helena Alves [1]

[1] Research Center in Business Sciences (NECE), Department of Management and Economics, Faculty of Social Sciences and Humanities, University of Beira Interior, 6200-209 Covilhã, Portugal; jleitao@ubi.pt (J.L.); halves@ubi.pt (H.A.)
[2] CEG-IST—Centre for Management Studies of Instituto Superior Técnico, University of Lisbon, 1049-001 Lisbon, Portugal
[3] ICS—Instituto de Ciências Sociais, University of Lisbon, 1600-189 Lisbon, Portugal
* Correspondence: eugenia@ubi.pt

Abstract: This study assesses the efficiency of higher education institutions (HEIs), considering the social, environmental and cultural factors (pro-sustainability), and at the same time examines how this efficiency can influence regional quality of life (QoL). The study adopts a two-step methodology. In the first step, the standard Data Envelopment Analysis (DEA) is used to estimate the efficiency scores of 23 Portuguese public HEIs; and in the second step, a multivariate logit regression is performed to assess the role played by the HEIs' pro-sustainability efficiency in regional QoL. The main findings reveal that the HEIs located in the Greater Lisbon area have a higher pro-sustainability efficiency, but that efficiency is more significant regarding social factors. Concerning the contribution of pro-sustainability efficiency to the region's QoL, this is significant for all the components, with the environmental and cultural aspects contributing positively to this significance.

Keywords: data envelopment analysis; higher education institutions; quality of life; pro-sustainability

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1. Introduction

Improved living conditions, decentralised decision-making, well-being and the life expectancy of people and places are increasingly important strategic issues in a world with growing social inequalities and injustice and intensified environmental pressure, as seen in different regions [1]. Work and technological progress are no longer the main factors interfering with economic growth [2], as natural capital and social capital have occupied a prominent place in regional development [3]. A focus only on economic concerns has been re-interpreted as restricted, reductionist and unable to appropriately capture the significant and valuable aspects of individual and social existence, such as health, quality of life (QoL) and well-being [4,5].

The regional availability of knowledge and skills is as important as physical infrastructure, resulting in regionally committed higher education institutions (HEIs) that can become essential and potential assets with a fundamental role in economic [6], social [3] and sustainable [7] development. So, the HEIs' regional involvement, more than a process that can be objectively planned or forecast, is a learning process that characterises the specificities of a subjective deliberation process. This is claimed by [8], according to whom this process is influenced simultaneously by factors operating at the intra-organisational and regional levels, and at the level of the environment the HEIs belong to. Greater HEI involvement is expected with the different agents of the region of influence, incorporating in the former's mission the solid intention to ensure responses to the region's needs and produce improvements also in terms of the resident population's QoL [9]. Therefore, a region's QoL emerges as a multidimensional indicator of performance, which helps to understand the region's situation, as well as the efficiency the HEIs can have in transforming inputs,

arising from national policies, into outputs, with repercussions for the region. HEIs are not only located in places, they belong to them, and so the HEIs' capacities and potential are also shaped by how they interact with their region [9].

Although the function of HEIs has been extended beyond teaching and research, the problem focused by [6] is that often they tend towards internationalization more than regional action, especially with regard to research, reflecting the priorities of governments and their research councils as the those mainly financing that research. It is therefore fundamental to study to what extent HEIs are synchronized with, and contribute to, their region, to understand how efficient HEIs are and whether all their missions are being fulfilled. In addition, social, environmental and cultural impacts stimulate organisations to reconsider their management models, seeking re-dimensioning that goes beyond traditional forms and moves towards pro-sustainability management [10].

Given the importance of resource management nowadays, all organisations are encouraged to have pro-sustainability management, recognise the importance of their social and environmental impacts and carry out actions to reduce their environmental impact [11]. Therefore, pro-sustainability management must also involve social, environmental and cultural variables throughout the process of managing, planning, organising, directing and controlling, using the functions that form that process, as well as the interactions occurring with the region [10]. The HEIs' traditional form of centralized and bureaucratic organisation is now challenged by the need to respond flexibly and pro-sustainably to increasingly unpredictable environmental changes, to become actively involved in the region's various needs and seek sources of finance besides those traditionally associated with teaching and research activities [12]. Furthermore, HEIs are drivers of social and individual development, being endogenous factors of their increased capacities as promoters of human rights such as intellectual solidarity, democracy, peace and justice [13]. The nature of that role will depend on the missions and skills of each HEI, but in all cases, HEIs are the main stimulants in their region in terms of the social and cultural contribution they make to society [14]. In this respect, Boulton and Lucas [15] say that HEIs contribute to regional vitality and serve as agents of social justice and cultural mobility wherever they are located.

Most studies on HEI efficiency focus, above all, on aspects related to teaching and research activities, e.g., [16–18], with a lack of attention paid exclusively to the social, environmental and cultural aspects. For example, Wolszczak-Derlacz [16] identifies as a study limitation the fact of not including variables to measure HEIs' contribution to the surrounding community regarding the social aspects. Since HEIs operate in different environments, studying the transformation of their inputs into outputs related to these environments can bring new contributions and implications able to redefine action strategies, both for HEI managers and regional authorities.

HEIs have several multiplier effects and impacts, the economic ones being the most recognized through several studies, e.g., [19–21]. The approach now operationalized complements the studies focused so far on economic efficiency, incorporating the still unexplored social, environmental and cultural components. Bearing in mind the growing importance of the sustainability of institutions in general, for HEIs in particular, and for the regions in which they are located, this study explores, in a pioneering way, the three components of sustainability, namely, social, environmental and cultural, which contributes to a better understanding and deepening of the HEIs' pro-sustainability orientation. Despite the wide range of previous studies dealing with the economic efficiency of HEIs, a gap was detected in the literature; that is, there is a lack of studies on the different types of HEI efficiency, social, environmental and cultural, jointly treated for assessing the influence of pro-sustainability efficiency, specifically integrating the three types of efficiency variables previously mentioned in terms of determining the regional QoL.

System-wide and transformative change in HEIs are seen as a precondition, which facilitates sustainability [22]. The most efficient HEIs are expected to contribute to the strengthening of regional QoL, since (i) in social terms, they increase the effectiveness of

the use of public money for increasing social cohesion and mobility at the regional level; (ii) in environmental terms, they reduce pollution and waste by educating stakeholders in the region to become more environmentally friendly; and (iii) in cultural terms, they provide a greater access to culture goods and services, and promote different cultural and scientific activities with a high impact.

Considering the context described in the literature of reference, an important contribution of this study will be to assess HEI efficiency with regard to social, environmental and cultural factors, which hereafter will be referred to as pro-sustainability factors, and at the same time indicate the way for HEIs to promote regional QoL, admitting that the latter can be influenced by the efficiency of these institutions. This study adds to the knowledge on HEIs' impact on their regions, at the same time summarising the HEIs' role in transforming society, considering society's pro-sustainable situation. It will also give better orientation to the HEIs' mission of social responsibility, in order to develop reference frameworks considering the external environment, by defining its objectives. It will allow policy-makers and designers of public policies to gain better knowledge of a HEI's potential as an institution rooted in the region and an important actor in present and future development. This is an innovative study that can contribute important knowledge to the literature of reference and to HEIs and their regions.

Considering the above, this study intends to address the following questions:

Q1: Are HEIs efficient in transforming their inputs into pro-sustainability outputs (social, environmental and cultural)?

Q2: What is the role of this efficiency as a predictor of regional QoL?

This research analyses efficiency using the two-step DEA method, to make a comparative analysis of the efficiency of twenty-three Portuguese HEIs. In the first step, the efficiency scores are determined using DEA with different sets of inputs/outputs that have been previously identified through a literature review, and validated through qualitative assessment carried out with diverse HEIs stakeholders. The DEA method and its variants have multiple applications in the literature [23], including in the analysis of the efficiency of HEIs, e.g., [16,23–26].

In the second step, the efficiency scores obtained in the first stage are regressed on a collection of explanatory variables referring to QoL. The regression models commonly used in the second stage include the ordinary least square (OLS), censored regression (e.g., logit, probit and tobit models), truncated regression and panel data models [27]. Banker and Natarajan [28] show that the two-stage approach for the DEA can yield statistically consistent coefficient estimators under certain general distributional assumptions. Johnson and Kuosmanen [29] further show that the estimators remain statistically consistent even when the first-stage input and output variables in the DEA are correlated with the second-stage variables in the regression model [27]. Having in mind the above, in this study, after the efficiency analysis, a logit regression is used, resorting to the multivariate model, to determine the influence of HEI efficiency, using the scores resulting from the DEA analysis, on the QoL of the regions in which the HEIs studied are situated. This type of regression is used to predict categorical placement or the likelihood of category association in a dependent variable based on multiple independent variables. The dimensions used for QoL consider the studies of the OECD (Organisation for Economic Co-operation and Development), Eurostat (Statistical Office of the European Union) and INE (Statistics Portugal).

The article is innovative and contributes to the literature on HEI efficiency in two ways: firstly, it allows mapping of the most efficient HEIs through gathering the key indicators (inputs and outputs) based on studies of the HEIs' impact on regions and from data of a field study, for the purpose of executing a DEA analysis of the pro-sustainability efficiency (social, environmental and cultural); and secondly, it analyses whether this efficiency influences the region's QoL through testing different selected specifications of logit models, of the multivariate type, using the HEIs' efficiency scores as explanatory factors of regional QoL. This type of association, which so far has not been found in the reference literature about sustainable HEIs and regions, increases the knowledge

about HEIs' impact on regions, summarising at the same time the change in the social, environmental and cultural role of the HEIs, considering the population's QoL. It also lets the HEIs strengthen their institutional orientation towards social responsibility and improve their pro-sustainability management, as well as reinforcing the HEIs' role as levers of QoL and social, environmental and cultural sustainability at the regional level.

The paper is structured as follows. The literature on the importance of HEIs for regions and the importance of QoL for regions and HEIs is reviewed, in order to define the inputs and outputs for the purpose of measuring the HEIs' efficiency, as well as the variables to measure the region's QoL. This is followed by a two-stage approach, with presentation and discussion of the results. Finally, the conclusions, implications and limitations of the study are presented.

2. Regional Needs and HEIs' Reaction

Activities linked to the new HEIs mission of regional economic development, which involves technology transfer, life-long learning or social involvement [30], are related to the generation, use, application and exploitation of knowledge with all external stakeholders and with society in general, and so this mission cannot be considered as a residual function, but as complementary to the other two missions of teaching and research [31]. A HEI's capacity to respond to the regional needs is influenced by various conditions resulting from the inter-relations between the various geographical levels and the historical legacy of each HEI and its region [6]. HEIs have a great deal to offer, since besides knowledge and human capital, they are crucial drivers of prosperity, inclusion and territorial development, contributing in a wide-ranging way to social questions, environmental innovation and critical reflection, vital in times of challenges and with considerable risks for regions and nations [32]. Geographical proximity and regional involvement are major advantages for HEIs to act as agents of change, promoting human interaction, transferring knowledge and building trust and common purposes among a diversity of actors and interests within regional structures [33].

Considering the unstable external environment, e.g., social and cultural inequalities [34,35] and environmental changes [36], in need of constant innovation, HEIs' behaviour was forced to adopt a strategic business administration, despite the differences between an HEI and a typical business organisation [37,38]. This new situation, in the first phase, led HEIs to draw up innovative competitive strategies with the triple purpose of attracting, capturing and retaining students, ensuring or increasing their participation in the market [39]. However, more recently, HEIs have been adopting new strategies more focused on fulfilling their third mission, directed towards the transfer of knowledge and technology, life-long learning and social, environmental and cultural responsibility [30,40]. Despite their different missions and histories, most HEIs consider the social, environmental and cultural contribution as part of their role, as they contribute to the regeneration of urban and rural areas, social services and health, library services, research to benefit the community and cultural and environmental development [41], among other domains. More than involving active academic participation to create economic, social and environmental programs that improve living standards, generate empowerment and respect interdependence [42], this means that sustainability must go further than acquiring knowledge on issues related to sustainability to provide a transformation of the dominant ways of being and understanding this new social reality [43]. Knowing regional asymmetries can provide educational systems with opportunities to find innovative solutions in disadvantaged areas [44]. Mainardes et al. [38] argue that organisations adapting a strategy to their external environment is a principle of competitiveness. They also say that the Theory of Territorial Competitiveness [45,46] is framed in the current conjuncture of HEIs' competitive management. Consequently, considering this theory, strategies for competitiveness include an important component, local territorial aspects [47]. The strategic path of organisations is to draw up their structures and operations to be linked to their territory of action; i.e., the place where they act defines how these organisations work [45]. In this

regard, Mainardes et al. [38] underline that it is the local community and its actors who define and seek an integrated development strategy, in shared pursuit of solutions to their problems. In this context, standing out are local HEIs, which assume the strategy of market competition, considering companies' needs and preparing professionals who will act in these local companies, thereby creating economic advantages [38]. At the same time, they contribute to a healthier environment where social, cultural and environmental disparities are less pronounced. Therefore, the economic and social benefits obtained by the HEIs are considerable, making them more competitive in the education market and meaning they fulfil their mission in society [45,46].

Contrasting with the first two pillars of HEIs (research and teaching), regional involvement is a multifaceted phenomenon and difficult to delimit [8]. A wide-ranging study involving 14 countries in five continents and carried out by the OECD [48] found that the joint development trajectories of HEIs and their respective regions are shaped by the combination of a wide range of factors that influence and are influenced. This study, which draws attention to and "begins a debate" on the importance of HEIs for their regions of influence, mentions that few take the surrounding environment into consideration. Taking the example of a study by Radinger-Peer [8] in the region of Kaiserslautern (Germany), the multi-level environment in which the HEI is situated influences the HEIs' regional involvement. This shows that the occurrence of activities with a regional commitment (commercial and non-commercial) cannot be explained only by individual indicators (e.g., gender, age and experience), but must be accompanied more systematically and interactively.

3. HEIs' Efficiency in Their Region of Influence

A critical factor of HEI positioning over time has to do with the nature, number and distribution of organisations in a given place, which depends on the availability of resources and the level of competition, making environments competitive [49,50]. In the light of Neo-Institutional Theory, HEIs' positioning is generated by the search for legitimacy to deal with the external pressures of their surrounding environment [49]. Consequently, in the positioning process, only the capacity to differentiate from competitors, through creating a unique profile that cannot be reproduced, lets HEIs obtain competitive advantages [51,52]. Olivares and Wetzel [53] say that a unique position is built through inputs (combination of resources used) and outputs (activities provided) and effective and efficient processes, with implications for the capacity to implement and manage the most suitable combinations of an inputs–outputs process [54]. Therefore, HEIs' increased strategic planning capacity makes them more efficient with their resources and become more pro-active in anticipating changes and in developing the capacity to respond suitably to the needs encountered [51].

Oliver's theory states that the capacity to respond to organisational pressure or political objectives is delimited by legitimacy or social efficiency [55]. Legitimacy is a subjective interpretation found in the beliefs and perceptions of individuals and groups in relation to the actions and behaviour of others [56]. Efficiency is essentially the comparison between the inputs used in certain activities and the outputs produced [57]. In the case of HEI efficiency, it refers to a comparison of the marginal social costs and benefits, and does not solely relate to a comparison of the HEIs' costs and revenues [58]. Therefore, legitimacy and efficiency are two concepts that should not be disassociated when speaking about the HEIs' influence on their regions: firstly, because legitimacy implies a general trust in society that a given entity's power to make binding decisions is justified and appropriate [59]; and secondly, because the HEI's efficiency has repercussions on the region through economic impacts arising from public investment, spending on general consumption, jobs created and, in particular, students' spending in the region, as well as that of the academic community in general. In turn, this expenditure has an impact on regional indicators: (i) through the volume of business, employment, income, property values and local authority expenditure [60]; (ii) through impacts caused by the indirect supply of services such as health, sport, culture, technology transfer and others; and (iii) through the HEIs' transformational activities arising from the improved quality of the local economies

and political systems [61] and the supply of services that serve as inputs to the region. These transformational activities are legitimized by the processes through which the HEIs organise their fundamental tasks, such as teaching, research and activities arising from the third mission, through transforming their inputs into outputs for the region.

Definition of the Key Indicators to Measure Efficiency

There is extensive literature on measuring HEIs' efficiency [18,62]. In HEIs, efficiency can be measured though various techniques and approaches, considering the subject of analysis and the characteristics of the organisations to be studied [63]. Despite differences in the methods used (i.e., parametric and non-parametric) and in the details of model specification, all existing studies consider higher education activity as combining inputs (e.g., human and financial resources, premises, etc.) to produce important outputs (results) such as education (e.g., number of graduates), research (publications), knowledge transfer (patents, academic spin-offs, public events, etc.) [64] and social, cultural and environmental involvement (e.g., cultural and social activities) [65]. The inputs and outputs vary substantially from one study to another, making it necessary to make a survey to have a general idea of the most commonly used key indicators. As this study focuses on assessing pro-sustainability efficiency, these inputs and outputs will be seen as part of the HEIs' social, cultural and environmental objectives.

To determine the key indicators (inputs-outputs) used to measure HEI efficiency, from the perspective of the effects of those institutions on the region, various previous studies were first considered [19–21,65–69]. It is worthy of note that some of the indicators that were identified in the scope of the current study are partially influenced by the HEIs, since the former were collected at the regional level. Similar variables were also used in the previous studies included in this literature review; for example [69] stated that the outputs of HEIs can be measured through their impacts on the social and environmental well-being of the region.

Then, to identify and validate the key indicators found in those studies, a semi-structured interview script was drawn up. These interviews were held face-to-face or via Skype with 20 relevant individuals in the academic, political and social spheres, as well as with the economic agents resident in regions in which the HEIs are located. Next, the results of the interviews were discussed and analysed in a meeting of the research group.

Given the need to identify the HEIs' inputs in order to measure these institutions' impact on their surrounding region, taking as reference the studies of Goldstein and Renault [21], Jonkers et al. [68] and Skyrme and Thompson [69], a framework of analysis was defined to classify the inputs proposed by the interviewees in seven categories: the HEI's Economic Support (income); the HEI's expenditure (expenses); the HEI's students; the Employment in the HEI and provision of qualified work; the volume of service provision activities; the HEI's institutions/R&D centres; and the HEI's social and cultural environment (see Table 1).

Similarly to the procedure described above, and given the need to identify the HEIs' outputs able to measure these institutions' impact on their surrounding region, considering the social, civic and environmental outputs in the local and regional surroundings, as referred by Drucker and Goldstein [70], Kroll and Schubert [71] and Skyrme and Thompson [69], a framework of analysis was defined for classifying the results/indicators proposed by the interviewees, in terms of social, environmental and cultural factors (pro-sustainability), as advocated by Alves et al. [10] (see Table 1).

For the purpose of the efficiency analysis (DEA), the key inputs/outputs and respective indicators presented in Table 1 were defined, based on the year 2018. Three aspects were considered: interviewees' classification of the variables proposed in the interview script; interviewees' answers to the open questions; and the availability of data for collection. The indicators were gathered on the platforms of INE, PORDATA (Database of Contemporary Portugal) and the Sales Index (Marktest Group) database, according to data available at the NUTS III level. Data referring to the HEIs were gathered from the institutions'

activity reports, management and accounting reports and websites. Regarding the students' expenditure, the figures were gathered from the study made by [72]. Table 1 presents the key indicators determined.

Table 1. Inputs and outputs: Key indicators to measure pro-sustainability efficiency.

INPUTS/Indicators	OUTPUTS/Indicators
HEI's Economic Support (income) I1—Ratio: Own income/SB HEI's Expenditure (expenses) I2—Ratio: Expenditure on staff/SB HEI's Students I3—Ratio: No. of 1st-cycle students */total students Employment in the HEI and Provision of Qualified Work I4—Ratio: Total no. of lecturers and researchers/total students Volume of Service Provision Activities I5—Ratio: Amount declared in service provision/total own income HEI's Institutions/R&D Centres I6—Ratio: No. of publications ISI/total no. of publications (ISI + SCOPUS) HEI's Social and Cultural Environment I7—Rate of scientific, cultural and social, and sporting events I8—Ratio: Student's annual cost of living (per HEI)/national minimum salary	Social Pro-Sustainability O1A—Ratio: Total no. of social action grants awarded/total grants requested O1B—Access to broadband internet per 100 inhabitants (%) O1C—Proportion of women in higher education graduates O1D—Inequality in the distribution of the declared gross income of tax aggregates Environmental Pro-Sustainability O2A—Wastewater treatment stations (No.) O2B—Municipal expenditure on the environment per capita: by management domains and environmental protection O2C—Environmental invention patents registered by HEIs and research institutions per region (No.) O2D—Investment in protecting municipal biodiversity and landscape Cultural Pro-Sustainability O3A—Municipal expenditure on cultural and creative activities (€) O3B—No. of people in cultural and social, and sporting activities O3C—Cultural premises/facilities (No.) O3D—Municipal expenditure on sporting activities and equipment (€)

* Polytechnic education includes the variant of Professional Technical Course. Legend: SB: State Budget; ISI: International Scientific Indexing Web of Science; SCOPUS: SciVerse Scopus. Source: Own elaboration.

4. Regional Quality of Life and HEIs

Regional quality of life reflects the levels of regional disparities within different countries, separating privileged and lagging regions with respect to standards of living and individual well-being [73]. Although economic factors are important in determining the attractiveness of regions for organisations, the quality of the environment (social, political, natural, etc.) also plays an important role [74]. In order to create economic growth, it is essential to strengthen competitiveness, and an important aspect of this competitiveness is QoL [74].

Briefly, regions wish to attain a balance of economic, social, environmental and cultural standards, so that the resident population can enjoy an excellent QoL. It is assumed that HEIs can contribute to that improvement and increase the QoL through research done on the university campus and the transfer of knowledge to society, and by providing the surrounding area with a wide variety of cultural, sporting and social activities [75], increasing the education, qualifications and mobility of human capital [76–78], developing and raising technological levels, increasing productivity and consequently improving the region's economic performance [76,77]. HEIs are therefore expected to be able to contribute to a region's attractiveness and development, as drivers of positive externalities regarding QoL [79].

As suggested by Shapiro [80], the local human capital level increases the implicit value of an area's consumption amenities; i.e., the stock of human capital transforms an area into a more desirable place to live and increases the QoL [81]. From this line of reasoning, it is reasonable to assume that the QoL of the region surrounding the HEI can be influenced positively or negatively by this type of institution, both through the human capital that carries out its activities and if a good QoL is ensured within the institution; this

can be reflected positively (1) through the human capital's behaviour, in the environment surrounding the institution and through the surrounding systems that support the HEIs' human capital and the population in general, through creating better living conditions, more employment, better health services, better artistic and cultural services, more areas for recreation and leisure, etc., causing them to feel satisfied and content, and (2) through the HEI itself, which should match its objectives, missions and values to the needs encountered. The following sub-section defines the dimensions for measuring regional QoL.

Dimensions for Measuring Regional QoL: Definition

Recently, the OECD has become deeply involved in the debate on the most appropriate way to measure a population's well-being and has made studies in the area of QoL. The OECD created the Better Life Index (In http://www.oecdbetterlifeindex.org), with 11 variables reflecting well-being in terms of the material conditions of life: housing, income and work; and in terms of QoL: community, education, environment, governance, health, satisfaction with life, safety and work–life balance.

The European Union, through Eurostat, also divulged through its online publication (In http://ec.europa.eu) an index designated as Quality of Life Indicators (measuring the quality of life). This index presents nine dimensions of QoL: material living conditions, production or main activity, health, education, leisure and social interactions, economic and physical security, governance and basic rights, natural, living environment and general experience of life.

INE [82] presented an index of 10 indicators of well-being in two dimensions. The first, referring to the material living conditions, includes economic well-being, economic vulnerability and work and remuneration. The second, referring to QoL, covers health, work–life balance, education, knowledge and competences, social relations and subjective well-being, civic participation and governance and personal and environmental safety.

Accordingly, and using the indicators available, for the year 2018, on the INE, PORDATA and Sales Index platforms, for NUTS III (Nomenclature of Territorial Units for Statistics), to measure the QoL the following composite index is considered: material life conditions, health, education, environment and leisure and safety. It is noted that these indicators are common in the three examples presented (OECD, Eurostat and INE). Therefore, for the purpose of measuring regional QoL, Table 2 presents the dimensions, respective measurement indicators and codes attributed.

Table 2. Data to measure regional quality of life (QoL).

Dimension/ Variable	Indicators (NUTS III)	Codes
Material life conditions	- Credit granted to customers by banks, savings banks and mutual agricultural banks	Credit
	- Unemployment registered per 100 inhabitants aged 15 or older	Unemployment
	- Purchasing power per capita	Purchasing power Housing
	- Housing loan per inhabitant	
Health	- No. state hospital beds universally available and in hospitals in public-private partnership by geographical location	Hospitals Deaths Health activities
	- Deaths of residents in Portugal from certain causes	
	- Average No. of people working in human health and social support activities	
Education	- Gross rate of schooling in higher education	Schooling. Higher Ed. Non-Higher Ed. Estab. Higher Ed. Estab. Computers
	- No. of non-higher education establishments	
	- No. of higher education establishments	
	- No. of computers in primary and secondary education	

Table 2. *Cont.*

Dimension/ Variable	Indicators (NUTS III)	Codes
Environment	- Ratio: Municipal expenditure on the environment per capita (environmental management and protection)	Environment Waste NGEO
	- Separated urban waste collected per inhabitant	
	- Non-governmental environmental organisations (NGEO): number	
Leisure	- No. of cultural premises/facilities	Premises Artistic activities Museums
	- No. of people in artistic, performance, sporting and recreational activities - No. of museums	
Safety	- Crime rate (‰) - Crimes registered by police - No. of inhabitants per firefighter - No. of accidents	Criminality Crimes Firefighter Accidents

Source: Own elaboration.

5. Methodological Design

This methodology includes two-stages. In the first stage, the DEA was used to measure the HEIs' efficiency, considering the inputs and outputs presented in Table 1 (p. 6); the Frontier Analyst Application (version 4.4.0) was used to execute the DEA. In the second stage, a multivariate logit regression was used, with the scores generated in the DEA analysis and from the dimensions of QoL presented in Table 2 (p. 8); in this analysis, Stata software version 15.1 was used.

The study aims to determine the efficiency of 23 state HEIs in Portugal, using data referring to 2018. The data were obtained from the INE, PORDATA and Sales Index databases, also including elements available such as their activity reports, management and accounting reports, as well as information on the websites of the HEIs analysed.

Selection of the 23 HEIs for this study was according to the following criteria: (i) Portuguese state HEIs, universities and polytechnics; (ii) state universities belonging to the Council of Rectors of Portuguese Universities (CRUP), an entity coordinating university teaching in Portugal; (iii) HEIs located in each of the 7 regions of Portugal at the NUTS II level, since Portugal has an asymmetric socio-economic situation between regions [83]; and (iv) complete data availability for the year 2018.

5.1. DEA Analysis

The DEA model evaluates efficiency by forming performance measures obtained as ratios of the multiple inputs and multiple outputs selected in Table 1. The DEA method was first developed by Charnes et al. [84], who proposed the CCR model (initials of Charnes, Cooper and Rhodes), also known as the CRS model (Constant Returns to Scale). This model, which establishes an analysis with constant returns to scale, determines a proportional relationship between the inputs and outputs, similar to a regression. Years later, the BCC model (initials of Banker, Charnes and Cooper) appeared, also known as VRS (Variable Returns to Scale), proposed by Banker et al. [85], which considers the variable returns to scale.

In this case, the relation between the inputs and outputs is not linear, but convex. According to the same authors, aiming to ensure maximum efficiency, these two basic DEA models can be designed in two ways: (i) oriented towards the inputs: so as to minimize the inputs allocated, maintaining the level of outputs; and (ii) oriented towards the outputs: so as to maximize the outputs, maintaining the level of inputs. Following Agasisti [86], this study uses the CCR type of model, which is an output-oriented framework, because it wants to establish an analysis with constant returns to scale, as well as to determine

a proportional relationship between the inputs and outputs, where the inputs are fixed. The aim is to maximize the outputs; i.e., the outputs directly reflect the input levels.

Before starting the efficiency analysis, it is always useful to have an idea of the data we are going to deal with [87], and so descriptive statistics of the inputs and outputs presented in Table 1 is offered in Table 3.

Table 3. Descriptive statistics of the higher education institutions' (HEIs') inputs and outputs (n = 23).

Variable	Mean	Stand. Dev.	Min Value	Max Value
I1	0.558	0.327	1.02	1.65
I2	1.261	0.134	0.31	0.92
I3	0.676	0.211	0.03	0.12
I4	0.081	0.019	0.00	0.78
I5	0.147	0.168	0.07	0.72
I6	0.481	0.140	0.00	1.73
I7	0.314	0.442	2.35	3.24
I8	2.799	0.243	0.00	0.84
O1A	0.735	0.164	0.02	1.21
O1B	0.287	0.500	0.95	1.16
O1C	1.015	0.054	0.86	1.17
O1D	0.999	0.103	0.00	0.18
O2A	0.054	0.051	0.41	1.68
O2B	1.016	0.326	0.00	0.36
O2C	0.186	0.136	0.00	0.14
O2D	0.063	0.051	0.02	0.23
O3A	0.087	0.090	0.00	0.47
O3B	0.129	0.188	0.02	0.15
O3C	0.072	0.047	0.02	0.16
O3D	0.067	0.052	1.02	1.65

According to Mainardes [88], it is necessary to find a point of balance in the number of DMUs and indicators, with a view to extend the discriminatory power of the DEA, which can require the insertion or exclusion of indicators during the analysis process. The validity of the DEA should be confirmed through a decision rule formulated by Avkiran [89], according to which the ratio between the number of DMUs and the product between the number of inputs and outputs must be above 1.333 (e.g., No. DMU/(No. inputs * No. outputs). If this rule is not respected, there will be the possibility of a large number of DMUs positioning on the frontier established, which contributes to reducing the DEA's capacity to make a valid discrimination between efficient and inefficient DMUs [88].

For each model, we consider two inputs and one output active for the purpose of output maximization. With this more stratified type of analysis, it is possible to find DMUs that stand out at specific points, which would not happen if the efficiency analysis was general [88]; i.e., if it included all the variables studied simultaneously. This stratification also reveals which variables are most important and those needing greater attention. Accordingly, considering the indicators presented in Table 1, it was necessary to create a composite indicator (CI) for each factor forming the pro-sustainability efficiency, namely, social, environmental and cultural, and a CI joining these three factors in a single output.

Following Daraio and Simar [87], there are several multivariate statistical tools that may be of interest to see a multivariate dataset, e.g., [90]. One of the most-known tools is the normalized principal component analysis (PCA). This kind of analysis aims at reducing the information contained in a multivariate space, providing illustrations in two dimensions. Firstly, it can analyse the correlation structure existing among the variables, and secondly, all the individuals are projected on a reduced two-dimensional space [87]. The observation of the correlation matrix reported in Table 4 tells us that the correlation among all the inputs and outputs, in most cases, is not a problem. To complement this information, see Table 4, in which the correlations of the first two principal components with the original variables are reported. It appears that the information is quite homogeneous among all the variables. This is the information provided by the cumulated percentage of variance explained by the eigenvalues reported in Table 5. In sequence, the correlations of the first two principal components (PCs) with the original variables are displayed below in Table 6.

Table 4. Correlation matrix of the inputs and outputs of the HEIs (n = 23).

Variable	I1	I2	I3	I4	I5	I6	I7	I8	O1A	O1B	O1C	O1D	O2A	O2B	O2C	O2D	O3A	O3B	O3C	O3D
I1	1																			
I2	0.461 *	1																		
I3	−0.217	−0.329	1																	
I4	−0.187	−0.087	0.017	1																
I5	0.144	−0.011	0.065	0.317	1															
I6	0.193	−0.369	−0.260	−0.097	−0.344	1														
I7	0.181	0.219	−0.613 **	0.098	−0.136	0.055	1													
I8	0.108	0.267	−0.053	−0.193	0.123	−0.376	−0.058	1												
O1A	0.030	0.107	−0.137	0.519 *	0.229	0.105	−0.047	0.142	1											
O1B	0.088	0.147	−0.240	−0.246	−0.184	0.154	−0.052	0.056	−0.416 *	1										
O1C	−0.307	−0.353	0.194	0.159	0.342	−0.022	−0.170	−0.401	0.175	−0.388	1									
O1D	0.051	0.047	−0.244	−0.256	−0.123	0.366	−0.086	−0.071	−0.344	0.882 **	−0.328	1								
O2A	−0.211	−0.196	0.138	0.054	−0.114	0.091	−0.115	−0.461 *	−0.088	−0.002	0.253	−0.103	1							
O2B	−0.336	−0.149	0.080	0.074	−0.206	0.095	−0.118	−0.420 *	−0.189	0.297	0.297	0.283	0.094	1						
O2C	0.083	0.233	−0.222	−0.102	0.018	−0.184	0.041	0.229	−0.326	0.706 **	−0.332	0.594 **	0.112	0.190	1					
O2D	−0.060	0.072	−0.122	−0.083	−0.169	0.075	−0.188	0.072	−0.308	0.668 **	−0.399	0.647 **	−0.174	0.566 **	0.531 **	1				
O3A	0.351	0.155	−0.343	−0.154	−0.031	0.275	0.099	−0.126	−0.395	0.878 **	−0.387	0.858 **	−0.083	0.212	0.588 **	0.611 **	1			
O3B	0.220	0.161	−0.293	−0.210	−0.110	0.214	0.018	−0.027	−0.420 *	0.870 **	−0.407	0.896 **	−0.047	0.273	0.662 **	0.670 **	0.866 **	1		
O3C	0.159	0.024	−0.330	−0.180	−0.135	0.399	−0.048	−0.126	−0.326	0.841 **	−0.276	0.862 **	−0.026	0.272	0.482 *	0.660 **	0.875 **	0.873 **	1	
O3D	0.560 **	0.198	−0.344	−0.211	0.012	0.316	0.150	−0.049	−0.310	0.645 **	−0.432 *	0.686 **	−0.219	0.008	0.420 *	0.459 *	0.898 **	0.796 **	0.689 **	1
Kurtosis	2.005	1.271	−0.449	−0.59	2.755	−1.223	2.115	0.03	−4.431	1.468	1.086	0.705	1.527	0.008	0.01	0.106	0.948	1.276	0.482	0.607
Sweetness	5.685	2.402	−1.409	0.846	9.129	3.213	4.332	−0.842	2.629	0.16	0.558	−0.836	1.867	−0.102	−1.572	−1.662	−1.055	−0.202	−1.063	−1.335
VIF	2.402	2.929	2.667	1.339	1.912	3.327	2.031	1.359	9.910	2.700	6.768	1.618	3.653	4.783	7.981	3.154	8.399	9.486	6.274	1.271

* The correlation is significant at the 0.05 level (2 tails). ** The correlation is significant at the 0.01 level (2 tails).

Table 5. Eigenvalues and percentage of variance explained by the HEIs' inputs and outputs (n = 23).

Eigenvalues	% of Variance	Cumulated %
6.984	0.349	0.349
2.802	0.140	0.489
1.969	0.098	0.588
1.592	0.080	0.667
1.367	0.068	0.736
1.221	0.061	0.797
0.928	0.046	0.843
0.865	0.043	0.886
0.727	0.036	0.923
0.432	0.022	0.944
0.327	0.016	0.961
0.214	0.011	0.971
0.171	0.009	0.980
0.160	0.008	0.988
0.101	0.005	0.993
0.089	0.005	0.997
0.040	0.002	0.999
0.009	0.001	1.000
0.002	0.000	1.000
0.000	0.000	1.000

Table 6. Correlations of the first two principal components (PCs) with the original variables (factors loadings) of the HEIs' inputs and outputs (n = 23).

Original Variable	First PC	Second PC
I1	0.103	−0.363
I2	0.074	−0.391
I3	−0.136	0.241
I4	−0.109	0.043
I5	−0.072	−0.110
I6	0.104	0.159
I7	0.023	−0.242
I8	−0.001	−0.376
O1A	−0.170	−0.142
O1B	0.352	0.065
O1C	−0.185	0.301
O1D	0.343	0.103
O2A	−0.041	0.295
O2B	0.102	0.399
O2C	0.256	−0.036
O2D	0.277	0.125
O3A	0.362	−0.003
O3B	0.368	0.032
O3C	0.338	0.104
O3D	0.312	−0.133

Having in mind these results, to build the CIs, the percentage corresponding to the information of each variable in the initial model was added to the initial value of each indicator, which will constitute the social output, the environmental output, the environmental output and the pro-sustainability output.

The formulas used in building the CIs were the following:

$$\text{CI 1: Social output (SO): } [((O1A \times 0.036) + (O1B \times 0.022) + (O1C \times 0.016) + (O1D \times 0.011))/4] \quad (1)$$

$$\text{CI 2: Environmental output (EO): } [((O2A \times 0.009) + (O2B \times 0.008) + (O2C \times 0.005) + (O2D \times 0.005))/4] \quad (2)$$

$$\text{CI 3: Cultural output (CO): } [((O3A \times 0.002) + (O3B \times 0.001) + (O3C \times 0.000) + (O3D \times 0.000))/4] \quad (3)$$

$$\text{CI 4: Pro-sustainability output (PSO): } [((O1A \times 0.036) + (O1B \times 0.022) + (O1C \times 0.016) + (O1D \times 0.11) + (O2A \times 0.009) + (O2B \times 0.008) + (O2C \times 0.005) + (O2D \times 0.005) + (O3A0.002) + (O3B \times 0.001) + (O3C \times 0.000) + (O3D \times 0.000))/12)] \quad (4)$$

where O1A = ratio: total no. of social action grants awarded/total grants requested; O1B = % access to broadband internet per 100 inhabitants; O1C = proportion of women among higher education graduates; O1D = inequality in the distribution of declared gross income of households for tax purposes; O2A = no. of waste water treatment stations; O2B = municipal expenditure in the areas of environmental management and protection; O2C = no. of environmental invention patents registered by the HEIs and research institutions; O2D = investment in protecting biodiversity and the municipal landscape; O3A = municipal expenditure on cultural and creative activities; O3B = no. of people in cultural, social and sporting activities; O3C = no. of cultural premises/facilities; and O3D = municipal expenditure on sporting activities and equipment.

Table 7 presents the models defined for the DEA analysis.

Table 7. The DEA models.

Model No.	Input (I)	Outputs (O)			
		Social Models (A)	**Environmental Models (B)**	**Cultural Models (C)**	**Pro-Sustainability Models (D)**
1	I1—Ratio: own income/SB I2—Ratio: expenditure on staff/SB	Social output (SO)	Environmental output (EO)	Cultural output (CO)	Pro-sustainability output (PSO)
2	I3—Ratio: no. of 1st-cycle students/total students I4—Ratio: total no. of lecturers and researchers/total students				
3	I5—Ratio: declared value of service provision/total own income I6—Ratio: no. de publications ISI/total no. of publications (ISI + SCOPUS)				
4	I7—Rate of scientific, cultural, social and sporting events I8—Ratio: student's annual cost of living (by HEI)/national minimum salary				

Source: Own elaboration.

5.2. Multinomial Logit Model Analysis

The second stage assesses the technical efficiency, through a multinomial logit regression analysis. Logit regression was chosen because it is a regression technique that is used to model the occurrence, in probabilistic terms, of one of the two achievements of the classes of the dependent variable, where the independent variables can be qualitative or quantitative; the logistic model allows to evaluate also the significance of each of the independent variables in the model [91]. The multinomial logit model was chosen because is used to predict categorical placement or the likelihood of category association in a dependent variable based on multiple independent variables, with independent variables being either dichotomous (i.e., binary) or continuous (i.e., interval or proportion in scale) [92]. As in the binary logistic regression, multinomial logistic regression uses the maximum likelihood estimate to assess the likelihood of categorical association [92]. The data were analysed using SPSS software (vs 25). The dependent variables are presented in Table 2: material living conditions, health, education, environment, leisure and safety. The independent variable is HEI efficiency, which was calculated from the scores produced by the CCR models.

First, all the values of the variables were normalized and then the dependent variable (QoL) and independent variables (social efficiency, environmental efficiency, cultural efficiency and pro-sustainability efficiency) were transformed in polychotomous nominal variables, presenting three mutually exclusive classes. In order to identify the intervals, namely, 0 (weak variation), 1 (average variation) and 2 (high variation), an algorithm was

used: (i) the maximum and minimum variation was found in each of the variables; (ii) the maximum (M) minus the minimum (m) to be divided by two was calculated to find the size of each interval (s); and (iii) three intervals were built incrementally: [m,m + s[;[m + s,m + s+s[;[m + s+s,M[. Then, a final dummy variable was introduced, for control purposes, aiming to determine whether the HEI's size, according to the number of students enrolled, had a significant effect on the results. Two regression models will be considered: Model 1, including the independent variables "social efficiency", "environmental efficiency", "cultural efficiency" and the control variable "size"; and Model 2, considering as the independent variable "pro-sustainability efficiency" and as the control variable "size". Both models have the dependent variable of QoL. Table 8 presents the variables included in this study as well as the measurement scales defined.

Table 8. Variables of the multinomial logistic regression and measurement scales.

Model	Type	Description	Scales/Measurement
1 and 2	Dependent	QoL (life conditions + health + education + environment + leisure + security)	[≥0.370 and >0.637[=0; [≥0.637 and <0.903[=1; [≥0.903 and <1.170[=2
1	Independent	SE: Social efficiency scores obtained from the DEA analysis	[≥−1.436 and >−0.375[=0; [≥−0.375 and <0.686[=1; [≥0.686 and<1.747[=2
1	Independent	EE: Environmental efficiency scores obtained from the DEA analysis	[≥−1.737 and >−0.548[=0; [≥−0.548 and <0.641[=1; [≥0.641 and <1.829[=2
1	Independent	CE: Cultural efficiency scores obtained from the DEA analysis	[≥−0.762 and >0.203[=0; [≥0.203 and <1.167[=1; [≥1.167 and <2.132[=2
2	Independent	PS: Pro-sustainability efficiency scores obtained from the DEA analysis	[≥−1.476 and >−0.425[=0; [≥−0.425 and <0.626[=1; [≥0.626 and <1.676[=2
1 and 2	Independent	SIZE-Size by n° of students in the HEI	= 0 < Average value of the n° of students enrolled = 1 ≥ Average value of the n° of students enrolled

Source: Own elaboration.

In general terms, the multinomial logistic regression model estimator is represented by the following:

$$P(Y=0|X) = \frac{e^{\beta_{00}+\beta_{01}X_1+\ldots+\beta_{0p}X_p}}{e^{\beta_{00}+\beta_{01}X_1+\ldots+\beta_{0p}X_p} + e^{\beta_{10}+\beta_{11}X_1+\ldots+\beta_{1p}X_p} + e^{\beta_{21}+\beta_{01}X_1+\ldots+\beta_{2p}X_p}} \quad (5)$$

$$P(Y=1|X) = \frac{e^{\beta_{10}+\beta_{11}X_1+\ldots+\beta_{1p}X_p}}{e^{\beta_{00}+\beta_{01}X_1+\ldots+\beta_{0p}X_p} + e^{\beta_{10}+\beta_{11}X_1+\ldots+\beta_{1p}X_p} + e^{\beta_{21}+\beta_{01}X_1+\ldots+\beta_{2p}X_p}} \quad (6)$$

$$P(Y=2|X) = \frac{e^{\beta_{20}+\beta_{21}X_1+\ldots+\beta_{2p}X_p}}{e^{\beta_{00}+\beta_{01}X_1+\ldots+\beta_{0p}X_p} + e^{\beta_{10}+\beta_{11}X_1+\ldots+\beta_{1p}X_p} + e^{\beta_{21}+\beta_{01}X_1+\ldots+\beta_{2p}X_p}} \quad (7)$$

where

$P(Y=0|X)$;$P(Y=1|X)$; $P(Y=2|X)$ = vectors of estimated probabilities;
Y = dependent variable;
β = vector of logistic regression coefficients;

$X = (X_1, \ldots, X_p)$ independent variables;
$p = 1, \ldots, n$.

The specification of the two econometric models, with indication of the multiple regression equation and identification of all operationalized variables, as well as the random disturbance term, is defined as follows:

$$\text{Model 1}: \text{ Logit } (\hat{\pi}_p) = \beta_0 + \beta_1 X_{1p} + \beta_2 X_{2p} + \beta_3 X_{3p} + \beta_4 X_{4p} + \varepsilon_p \quad (8)$$

where

$\hat{\pi}$ = dependent variable QoL;
X_1 = independent variable SE;
X_2 = independent variable AE;
χ_3 = independent variable CE;
χ_4 = independent variable SIZE;
ε_p = error (other factors/unobservable characteristics);
with $p = 1, \ldots, 23$.

$$\text{Model 2}: \text{ Logit } (\hat{\pi}_p) = \beta_0 + \beta_1 X_{1p} + \beta_2 X_{2p} + \varepsilon_p \quad (9)$$

where

$\hat{\pi}$ = dependent variable QoL;
X_1 = independent variable PS;
X_2 = independent variable SIZE;
ε_p = error (other factors/unobservable characteristics);
with $p = 1, \ldots, 23$.

To contrast these results, a probit regression was also performed. Logit and probit regressions are similar because each returns sigmoid probabilities that sum to one over all alternatives; however, probit offers a potential advantage over logit in that the probit error specification allows correlations between the errors [93]; that is, for the logit models, the errors are assumed to follow the standard logistic distribution and for the probit the errors are assumed to follow a normal distribution [94].

6. Presentation and Discussion of the Results

6.1. First-Stage Results: DEA

A DEA was used to estimate the efficiency scores of the pro-sustainability activities of 23 public HEIs. In this phase, the 16 models presented in Table 7 were analysed and the means of the results (scores) are presented in Table 9 for each model (A–D), as well as the global average, variance, skewness and kurtosis. A radar chart is also presented in Figure 1, to facilitate visual inspection of the set of values obtained in the DEA analysis, by model.

As observed in Table 5, for the social efficiency activities (Model A), taking as a reference the average obtained per DMU, a homogeneous distribution is revealed, highlighting that none of them is below the median threshold of 50%. Four institutions recorded averages above 80% (UNL, UL, ISCTE and UAB); ten HEIs are between 60% and 80%; and nine obtained values between 50% and 60%. The global average of social efficiency is found to be 66%, with this being the highest average of the four models (A–D).

As for the average of Model B, the environmental efficiency activities, two HEIs stand out with averages above 80% (UAB and IPV); eleven are between 60% and 80%; two between 50% and 60%; and the remainder are below 50%. The global average of environmental efficiency is 60%.

Table 9. Average values (scores) by model: Data Envelopment Analysis (DEA).

Higher Education Institutions (HEIs)	Mean Social Efficiency (Model A)	Mean Environmental Efficiency (Model B)	Mean Cultural Efficiency (Model C)	Mean Pro-sustainability Efficiency (Model D)
Universidade de Lisboa (UL)	84.123	69.995	86.445	83.990
Universidade do Porto (UP)	58.078	42.735	52.465	57.060
Universidade de Coimbra (UC)	53.238	48.633	8.285	53.413
Universidade Nova de Lisboa (UNL)	85.495	73.028	85.048	85.218
Instituto Politécnico do Porto (IPP)	50.113	31.250	43.983	49.008
Universidade do Minho UM	57.108	24.535	5.873	52.658
Universidade de Aveiro UA	51.815	50.350	9.135	52.035
Instituto Politécnico de Leiria IPL	61.230	73.140	6.123	61.388
Instituto Universitário de Lisboa ISCTE	82.640	74.200	79.633	82.738
Universidade do Algarve UAL	58.115	79.733	19.965	63.125
Universidade da Beira Interior UBI	55.608	72.963	7.758	58.693
Universidade de Évora UE	54.408	55.340	7.195	54.890
Universidade de Trás-os-Montes e Alto Douro UTAD	59.273	43.340	4.923	58.505
Universidade Aberta UAB	82.555	96.385	98.950	84.770
Instituto Politécnico de Viseu IPV	76.610	89.285	9.408	78.788
Instituto Politécnico do Cávado e Ave IPCA	64.783	25.243	5.965	58.460
Instituto Politécnico de Viana do Castelo IPVC	69.043	45.578	25.933	67.625
Instituto Politécnico de Castelo Branco IPCB	71.468	69.305	11.268	69.258
Instituto Politécnico de Santarém IPS	66.348	60.045	17.495	67.138
Universidade dos Açores UAC	67.823	33.245	7.860	63.468
Universidade da Madeira UMA	68.913	77.718	6.670	71.020
Instituto Politécnico de Portalegre IPPortal	62.593	70.320	5.800	65.663
Escola Superior de Enfermagem de Lisboa ESEL	78.318	62.860	76.338	78.215
Mean By model	66.074	59.532	29.675	65.962
Variance	123.576	405.858	1055.814	131.997
Skewness	0.414	−0.202	1.128	0.432
Kurtosis	−1.053	−0.812	−0.379	−1.039

Source: Own elaboration.

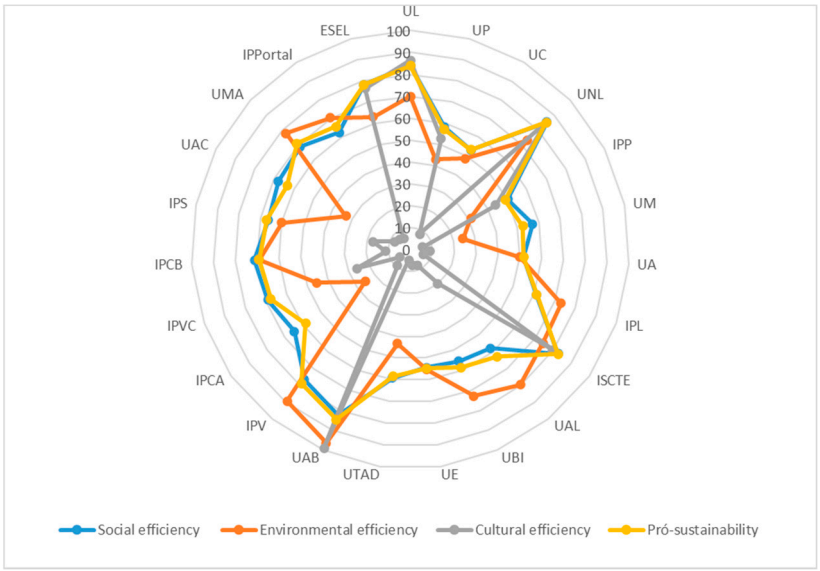

Figure 1. Distribution of the average values (scores), by model, of the DEA. Source: Own elaboration.

Model C, measuring cultural efficiency, reveal a heterogeneous distribution: three HEIs with an average above 80% (UAB, UL and UNL); two with averages between 60% and 80%; and the remaining sixteen with averages under 50%. The global average of cultural efficiency is only 30%.

Concerning pro-sustainability efficiency, Model D, including simultaneously the social, environmental and cultural factors, four HEIs are found to be above 80% (UNL, UAB, UL and ISCTE); ten between 60% and 80%; eight between 50% and 60%; and only one is below this, but very close to 50%. The global average of pro-sustainability efficiency is 66%. Regarding skewness and kurtosis, all the values indicate a normal distribution.

The radar chart in Figure 1 shows that, indeed, the values oscillating most are those related to cultural efficiency, followed by environmental efficiency. Social efficiency reveals the least variability and comes closest to the line referring to pro-sustainability efficiency.

6.2. Second-Stage Results: Multinomial Logit and Probit Regression

The second-stage analysis investigates whether the variation in efficiency can influence the dimensions characterising regional QoL. To do so, two selected model specifications were considered (see Table 7) and analysed through estimation of a multinomial logistic regression.

The first step is to produce descriptive statistics of the variables studied for each model. The distribution of the average values was found to be homogenous. The correlational relation between the variables, kurtosis, asymmetry and VIF were also analysed and the results reveal that all the values are within normality (see Table 10), except for the "cultural efficiency" correlation with QoL, which exceed the value of 0.7.

Table 10. Descriptive statistics, correlations, kurtosis, asymmetry and VIF among the variables.

Variables Model 1	**1**	**2**	**3**	**4**	**5**
QoL	1				
Social efficiency	0.661 **	1			
Environmental efficiency	0.312	0.536 **	1		
Cultural efficiency	0.969 **	0.698 **	0.341	1	
Size	0.423 *	−0.087	−0.338	0.374	1
Mean	0.629	66.074	59.532	29.675	0.348
Variance	0.098	123.58	405.86	1055.8	0.237
Asymmetry	1.079	0.414	−0.202	1.128	0.684
Kurtosis	0.481	0.481	0.481	0.481	0.481
VIF	(a)	2.83	1.667	3.237	1.896
Variables Model 2	**1**	**2**	**3**		
QoL	1				
Pro-sustainability efficiency	0.661 **	1			
Size	0.423 *	−0.131	1		
Mean	0.629	65.962	0.348		
Variance	0.098	132.0	0.237		
Asymmetry	1.079	0.432	0.684		
Kurtosis	0.481	0.481	0.481		
VIF	(a)	1.017	1.017		

** The correlation is significant at 0.01 (2 extremities). * The correlation is significant at 0.05 (2 extremities). (a) Dependent variable: QoL. Source: Own elaboration.

The probability of each of the "efficiency" variations (0—weak; 1—average; and 2—high) was estimated from the QoL variable (material living conditions + health + education + environment + leisure + safety). All the models were adjusted with Stata software. Table 7 presents the estimates of the coefficients and respective outputs of the program for each of the eight models estimated. All the models are statistically significant ($p < 0.05$), except for Model 2. Concerning the quality of adjustment, the test statistic and the significance of the chi-squared tests are presented, with the results indicating the models are suitably adjusted. Unlike the likelihood-ratio, Wald and similar testing procedures, the models need not be nested to compare the information criteria [95]. Therefore, two statistics were performed to calculate the two information criteria used to compare the models: Akaike's information criterion (BIC) and the Bayesian information criterion (AIC).

In general, given the two models, the one with the smaller AIC fits the data better than the one with the larger AIC, as does a smaller BIC, indicating a better-fitting model. Table 11 shows the significant models and correspondent values.

Table 11. Coefficients of Model 1's multinomial logit and probit, with and without the control variable.

Multinomial Logit Models						**Probit Models**				
Logit Model 1a QoL [a]		Coef.	Std. Err	z	P > |z|	Probit Model 1a QoL	Coef.	Std. Err	z	P > |z|
Average variation (Dependent variable = 1)	Social efficiency	−1.740	1.049	−1.66	0.097 *	Social efficiency	−1.163	0.585	−1.99	0.047 **
	Environmental efficiency.	1.267	0.953	1.33	0.184	Environmental efficiency.	1.000	0.521	1.92	0.055 *
	Cultural efficiency	2.297	1.126	2.04	0.041 **	Cultural efficiency	1.563	0.602	2.60	0.009 **
	Constant	−0.906	1.013	−0.89	0.371	Constant	−0.634	0.557	−1.11	0.265
High variation (Dependent variable = 2)	Social efficiency	−3.351	2.416	−1.39	0.165					
	Environmental efficiency.	3.704	1.629	2.27	0.023 **					
	Cultural efficiency	4.519	2.534	1.78	0.074 *					
	Constant	−5.476	2.620	−02.09	0.037					
Number of obs = 23 LR chi2(6) = 18.51 Log likelihood = −15.150 Prob > chi2 = 0.005 AIC = 46.301 BIC = 55.385						Number of obs = 23 LR chi2(3) = 8.12 Log likelihood = −9.247 Prob > chi2 = 0.044 AIC = 26.496 BIC = 31.038				
Logit Model 1b QoL [a]		Coef.	Std. Err	z	P > |z|	Probit Model 1b QoL	Coef.	Std. Err	z	P > |z|
Average variation (Dependent variable = 1)	Social efficiency (SE)	−2.013	1.181	−1.70	0.088 *	Social efficiency	−1.345	0.659	−2.04	0.041 **
	Environmental efficiency.	1.171	0.976	1.20	0.230	Environmental efficiency.	0.894	0.540	1.65	1.953
	Cultural efficiency	2.753	1.450	1.90	0.058 *	Cultural efficiency	1.835	0.758	2.42	0.016 **
	Size	−0.981	1.758	−0.56	0.577	Size	−0.646	0.985	−0.66	0.512
	Constant	−0.484	1.233	−0.39	0.694	Constant	−0.299	0.740	−0.40	0.686
High variation (Dependent variable = 2)	Social efficiency	−3.817	2.705	−1.41	0.158					
	Environmental efficiency.	3.413	1.676	2.04	0.042 **					
	Cultural efficiency	5.313	2.987	1.78	0.075 *					
	Size	−1.903	2.529	−0.75	0.452					
	Constant	−4.660	2.783	−1.67	0.094					
Number of obs = 23 LR chi2(8) = 19.13 Log likelihood = −14.843 Prob > chi2 = 0.014 AIC = 49.687 BIC = 61.042						Number of obs = 23 LR chi2(4) = 8.42 Log likelihood = −9.027 Prob > chi2 = 0.077 AIC = 26.037 BIC = 31.713				

[a] The category of reference is: Weak variation (reference level). Level of significance * = $p < 0.100$; ** = $p < 0.050$.

Observation of Table 7 reveals that all the dimensions (social efficiency, environmental efficiency and cultural efficiency) have a significant effect on both models (Logit Model 1a: social efficiency: $p = 0.088$; environmental efficiency: $p = 0.023$; cultural efficiency: (average variation) $p = 0.041$, (hight variation) $p = 0.074$; Probit Model 1a: social efficiency: $p = 0.047$; environmental efficiency: $p = 0.055$; cultural efficiency: $p = 0.009$). When applying the control variable "Size" in Logit Model 1b, the introduction of this variable improves the significance of the "social efficiency" in the average variation ($p = 0.88$). Regarding environmental and cultural efficiency, when the control variable is introduced, the significance decreases. Probit Model 1b was insignificant.

As for AIC and BIC, when adding the control variable, the result is found to change slightly, but without much relevance. However, concerning the Multinomial Logit Models and Probit Models, this difference is greater, with the first fitting the data better.

These results indicate that all the dimensions are associated with increased levels of QoL, and all the dimensions are also influenced by the HEI's size. However, social efficiency is negatively related to intermediate levels of QoL, indicating that, probably, what is done within the HEI at a social level is not enough to have positive effects on the region's QoL. On the other hand, increasing the number of students makes this effect more negative. Regarding the effect of "size" on the influence of environmental and cultural efficiency on QoL, this may be lower if the number of students increases, since the control variable

decreases the significance of those relationships. In order to highlight the importance of social efficiency, environmental efficiency, and cultural efficiency, and the liaison with the size of the HEIs (control variable), Table 12 summarizes the statistically significant results found in the logit model, with and without this control variable.

Table 12. Coefficient and *p*-values of the social efficiency and size variables.

Variables with Significant Value	Coef.		*p*-Value	
	Without Control Variable "Size"	With Control Variable "Size"	Without Control Varable "Size"	With Control Variable "Size"
Social efficiency (average variation)	−1.740	−2.013	0.097 *	0.088 *
Environmental efficiency (high variation)	3.704	3.413	0.023 **	0.042 **
Cultural efficiency (average variation)	2.297	2.753	0.041 **	0.058 *
Cultural efficiency (high variation)	4.519	5.313	0.074 *	0.075 *

Level of significance * = $p < 0.100$; ** = $p < 0.050$. Source: Own elaboration.

6.3. Discussion

According to the results obtained from applying the DEA method and observation of Table 4, a pattern worthy of note is detected; i.e., HEIs with better pro-sustainability efficiency, especially in the social aspect, are located in the Greater Lisbon area. This result is not surprising and agrees with van Vught [49] and Lepori et al. [50] when stating that HEIs' positioning depends on the stock or resources available in the region. HEIs located in regions with greater resources (financial, logistic, physical, human capital, etc.) differentiate in being more efficient in transforming their resources and become more pro-active in anticipating changes and in developing the capacity to respond appropriately to the identified needs, as mentioned by Mazzarol and Soutar [51]. Indeed, regional asymmetries are greatly linked to both peripheral locations and the economic, social and institutional structures and dynamics of different regions [96]. More peripheral regions are usually expected to be less developed, as they are further from the main centres of decision-making, production and consumption [83]. Considering that if on one hand the HEIs must adapt to their surrounding population, and on the other that the population also ends up adapting to the existing educational supply, there is always a certain synergy between the characteristics of teaching, educational institutions and the local population/social context, as mentioned by [44]. So, it would be important to characterise the Portuguese higher education system and determine the presence of asymmetries between the various regions, assessing the different ways in which these institutions relate to their physical and social environment.

To respond to Q1, "Are HEIs efficient in transforming their inputs into pro-sustainability outputs?", two new insights are provided. Firstly, Portuguese HEIs manage to present intermediate levels of pro-sustainability efficiency, with social and environmental aspects showing the greatest efficiency. This result demonstrates the HEIs' concern about their social involvement in activities linked to the third mission [30], and each HEI's capacity to stimulate, for example, gender equality, direct (e.g., grants) and indirect (e.g., accommodation services, sport, psychological support, volunteerism, etc.) social support, combating academic drop-out and, more recently, support/encouragement for student mobility to peripheral regions. In the Portuguese case, as highlighted by some studies, for example in [34], social inequalities are very relevant when analysing the problem from a perspective more associated with income inequality or when focusing on the intersections and cumulative effects of various forms of educational, gender, territorial and ethnic inequality, etc. (e.g., [35,97]). The HEIs' contribution to their regions is through study grants awarded to needy students or those far from home, implementing activities to promote gender equality, both in terms of teaching and regarding the local population, and in implementing and extending social support to their students in particular, and to society in general.

Regarding the environmental contribution, although the results demonstrate that most HEIs manage to reach a reasonable level in transforming their inputs in environmental efficiency, there is certainly much work to be done. HEIs often have an important environmental concern on campus, but frequently the results do not extend to the surrounding regions, and if they do so, this is very localized and on a very small scale. These situations occur because regional entities do not have that concern about environmental sustainability or because there is not yet sufficient capital to develop the necessary infrastructure to accompany such activities. It is also necessary to develop greater environmental awareness through inter-generational education programmes. Regarding cultural efficiency, it was demonstrated that much remains to be done, principally in peripheral regions where resources and access to cultural goods are scarce or even non-existent.

Secondly, the HEIs presenting greater efficiency are located in the Greater Lisbon area. This may indicate that these institutions are well integrated in their region and present a differentiated, competitive orientation and positioning, being able to give greater prominence to activities directed to improving pro-sustainability efficiency, according to regional needs.

Therefore, the strategic path the HEIs follow, their structures and operations, are linked to the region wherein they operate [45]. This result also reflects the rapid and profound structural change in Portuguese society, resulting from the processes of social re-composition found over the last three decades, which underlined the country's regional asymmetries [35]. These authors mention the continued existence of inequalities, above all, in essentially rural regions more distant from major urban centres and their surrounding areas of influence, particularly in the regions of Alentejo, the Centre and the Autonomous Region of the Azores, with Greater Lisbon presenting values that tend to position this region in a more favourable wider context.

Regarding the second analysis, and to answer Q2, "What is the role of this efficiency as a predictor of regional QoL?", the results underline that the HEIs' pro-sustainability efficiency has a positive influence on the region's QoL, through environmental and cultural efficiency, but also reinforce the importance of the HEI's size, in terms of student numbers, as a component strengthening the significant effect of those dimensions. If the HEIs have more students, especially with regard to environmental and cultural efficiency, it can lead to a lower QoL in the region, which is justified by the fact that many times the agglomeration of students in a certain region can destabilize the lives of those that inhabit in that region, for example, with more noise, more garbage on the streets, more confusion, less security, etc. As mentioned by Goddart [9], HEIs are not just situated in places, they belong to their regions, as they interact with them in a diversity of ways. Therefore, the HEIs' pro-sustainability interaction with their regions of influence can take place in various ways, namely, through the students and staff who live in the region; activities of a social, environmental and cultural nature developed on and off campus; ethical social services, showing civic responsibility, provided to the community; and the creation of sustainable, ecological infrastructure on and off campus, etc. The whole dynamics should be ensured, considering the needs of both the HEI and its surrounding region, contributing to regions' attractiveness and sustainable development, and to inducing positive externalities with regard to regional QoL [79].

These results can be extrapolated to other regional realities, namely, in the European space, where there are national networks of public HEIs, aiming to promote territorial cohesion and social mobility through education, research and development, qualification, lifelong learning and, obviously, positively influencing the QoL of the regions.

7. Conclusions, Limitations, Research Agenda and Implications

This study assesses HEIs' pro-sustainability efficiency, considering the social, environmental and cultural factors, examining how their efficiency can influence regional QoL. The study uses a two-step methodology. In the first step, a standard DEA approach was used to estimate the efficiency scores of 23 Portuguese public HEIs; and in the second step,

a multivariate logit regression assessed the role played by the HEIs' pro-sustainability efficiency in the regional QoL.

The main findings reveal that HEIs located in the Lisbon region have a higher level of pro-sustainability efficiency, although that efficiency is more significant and positive in environmental and cultural factors. Regarding the contribution of the HEIs' pro-sustainability efficiency to the region's QoL, through the three dimensions of efficiency, the institution's size, in terms of student numbers, is shown to be a control variable contributing to the level of interaction between efficiency and regional QoL. In this analysis, the environmental component of efficiency was found to contribute most to regional QoL.

The article is innovative and contributes to the literature on HEIs' pro-sustainability efficiency in two ways: firstly, it maps the most efficient HEIs by collecting the key indicators (inputs and outputs) based on studies of HEIs' impact on their region and from data from a field study, in order to analyse the pro-sustainability efficiency (social, environmental and cultural), through constructing models that are estimated using the DEA method; and secondly, it analyses whether their efficiency influences the regional QoL through specification of logit and probit multivariate models, using the HEIs' efficiency scores as explanatory factors of regional QoL.

There are several limitations that must be underlined. Firstly, it is pointed out that only Portuguese HEIs were included, and so comparisons cannot be made with other international HEIs. However, significant and elucidative results were obtained for the Portuguese case, and the study can be replicated in other international higher education systems. Secondly, the limited number of HEIs under analysis, despite being justified by the unavailability of complete data regarding a greater number of institutions that take part in the scientific and technological system in Portugal. Nevertheless, the main public HEIs were included in the study. Thirdly, the was difficulty in gathering data at the NUTS III level, and especially concerning HEIs. Therefore, a suggestion for the future is to extend the population under study, including new samples of HEIs in other countries, for ensuring a higher number of DMUs and possibly prevent some potential bias present in reduced dimension samples. Fourthly, the fact is that the benchmarking exercise of the DEA analysis considers, by default, the best reference included in the DMU group. Fourthly, it can also be mentioned as another limitation the fact of using a limited set of indicators selected from the literature review. However, a large number of previous studies was reviewed, and the indicators found were tested and scrutinized in the scope of a field study undertaken with experts on higher education. Fifthly, the fact that there was no bootstrapping analysis in the deterministic DEA approach implemented to carry out the study may be an issue. Despite the various attempts made, the necessary convergence of the estimated parameters in the bootstrapping simulation was not ensured. This may be related to the reduced number of DMUs under analysis, already mentioned as a limitation of the empirical approach. Sixthly, a "static" view is presented here, since it was considered only for one year, which is why it is suggested, as an example of a research endeavour to be prosecuted, the future development of longitudinal studies.

Thus, in the light of the empirical evidence now obtained, it is necessary to pursue a future research agenda that includes longitudinal cross-country studies on the influence of the efficiency of HEIs on the regional QoL, to contrast the previous period and the period after the outbreak of the COVID−19 pandemic crisis, considering the different dimensions of the QoL, as recommended in the world reference initiative: "OECD Better Life Index". Additionally, it is suggested to continue the present study, through the development of a composite index that measures the efficiency of HEIs with pro-sustainability orientation, so that this index can be considered in financing decisions, both public and private, of this type of institutions.

The implications of the current study can be seen in two ways: firstly, through the type of association made, which strengthens knowledge about HEIs' influence on their regions, synthesizing at the same time the change in HEIs' social, environmental and cultural role, considering the population's QoL. Secondly, HEIs can reinforce the institutional orientation

of pro-sustainability management, and the study provides new lines for public policies devoted to strengthening HEIs' role in the necessary stimulation of more and better social and cultural activities, with environmental awareness, as levers of regional QoL.

Regional disparities are also connected to peripheral locations and to the economic, social, cultural and environmental structures and dynamics of the different regions. In this line of thought and argument, it is fundamental to consider the HEIs' history and location when making critical decisions on financing teaching, research and knowledge and technology transfer activities carried out by the HEIs, with a proven influence on regional QoL, and thereby emphasize the social, cultural and environmental components of efficiency required of these institutions, which are determinant for the education and absorption of sustainability values at the regional level.

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Dynamic Effects of Material Production and Environmental Sustainability on Economic Vitality Indicators: A Panel VAR Approach

João Leitão [1,2,3,4,*] and Joaquim Ferreira [2]

1 NECE-Research Center in Business Sciences, Faculty of Social and Human Sciences, University of Beira Interior, 6200-001 Covilhã, Portugal
2 NECE-Research Center in Business Sciences, University of Beira Interior, 6200-209 Covilhã, Portugal; joaquim.ferreira@ubi.pt
3 Centre of Management Studies of Instituto Superior Técnico (CEG-IST), University of Lisbon, 1649-004 Lisboa, Portugal
4 Instituto de Ciências Sociais (ICS), University of Lisbon, 1600-189 Lisboa, Portugal
* Correspondence: jleitao@ubi.pt; Tel.: +351-275-319-853

Abstract: This study analyzes the relationships and dynamics between material production, foreign direct investment (FDI), economic activity, carbon productivity, the stock market, and green tech, both in a global and European context, using panel vector autoregressive methodology (PVAR). The empirical evidence obtained for the Global Group reveals four significant and positive unidirectional causality relationships, where aggregate material production is the prominent variable. For the EU-15 group, six significant causality relationships were detected, among them three negative and three positive unidirectional relationships. The stock markets shock reveals to be the most dominant variable, despite FDI standing out as causing the greatest shock effect. Nevertheless, in the European context, limited evidence of dematerialization is detected. Economic recessions show a generally negative effect, which contrasts with the economic Kitchin cycles, which reveal the effect of a generally positive relationship.

Keywords: economic activity; environmental sustainability; cycle; materials; panel models; sustainable finance

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1. Introduction

The current scenario of global warming has led world institutions and political decision-makers to join various international discussion forums on mitigation strategies and the implementation of policies and measures to fight pollution and, generally, to adopt clean energy sources. However, these efforts have had a limited effect on the co-evolution of economic and population growth trajectories, resulting in an increasing demand for, and use of, natural resources and higher greenhouse gas emissions. This raises the question of the obligatory nature of sustainable economic development, aiming to implement a circular economy model as opposed to today's dominant model centered on fossil energy production and the exploitation of resources. In the same line of thought, the literature contains concepts and studies of reference that can illustrate better the still unexplored issue of the relationship between dematerialization and sustainable growth.

Highlighted first is the concept of dematerialization, characterized by decreasing use of material in the process of producing final products (Herman et al. 1990). It also serves to define a reduction in the intensity of raw material in economic activity (Bernardini and Galli 1993) or relative or absolute reduction of the amount of material and waste generated per production unit in the economy (Cleveland and Ruth 1998).

For there to be effective dematerialization of the economy, two processes stand out: the recycling process, which improves the product's quality and extends its useful life

(Herman et al. 1990); and the introduction of new technology, which consists of improving products' characteristics, leading to new products with less intensive use of materials (Tilton 1991; Bernardini and Galli 1993).

From a perspective of an harmonious relationship between growth and the environment, the literature applies the theoretical concept of the Environmental Kuznets Curve (EKC), or inverted U-shaped curve, according to which in a first stage of industrialization, the growth in domestic income accompanies increased environmental damage up to a certain threshold, with this diminishing a posteriori while income continues to grow (Grossman and Krueger 1991). In this view, the inverted U-shaped curve occurs because at the initial stage of economic growth, countries concentrate on increasing employment and income (Dasgupta et al. 2002; Dinda 2004), and at a second stage they focus on improving the quality of the environment (Dinda 2004). In turn, the first phase of the EKC may present a more stable configuration, as long as institutional policies to discourage the exploitation of natural resources are implemented (Panayotou 1993). It is noted, however, that such policies lead to faster adjustment of environmental quality in a phase of high incomes (Panayotou 1997).

The EKC hypothesis has been partially ratified through free trade between economies, in this way contributing to increased environmental damage, particularly in developing economies (Stern 1998). From another angle, based on an economic model concentrating on the industrial sector, developing economies tend to present lower levels of environmental damage than developed ones because the latter is based on sectors of great accumulation of physical and human capital (Grossman and Krueger 1991).

In this context, and despite observing a tendency towards greater investment in clean energy and ecological modernization allied to relocation and internationalization of industry (Aleluia and Leitão 2011), the environmental situation, in developed countries, continues to suffer because the coal industry benefits from low electricity prices, as opposed to increased prices for domestic electricity (Jänicke et al. 1997).

Therefore, with the main reasons of limiting the transfer of resources, implementing ecosystem cycles in economic cycles and respecting resource reproduction, the Circular Economy concept is promoted. This is based on a production-consumption system that aims to maximize the productive system following the linear form: Nature->Society->Natural Material->Energy Flows; through cycles of material and renewable sources of energy (Korhonen et al. 2018).

In the current context of globalization and economic integration, interdependences and spillover effects occur among markets. Given the information on the application of penalties and sanctions to listed companies whose behavior has an environmental impact, bearish behavior has been observed in markets (Muoghalu et al. 1990; Laplante and Lanoie 1994).

In this line of analysis, this study aims to analyze the behavioral effects and dynamics of shocks between material production, environmental sustainability and economic-financial variables, using the panel VAR (PVAR) methodology (Love and Zicchino 2006; Abrigo and Love 2016). Following the same previously referred authors, this advanced econometric methodology prevents endogeneity issues. In addition, it is not based on prior theory regarding variables' relationships, and provides the possibility of using two forecasting techniques, such as the orthogonalized impulse-response functions, and the forecast error decomposition variance, to gauge forecast effects on the system. Comparing to the VAR model, the current methodology in use, allows heterogeneity in panel estimation procedures.

The main contributions to the literature lie in analyzing dynamic feedback behavior or that of one-directional shocks originating in the variables representing material production, environmental sustainability and economic-financial indicators, including exogenous factors and the short-term economic cycles of Kitchin. The present empirical study presents a two-fold contribution for the literature on sustainable finance: (1) analyzing the still unexplored relationships between materials production, green growth, innovativeness,

and macroeconomic fundamentals, in order to deepen the knowledge on how to foster the production and financial strategies oriented to a green economy pathway; and (2) unveiling dematerialization paths, in terms of the relationship between sustainable/green growth and macroeconomic fundamentals, considering the short cycles of Kitchin.

The empirical study is structured as follows. It starts with a review of the theoretical and empirical literature on the relationships among material production, FDI, economic activity, environmental sustainability, stock markets, and environmental technologies, and developing the research hypotheses. Secondly, the econometric model and respective specification, are displayed. Then the results are presented, together with their discussion. Finally, the conclusions are presented, providing the main evidence and implications for policy-makers, the limitations of the study, and the guidelines for future research.

2. Theoretical Framework, Evidence and Hypothesis Development

The subjects of environmental degradation and climate change, resulting from the accelerated growth of industrial and economic activity in the 20th century and the beginning of this one, have gained prominence in the principal international forums for political, environmental and scientific discussion.

In terms of a theoretical paradigm, there is a certain convergence around the thesis that dematerialization, according to the EKC hypothesis, is only confirmed for low levels of growth (Ayres and Van Den Bergh 2005), which can arise from the fact that the costs of exploiting resources are greater than the wealth produced (Kemp-Benedict 2018). According to the same theoretical framework of reference, the spread of technology and technological progress do not influence the dematerialization process (Magee and Devezas 2017).

In this connection, given the empirical evidence obtained previously, the stylized fact stands out that the dematerialization process occurs above all in low income economies (Steinberger and Krausmann 2011; Shao et al. 2017) or in periods of economic recession (Shao et al. 2017), whereas in developed economies, growing material consumption is shown as a current process (Agnolucci et al. 2017). In addition, although material productivity tends to increase, dematerialization does not become particularly evident, given the substantial increase in the world population, leading to increased use of material consumption per capita (Krausmann et al. 2009).

In the empirical literature of reference, it is also worth highlighting the observation of that dematerialization process, according to the EKC hypothesis, in the context of developed or industrialized economies (Canas et al. 2003; Guzmán et al. 2005; Dong et al. 2017; Pothen and Welsch 2019).

In short, it is indicated that a lack of synchrony between levels of economic activity and material production/consumption has become more evident (Vehmas et al. 2007; Zhang et al. 2017), despite also finding a tendency towards increased dematerialization in fast-growing emerging economies, such as the case of China (Dai and Liu 2018). Therefore, the following hypothesis is considered:

Hypothesis 1 (H1). *The economic activity and material production denote a negative causality relationship.*

Considering the causal nexus established in the literature between economic activity and CO_2 emissions, diverging visions are found, based on different empirical approaches, which are worth reviewing in the framework this study belongs to. On one hand, there is an indication of decoupling between economic activity and CO_2 emissions (Wu et al. 2018; Chen et al. 2018; Dai and Liu 2018; Vo et al. 2019), and on the other hand, it underlines the lack of any statistically significant relationships regarding the causal nexus of reference (Cai et al. 2018) as well as a moderate positive effect between economic activity and CO_2 emissions (Kalaitzidakis et al. 2018). This leads to the following research hypothesis:

Hypothesis 2 (H2). *The economic activity and carbon productivity present a positive causality relationship.*

Bringing to this study the issue related to the integration of markets and their interdependences, it is considered necessary to study the behavior of those markets when faced with a shock of material production and CO_2 emissions. However, the literature focuses on commodity markets, on carbon energy markets and renewable energy markets and hedging strategies, and does not generally examine the relationship between stock markets, in relation to a variation in material production or between stock markets and variation in carbon levels.

It should be pointed out that some studies find no relationship between commodity markets and stock markets (Huang et al. 1996; Singhal and Ghosh 2016), despite finding a positive relationship with oil company stocks (Huang et al. 1996). Spillover effects are not observed between metal commodity markets and the stock market (Irandoust 2017).

From another perspective, the weak performance of stock markets has a positive effect on oil commodity prices (Jain and Biswal 2016), indicating a negative relationship between these two types of market. Indeed, pointed out as examples of better hedging strategies are investment in stock and oil commodity markets, in that a fall in prices causes increased volatility, leading to a significant asymmetrical effect between prices of the commodity and of the stock markets (Sadorsky 2014). In addition, commodity markets emerge as markets of monetary compensation, market instruments and substitute instruments, concerning investments based on a share portfolio (Batten et al. 2010).

Therefore, the following hypothesis is formulated:

Hypothesis 3 (H3). *The stock market and material production denote a negative causality relationship.*

Concerning the relationship between stock markets and carbon productivity, the empirical literature only contains studies on the relationships between the indices of shares of reference and those of the carbon market.

To optimize the value hoped for from an asset portfolio, a short position in the oil and carbon markets is suggested (European Union Allowances), as opposed to a long position in stock markets (Luo and Wu 2016). However, the relationship with the carbon market is found to be heterogeneous, in that stock market performance has a negative effect on the volatility of the carbon markets of the EUA and ERU (European Reduction Units), and has a positive impact on the volatility of the CER (Certificated Emission Reduction) market (Reckling 2016).

The carbon market has a positive influence on the shares of green energy companies, while having a negative impact on those of fossil fuel companies (da Silva et al. 2016), forming positive spillover effects of the volatility of the carbon market on the green energy share market (Dutta et al. 2018).

It is noted that development of the financial market has stimulated the demand for clean energy (Mamun et al. 2018), which means a negative relationship between financial markets and CO_2 emissions (Paramati et al. 2016; Paramati et al. 2017).

Furthermore, when a given company faces judicial actions, penalties, sanctions or any information regarding environmental degradation, it will be evaluated negatively by investors who will heavily penalize its shares on the market (Muoghalu et al. 1990; Laplante and Lanoie 1994). Therefore, considering the literature presented, the following hypothesis is presented:

Hypothesis 4 (H4). *The stock market and carbon productivity have a positive causality relationship*.

Concerning the relationship between Foreign Direct Investment (FDI) and CO_2 emissions, there is a notable shortage of previous empirical evidence. However, it can be confirmed that the relationship between FDI and CO_2 emissions is essentially positive (Lau et al. 2014; Seker et al. 2015), this being more evident in the long term (Paramati et al. 2016), which demonstrates that the economy's degree of openness leads to increased CO_2 emis-

sions. Analyzing the impact of adopting new processes or alternative forms of technology on CO_2 emissions, a positive association is also found (Paramati et al. 2017), confirming the importance of multinationals implementing efficient technology and processes.

Consequently, the following research hypothesis is considered:

Hypothesis 5 (H5). *The FDI and carbon productivity have a negative causality relationship.*

The literature on the relationships of interaction between financial markets and FDI concludes that: currency devaluation stimulates foreign investors to acquire domestic assets (Froot and Stein 1991); FDI contributes to the progress of macroeconomic fundamentals (Claessens et al. 2001), promoting financial markets' development (Agbloyor et al. 2013), which means agents have a greater appetite for local assets such as investors and funds (Boyer and Zheng 2009), contributing to increased share prices (Alfaro et al. 2004; Lizardo and Mollick 2009; Azman-Saini et al. 2010). From the above, the following hypothesis is formulated:

Hypothesis 6 (H6). *The FDI and stock market denote a positive causality relationship.*

Considering the causal nexus established in the literature between FDI and economic activity, the efficiency of the former is found to be greater than domestic investment, inasmuch as developing economies, especially, face restrictions in accessing finance in international markets (De Gregorio 1992). Indeed, the positive effect is greater in economies with strong policies on international trade (De Gregorio 1992), above all those directed towards exports (Balasubramanyam et al. 1996).

FDI is a driver of technology transfer, contributing to economic growth (Li and Liu 2005; Leitão and Baptista 2011; Makiela and Ouattara 2018), above all in economies with great capacity in terms of technology absorption and human capital (Li and Liu 2005). Added to this is the fact that economies with better indicators of financial development (Lee and Chang 2009; Iamsiraroj and Ulubaşoğlu 2015) and commercial openness (Iamsiraroj and Ulubaşoğlu 2015) are more able to attract FDI.

Moreover, capturing FDI promotes productivity spillovers, above all backward spillovers (e.g., linkages with domestic firms in different industries, such as upstream suppliers) (Javorcik 2004).

However, it is also true that FDI can have a negative influence on exporting economies where the primary sector dominates, signaling that FDI is negatively related to the abundance of resources (Herzer 2012). Considering the above, the following hypothesis is formulated:

Hypothesis 7 (H7). *The FDI and economic activity present a positive causality relationship.*

In carrying out this study, it is also necessary to consider the importance of economic activity in determining financial market behavior. Here, the causal nexus between the stock market and economic activity is characterized by a positive relationship (Schwert 1990; Choi et al. 1999).

Consequently, markets' behavior is considered an important predictive indicator of the behavior of economic activity (Choi et al. 1999; Hassapis and Kalyvitis 2002). Furthermore, financial development has a dominant role in determining the level of economic activity, especially by determining the level of liquidity, which is positively related to economies' contemporary and future behavior (Levine and Zervos 1998).

There is also previous evidence of a positive correlation between bilateral commercial relationships and the stock market (Tavares 2009). Thus, the following research hypothesis is raised:

Hypothesis 8 (H8). *The stock market and economic activity have a positive causality relationship.*

More recently, the technological innovation appears in the global policy agenda as a means of carbon mitigation and for the transition to a sustainable and green economy. However, although some empirical evidence shows that technological innovation becomes an important factor in carbon mitigation (Fernández et al. 2018), other studies identify the possibility of a rebound effect (Magee and Devezas 2017; Wang et al. 2019; Cheng et al. 2019) or from another angle, technological development does not decrease gas emission (Samargandi 2017; Mensah et al. 2018).

Considering the previous evidences, the following hypothesis is considered:

Hypothesis 9 (H9). *The carbon productivity and green technology have a negative causality relationship.*

3. Methodology

3.1. Econometric Model

This study aims to determine the relationships of causality and the effects of exogenous shocks on economic-financial indicators, resource productivity indicators and material production indicators, using a VAR model with panel data (PVAR) (Love and Zicchino 2006; Abrigo and Love 2016).

The mathematical formulation of the PVAR model is as follows:

$$Y_{i,t} = Y_{it-1}A_1 + Y_{it-2}A_2 + \ldots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + \mu_i + \epsilon_{it} \quad i \in \{1, 2, \ldots, N\},\ t \in \{1, 2, \ldots, T_i\} \tag{1}$$

where: i corresponds to countries encompassed in the present study; t is the time horizon for each i; Y_{it} is a *kx1* vector of endogenous variables; X_{it} is a *lx1* vector of exogenous variables; μ_i is a *1xk* vector of individual fixed effects; and and ϵ_{it} is a *1xk* vector of idiosyncratic errors (ϵ_{it}~ i.i.d.). The *kxk* matrices: $A_1, A_2, \ldots, A_p, A_{p-1}$; and the *lxk* matrix: B; represent the estimated parameters. Therefore, the PVAR model assumes that cross-sections hold same units in data generating process, which result in common parameters in matrixes: A_1, $A_2, \ldots, A_p, A_{p-1}$; and B; encompassing heterogeneity through panel-specific fixed effects (Holtz-Eakin et al. 1988; Abrigo and Love 2016).

Bearing in mind that μ_i is correlated with the lagged regressors, the use of OLS estimator can lead to bias of the coefficients (Nickell 1981; Abrigo and Love 2016). For reducing potential bias, the Helmert transformation procedure is performed (Arellano and Bover 1995). This leads to removal of the future means (i.e., the average of the set of future observations available for each unit of time, *per* country studied), thereby contributing to orthogonality between the dependent variables and the lagged regressors, as well as allowing their use as instrumental variables[1] and use of the GMM estimator.

To allow analysis of the forecast error variance decomposition (FEVD) and the simulated coefficients of the impulse-response functions (IRF), the stability condition of the estimated model should be validated, i.e., the modulus eigenvalues of a companion matrix A should be in an interval [0, 1] (Lütkepohl 2005). After check the stability condition of the estimated model, FEVD and IRF are used, as these tools can determine the dynamics of the endogenous variables in relation to exogenous shocks. These tools are expressed as follows:

$$\text{FEVD} \equiv \phi_i = \begin{cases} I_K, & i = 0 \\ \sum_{j=1}^{i} \phi_{t-j} A_j, & i = 1, 2, \ldots \end{cases} \tag{2}$$

$$\text{IRF} \equiv Y_{it+h} - E[Y_{it+h}] = \sum_{i=0}^{h-1} e_{i(t+h-i)} \phi_i \tag{3}$$

To do so, the orthogonal decomposition of Cholesky is performed, whereby the order of variables' entry is decided primarily by the greater degree of exogeneity of each of the variables of the model's selected specification.

[1] The instrumental variables are specified according to the procedures proposed by Holtz-Eakin et al. (1988).

3.2. Data, Variables, and Specification of the Model

This study analyzes the response dynamics of economic, financial, production and resource sustainability indicators, in relation to an exogenous shock.

Therefore, annual unbalanced panel data are used, referring to the period 1990–2016 for 24 countries (Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Mexico, Netherlands, Norway, Portugal, Russia, Spain, Sweden, United Kingdom and United States of America). The period of the sample is justified for two reasons: (i) limited access to data; and (ii) this being the longest period available (with annual frequency) to carry out this study. The data were gathered from the following databases: Investing.com; UNCTAD; OECD Statistics; British Geological Survey; and World Bank.

In the specification selected for the model, five endogenous variables are considered, namely: MAT_PR_{it}, representing aggregate production (in tons) of the groups of material selected[2] in each country included; FDI_{it}, representing entry flows of Foreign Direct Investment (FDI), deflated by the GDP deflator, in each country included; $CO_2\_PR_{it}$, which is an incomplete proxy for the carbon productivity of each country; $GDP\text{-}PC_{it}$, which represents the national wealth, at constant prices, of each country; $SMKT_{it}$, representing the stock market indices of reference of each country; and $ENV\_TECH_{it,}$, representing the amount of environmental-related technologies (e.g., patents).

Concerning the variables selected, in Table 1 presented below, the associated concepts, description, units, and statistical sources are displayed.

Table 1. Variables selected.

Variables	Associated Concepts	Description	Units	Statistical Sources
Material Production (MAT_PR)	Aggregate Material Production	Production of minerals commodities	Tons	British Geological Survey
Foreign Direct Investment (FDI)	Foreign Direct Investment or FDI	Inward and outward flows and stock	US Millions deflated by GDP deflator	UNCTAD
Gross Domestic Product (GDP_PC)	Economic Activity	Total of GDP per capita	US Millions in constant prices	UNCTAD
CO_2 productivity (CO_2_PR)	Carbon productivity	GDP per units of energy-related CO_2 emissions	US dollar per kilogram	OECD
Stock Markets (SMKT)	Stock Markets	Major domestic stock markets indexes	Index points	investing.com
Environment-related technologies (ENV_TECH)	Green Tech	Patents related with environmental management, water adaptation and climate change mitigation	Units of patents	OECD

Source: Own elaboration.

The next step was logarithmic transformation of the series, in order to ensure greater convergence of the coefficients estimated and contribute to better adjustment of the model.

Aiming for a subsequent comparative analysis, the study's methodological design considers the possibility of determining the response dynamics in two groups of countries. The first group corresponds to all twenty-four countries in the sample (Global Group). The second corresponds to the 15 European Union countries[3] (EU-15 Group). For each group,

[2] Given the limited access to data, these were collected referring to the group of metals and the group of minerals. Concerning the group of metals, the materials included in the study variable are: aluminium, steel, cadmium, bismuth, lead, cobalt, copper, tin, iron, pig iron, lithium, magnesium, manganese, nickel, gold, silver, platinum and its derivatives and zinc. The group of minerals includes the following materials: asbestos, alumina, barite, feldspar, rock phosphate, gypsum, graphite, mica, salt and zirconia.

[3] For the European Union, only Luxembourg was not included due to the unavailability of data.

three dummy variables are considered, aiming to capture the main crises originated from emerging markets ($D^{Crises\ EM}$), and developed markets ($D^{Crises\ DM}$)$D^{Crises\ EM}D^{Crises\ DM}$[4], covering two economic cycles of Kitchin[5], and another dummy variable that characterizes recession periods in the larger economies in each group $\left(D^{Global}; D^{EU}\right)D^{Global}D^{EU}$[6].

The selected specification of the model is as follows:

$$\begin{gathered} Y_{it} = \mathrm{A}_0 + A_1 Y_{t-p} + D^{Crises\ EM} + D^{Crises\ DM} + D^{Global/EU} + \mu_i + \epsilon_{it}\,, \epsilon_{it} \ \sim \ \text{i.i.d.} \\ i \in \{1,\ 2,\ \ldots,\ 24\}^{\text{GLOBAL}},\ t \in \{1990,\ 1991,\ \ldots,\ 2016\}^{\text{GLOBAL}} \\ i \in \{1,\ 2,\ \ldots,\ 14\}^{\text{EU-15}},\ t \in \{1990,\ 1991,\ \ldots,\ 2016\}^{\text{EU-15}} \end{gathered} \tag{4}$$

where, $Y_{it} \equiv \{MAT_{PRit}\ FDI_{it}\ GDP_{PCit}\ CO2_{PRit}\ SMKT_{it}\ ENV\_TECH_{it}\}$.

4. Results and Discussion

4.1. Empirical Evidence

The results obtained from estimating the PVAR model and evidence from the dynamic analysis are now presented, using three tools for testing and forecasting: Granger causality, FEVD, and IRF.

Before estimating the model, diagnostic tests were performed to ensure no misspecification. To do so, the cross-sectional dependence was verified (Pesaran 2015), which led to applying the unit root test CIPS (Pesaran 2007), proceeding to differentiation of the variables, in order to ensure they became stationary or integrated of order zero, that is, *I(0)*[7]. To determine the optimal number of lags and moments, the Andrews and Lu (2001) test was applied. It admits one optimal lag, considering from two until five lags (in both groups) concerning instrumental variables. The optimal number of lags was selected against application of the criterion that minimize the *J*-statistic of Hansen (1982).

In order to compare the two groups studied, i.e., Global Group and EU-15 Group, and after performing the introductory tests for estimation of the PVAR[8] model, the coefficients estimated were obtained (cf. Tables 2 and 3).

In Table 2 presented below, referring to the Global Group, the values obtained for the *J*-statistic of Hansen (1982) determine that the null hypothesis is not rejected, thereby ratifying the validity of the instruments used in estimating the model.

In model 1, and the dependent variable being MAT_PR_t; the variables with greatest statistical significance are MAT_PR_{t-1} and GDP_PC_{t-1}, with a positive effect and a negative effect, respectively, at the 5% level. The Dummy Crises DM shows a positive and statistically significant effect, at the 5% level, whereas the Dummy Global affects negatively and significantly, at the 1% significance level.

In model 2, with the dependent variable: FDI_t; the variables FDI_{t-1} and SMKT_{t-1} are the most predominant, exhibiting a positive and significant effect, at the 1% and 5% significance level, respectively. The MAT_PR_{t-1} and $\text{CO}_2\text{\_PR}_{t-1}$ denote a positive and negative effect on the behavior of FDI_t, respectively, with associated statistical significance

[4] The dummy variable $D^{Crises\ EM}$ has the value of 1 in the annual periods of 1991, 1994, 1995, 1997–2000, 2002, and the value of zero in the remaining periods. The periods under analysis correspond to different international crises, such as: the oil crisis (1991); the Mexican economic crisis (1994/1995); the Asian monetary crisis (1997); the Russian monetary crisis (1998); the Brazilian monetary crisis (1999); the Argentinian economic crisis (1999–2000); and the South American economic crisis (2002). The dummy variable $D^{Crises\ EM}$ equals to 1 in the annual periods of 2001 and 2007–2010, and 0 in other periods .These periods correspond to the dotcom bubble (2001), the subprime crisis (2007–2008) and the European debt crisis (2009–2010).

[5] The Kitchin cycles are classified as short-term cycles, i.e., cycles lasting 4 years. Therefore, the Kitchin cycles found in the period of analysis correspond to the periods 1997–2000 and 2007–2010.

[6] The dummy variable D^{Global} represents economic recession in the USA and People's Republic of China, having the value of 1 in the annual periods of 2008 and 2009 and the value of zero in the other periods. The dummy variable D^{EU} corresponds to economic recession in Germany, France and the United Kingdom, having the value of 1 in the annual periods of 1991–1992, 2002–2003 and 2008–2009 and the value of zero in the other periods analysed.

[7] In the Global Group, the FDI, SMKT and ENV_TECH variables appear as stationary at levels, whereas in the EU-15 Group only FDI is stationary, at levels.

[8] The tables of the tests applied can be obtained upon request to the authors.

of 10%. Therefore, the Dummy Crises EM is found to have a positive and significant effect on FDI_t, at the 1% significance level, whereas the Dummy Global affects negatively the FDI_t, at the 10% level.

In model 3, with the dependent variable: GDP_PC_t; there are positive effects of MAT_PR_{t-1} and GDP_PC_{t-1}, at the 1% significance level. In turn, both the Dummy Crises and Dummy Global, there is mixed evidence, detecting a positive and negative effect, respectively, at a 1% level of significance.

In model 4, considering as dependent variable: $CO_2\_PR_t$; GDP_PC_{t-1} and ENV_TECH_{t-1} are found to have a positive, and significant effect, at the 1% significance level, while for the variable $CO_2\_PR_{t-1}$ negative and significant effects are found, at the 1% significance level either.

In model 5, with the dependent variable: $SMKT_t$; $SMKT_{t-1}$ and $CO_2\_PR_{t-1}$ are found to have a positive and significant effect, at the 1% and 5% significance level, respectively. The Dummy Global presents, within the group of dummy variables, as the predominant insofar as affects negatively and significantly the FDI_t, at the 1% statistical significance level.

In model 6, with the dependent variable: ENV_TECH_t; the variables ENV_TECH_{t-1} and MAT_PR_{t-1} perform as the predominant ones, insofar as affect positively the FDI, at the 1% and 5% significance level. Regarding the Dummy Crises EM and Dummy Crises DM evidence positive and significant effect, at the 1% and 5% significance level, respectively. Unlike, the Dummy Global affects negatively at the 10% significance level.

Table 2. The Global Group PVAR estimators.

Models	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Dependent Variable	MAT_PR	FDI	GDP_PC	CO_2_PR	SMKT	ENV_TECH
MAT_PR	0.4120 **	1.9798 *	0.0719 ***	−0.0941	0.3907	1.0105 **
	[2.5700]	[1.9000]	[3.0400]	[−1.2700]	[1.3500]	[2.3700]
FDI	−0.0136	0.8452 ***	−0.0030	0.0038	0.0235	−0.0048
	[−1.3000]	[8.8300]	[−1.5500]	[0.8000]	[0.7900]	[−0.1700]
GDP_PC	−1.0465 **	0.0254	0.3489 ***	0.8836 ***	−1.1130	−0.6140
	[−1.9700]	[0.0100]	[3.4100]	[3.3700]	[−0.7500]	[−0.4000]
CO_2_PR	0.5478	−5.2331 *	−0.0535	−0.5501 ***	1.7834 **	0.5847
	[1.4300]	[−1.7200]	[−0.7800]	[−3.1900]	[2.3000]	[0.6500]
SMKT	−0.0147	0.1931 **	−0.0033	−0.0058	0.8226 ***	0.0146
	[−1.3500]	[2.0900]	[−1.6200]	[−1.1800]	[23.0100]	[0.4500]
ENV_TECH	−0.0231	0.0671	0.0030	0.0209 ***	0.0335	0.9463 ***
	[−1.6400]	[0.5400]	[0.9700]	[2.8400]	[0.7400]	[20.0700]
Dummy Crises EM	−0.0069	0.2746 **	0.0110 ***	0.0080	−0.0589	0.0054
	[−0.4700]	[1.6100]	[4.6200]	[1.2600]	[−1.6400]	[0.1300]
Dummy Crises DM	0.0560 **	0.0575	0.0189 ***	−0.0010	−0.0146	0.1384 **
	[2.3300]	[0.3200]	[5.3600]	[−0.1100]	[−0.3300]	[2.4800]
Dummy Global	−0.1571 ***	−0.3331 *	−0.0514 ***	−0.0037	−0.3125 ***	−0.1140 *
	[−4.7100]	[−1.9600]	[−9.3300]	[−0.3800]	[−4.7100]	[−1.9100]

Legend: Test of over identifying restriction: Hansen's J Chi^2 (108) = 121.8580 (p = 0.171). Notes: ***, **, * indicate significance at 1%, 5% and 10%, respectively. Z-statistics are in square brackets. Source: Own elaboration.

In the comparative analysis, in Table 3, presented below, referring to the EU-15 Group, it is highlighted that given the values obtained for the *J*-statistic of Hansen (1982), the null hypothesis is not rejected, thereby ratifying the validity of the instruments used in estimating the model.

Taking as a reference the results of model 1′s estimation, with the dependent variable being MAT_PR_t; both GDP_PC_{t-1} and $SMKT_{t-1}$ show negative and positive significant effects, respectively, at the 1% significance level. In turn, concerning exogenous variables, only the Dummy Crises reveals a positively significant effect, at a 1% level.

In model 2, considering as dependent variable: FDI_t; the lagged variable, that is, the FDI_{t-1}, denotes statistical significance, at a 1% level, with positive effects. In turn, the $SMKT_{t-1}$ reveals a negative and significant effect, at a 10% level. The dummy variables present statistical significance at the 1% level, albeit it should be noted that the Dummy Crises EM has a positive effect, contrasting with the negative effect of the Dummy EU.

In model 3, considering as dependent variable: GDP_PC_t; the lagged variable, that is, the GDP_PC_{t-1}, reveals to be the unique endogenous variable that affects significantly and positively the behavior of GDP_PC_t, at the 1% significance level. The dummy variables, mainly, the Dummy Crises EM and the Dummy EU present the opposite effects, at the 1% significance level.

For model 4, with the dependent variable: $CO_2\_PR_t$; on the one hand, variables of MAT_PR_{t-1}, FDI_{t-1}, and ENV_TECH_{t-1}, have a positive and statistically significant effect at 5% level. On the other hand, the variable $CO_2\_PR_{t-1}$ have a negative and statistically significant effect, at 5% level.

In model 5, with the dependent variable: $SMKT_t$; $CO_2\_PR_{t-1}$ and $SMKT_{t-1}$ produce positive effects at the 1% and 10% significance level, respectively, while in the GDP_PC_{t-1} is found opposite effects at the 5% significance level. In the case of the dummy variables, only Dummy Crises DM affects in a negative and significantly way the $SMKT_t$, at 1% level.

In model 6, with the dependent variable: ENV_TECH_t; the MAT_PR_{t-1} is the unique endogenous variable that impacts significantly ENV_TECH_t, with a negative sign at the 10% significance level. Concerning dummy variables, only Dummy Crises EM affects positively and significantly, however, at the 10% significance level.

Table 3. The EU-15 Group PVAR estimators.

Models	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Dependent Variable	MAT_PR	FDI	GDP_PC	CO_2_PR	SMKT	ENV_TECH
MAT_PR	0.0980	0.9915	0.0075	0.1032 **	−0.2974	0.4450 *
	[0.7700]	[1.0300]	[0.3200]	[2.4100]	[−0.9400]	[1.8600]
FDI	0.0129	0.9471 ***	−0.0049	0.0165 **	−0.0058	0.0396
	[0.5900]	[5.9600]	[−1.3600]	[2.0600]	[−0.1000]	[1.1500]
GDP_PC	−2.3522 ***	−1.6165	0.2052 ***	0.1862	−2.4965 **	−0.3280
	[−4.7900]	[−0.4900]	[2.7900]	[1.1400]	[−1.9700]	[−0.3900]
CO_2_PR	0.3538	−1.8769	0.0410	−0.2540 ***	2.1104 ***	0.2990
	[1.4800]	[−1.0600]	[0.9300]	[−2.9000]	[3.0000]	[0.7600]
SMKT	0.2345 ***	−0.7736 *	0.0153	0.0249	0.3182 *	0.0170
	[3.5100]	[−1.6900]	[1.4800]	[1.0300]	[1.8600]	[0.1700]
ENV_TECH	−0.1162	−0.2358	−0.0172	0.0509 **	0.0798	0.0259
	[−1.4600]	[−0.5200]	[−1.4400]	[2.3700]	[0.4900]	[0.1800]
Dummy Crises EM	0.0383 **	0.4088 ***	0.0135 ***	−0.0075	−0.0205	0.0475 *
	[2.0800]	[3.1600]	[4.7500]	[−1.1900]	[−0.4600]	[1.7600]
Dummy Crises DM	−0.0195	0.0029	0.0039	−0.0103	−0.2392 ***	0.0553
	[−0.8000]	[0.0100]	[1.0000]	[−1.1900]	[−4.2400]	[1.6200]
Dummy EU	0.0247	−0.6449 ***	−0.0190 ***	−0.0114	−0.0030	0.0339
	[0.8800]	[−3.1200]	[−4.4800]	[−1.1600]	[−0.0300]	[0.7400]

Legend: Test of over identifying restriction: Hansen's J Chi^2 (175) = 117.91124 (p = 0.242). Notes: ***, **, * indicate significance at 1%, 5% and 10%, respectively. Z-statistics are in square brackets. Source: Own elaboration.

The graphic representation presented below in Figure 1 reveals that the modulus of the eigenvalues of the companion matrix is within the unit circle, concluding therefore that the PVAR model satisfies the condition of stability, demonstrating that it is invertible and representing an infinite-order vector moving average, allowing estimation of the forecast error variance decomposition and coefficients of the impulse-response functions.

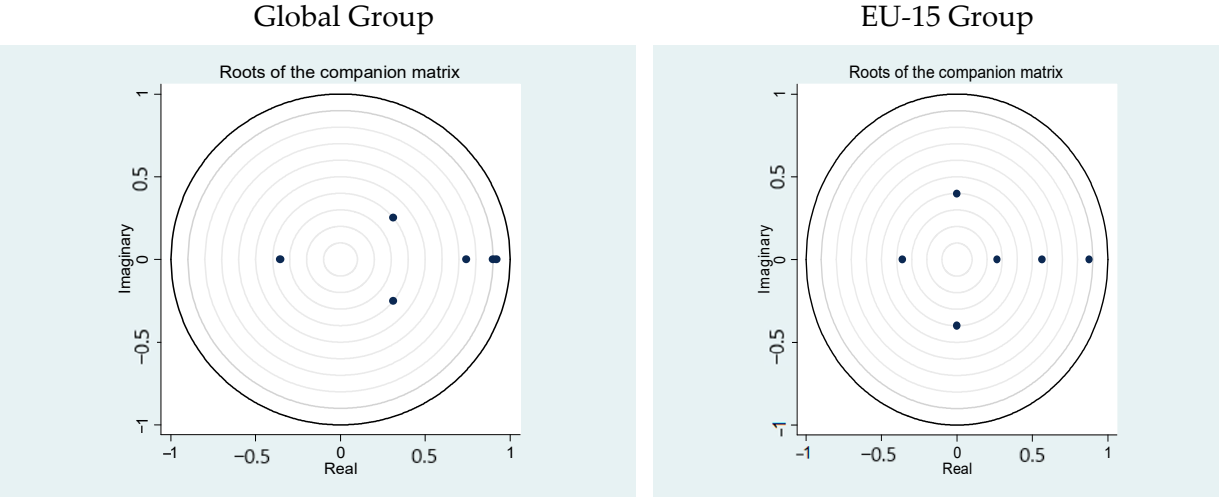

Figure 1. Eigenvalue stability condition.

As proposed by Abrigo and Love (2016), to study relationships of causality and amplitudes[9], dynamic analysis of the PVAR model is based on applying either the forecast error variance decomposition technique or the technique of impulse-response functions orthogonalized by Cholesky decomposition, with 200 Monte Carlo replications.

From the evidence obtained from that dynamic analysis, firstly for the Global Group (cf., Table 4), four causality relationships with a significant impact are found. Therefore, firstly, a shock arising from aggregate material production is seen to have a positive and significant impact on FDI, because, over the forecasting periods, FDI is explained around 8.4% through the shock in aggregate material production. Secondly, gross domestic product per capita responds positively and significantly to a shock in aggregate material production, ranging between 29% and 28%, over the forecast period. Thirdly, during the forecasting period, an economic activity shock leads to a positive and significant effect on carbon productivity at around 9%. Fourthly, there is a positive effect from aggregate material production shock on the green tech of 21.5%, after eight periods.

In overall calculation of the results of the analysis of causality and amplitude relationships, concerning the first group of countries, that is, the Global Group, the shock from aggregate material production stands out as the prominent one, revealing three causality relationships.

As for the EU-15 Group (cf. Table 5) is concerned, a greater number of significant relationships are found, i.e., six causality relationships with significant effects. Consequently, aggregate material production is now found to respond significantly and negatively to an economic activity shock between 10% and 8%, whose significant effect is not identified in Global Group results. In addition, bearing in mind a shock from the stock market, aggregate material production responds positively and significantly between 19% and 17%, during the forecasting period. In turn, a shock from stock markets has a negative and significant effect on FDI, between 5% and 7%, during the forecasting period, contrasting the outcomes from Global Group. Therefore, the aggregate material production shock produces a positive and significant effect on carbon productivity of between 9% and 7%, whilst a negative and significant shock from FDI presents an effect between 20% and 37%, during the forecasting period. Shocks from carbon productivity contribute positively and significantly to stock markets behavior between 9% and 8%. It is also worth pointing out that, for the EU-15 Group, the stock market shock becomes the predominant shock, despite the FDI inducing the higher effect amplitude.

[9] The PVAR Granger causality Wald test results, for the sake of brevity, can be obtained on request from the authors.

Table 4. Analysis of causality and amplitude relationships in the Global Group.

Equantion Variable	Excluded Variable	Dynamic Analysis	4 Years	8 Years	10 Years	Sign
MAT_PR						
	GDP_PC	FEVD	0.0312	0.0307	0.0306	-
		COIRF	−0.0289	−0.0241	−0.0228	
FDI						
	MAT_PR	FEVD	0.0842	0.0834	0.0825	+
		COIRF	0.8485	1.1720	1.2737	
	CO_2_PR	FEVD	0.0289	0.0238	0.0229	-
		COIRF	−0.3221	−0.3905	−0.4071	
	SMKT	FEVD	0.0122	0.0318	0.0390	+
		COIRF	0.3957	0.8743	1.0787	
GDP_PC						
	MAT_PR	FEVD	0.2924	0.2821	0.2799	+
		COIRF	0.0263	0.0219	0.0206	
CO_2_PR						
	GDP_PC	FEVD	0.0903	0.0894	0.0891	+
		COIRF	0.0226	0.0222	0.0222	
	ENV_TECH	FEVD	0.0153	0.0229	0.0251	+
		COIRF	0.0152	0.0248	0.0285	
SMKT						
	CO_2_PR	FEVD	0.0192	0.0165	0.0160	+
		COIRF	0.0838	0.1271	0.1410	
ENV_TECH						
	MAT_PR	FEVD	0.1988	0.2155	0.2152	+
		COIRF	0.5593	0.9260	1.0637	

Legend: FEVD—Forecast error variance decomposition; IRF—Cumulative Orthogonalized Impulse-Response Function. The causality sign is obtained from the accumulated value of the 10 periods' coefficients because from that period coefficients reach the necessary stability (Goux 1996). The direction of causality analyzed presents a significant impact, i.e., over 5% after eight periods (Goux 1996). Source: Own elaboration.

Table 5. Analysis of causality and amplitude relationships in the EU-15 Group.

Equation Variable	Excluded Variable	Dynamic Analysis	4 Years	8 Years	10 Years	Sign
MAT_PR						
	GDP_PC	FEVD	0.1047	0.0852	0.081	-
		COIRF	−0.0722	−0.0080	−0.0816	
	SMKT	FEVD	0.1940	0.1702	0.1672	+
		COIRF	0.0657	0.0265	0.010	
FDI						
	SMKT	FEVD	0.0485	0.0691	0.0728	-
		COIRF	−1.0312	−1.8847	−2.1822	
CO_2_PR						
	MAT_PR	FEVD	0.0855	0.0715	0.0685	+
		COIRF	0.0074	0.0149	0.0175	
	FDI	FEVD	0.2088	0.3415	0.3666	-
		COIRF	0.0745	0.1285	0.1474	
	ENV_TECH	FEVD	0.0411	0.0347	0.0338	-
		COIRF	0.0058	−0.0008	−0.0036	
SMKT						
	GDP_PC	FEVD	0.0181	0.0176	0.0172	-
		COIRF	−0.0621	−0.0759	−0.0783	
	CO_2_PR	FEVD	0.0913	0.0847	0.0832	+
		COIRF	0.1068	0.0800	0.0675	
ENV_TECH						
	MAT_PR	FEVD	0.0311	0.0286	0.0280	+
		COIRF	0.0633	0.0899	0.0992	

Legend: FEVD—forecast error variance decomposition; IRF—cumulative orthogonalized impulse response function. The causality sign is obtained from the accumulated value of the 10 periods coefficients because from that period coefficients reach the necessary stability (Goux 1996). The direction of causality analyzed presents a significant impact, i.e., over 5% after eight periods (Goux 1996). Source: Own elaboration.

4.2. Robustness of the Model

To determine the robustness of the model estimated, a change is introduced in the entry of endogenous variables in the Cholesky decomposition of the forecast error variance. The vector of endogenous variables introduced is described as follows:

$$Z_{it} \equiv \{SMKT_{it}\ ENV\_TECH_{it}\ FDI_{it}\ CO2\_PR_{it}\ MAT\_PR_{it}\ GDP\_PC_{it}\} \quad (5)$$

Concerning the Global Group (cf. Table 6), in the results obtained through the robustness test, no change in the typology of the sign is observed, and there is no change to the significance of the relationships, taking the estimators obtained for the benchmark model as a reference.

Table 6. Robustness test for the Global Group.

Equation Variable	Excluded Variable	Dynamic Analysis	4 Years	8 Years	10 Years	Sign
MAT_PR						
	GDP_PC	FEVD	0.0365	0.0369	0.0370	-
		COIRF	−0.0272	−0.0182	−0.0154	
FDI						
	MAT_PR	FEVD	0.0724	0.0735	0.0730	+
		COIRF	0.8137	1.1337	1.2359	
	CO_2_PR	FEVD	0.0474	0.0418	0.0406	-
		COIRF	−0.5433	−0.7033	−0.7446	
	SMKT	FEVD	0.0083	0.0231	0.0292	+
		COIRF	0.2945	0.7175	0.9048	
GDP_PC						
	MAT_PR	FEVD	0.2862	0.2757	0.2735	+
		COIRF	0.0265	0.0223	0.0209	
CO_2_PR						
	GDP_PC	FEVD	0.1096	0.1087	0.1084	+
		COIRF	0.0166	0.0156	0.0155	
	ENV_TECH	FEVD	0.0355	0.0426	0.0447	+
		COIRF	0.0159	0.0254	0.0291	
SMKT						
	CO_2_PR	FEVD	0.0261	0.0218	0.0208	+
		COIRF	0.1404	0.1790	0.1882	
ENV_TECH						
	MAT_PR	FEVD	0.1397	0.1531	0.1527	+
		COIRF	0.4489	0.7584	0.8735	

Legend: FEVD—forecast error variance decomposition; IRF—cumulative orthogonalized impulse Response function. The causality sign is obtained from the accumulated value of the 10 periods coefficients because from that period coefficients reach the necessary stability (Goux 1996). The direction of causality analyzed presents a significant impact, i.e., over 5% after eight periods (Goux 1996). Source: Own elaboration.

Regarding the EU-15 Group (cf. Table 7), it is observed a reduction in the total number of significant causality relationships, from six to five relationships, comparing with the benchmark model. On the one hand, it reveals that the relationship in which carbon productivity responds an aggregate material production shock is not significant, contrasting with the results of the benchmark model. On the other hand, the typology of the signal in some relationships is changed compared to the benchmark model. Thus, the significant relationships in which the aggregate material production response to a shock from stock markets, as well as the carbon productivity response to a shock from FDI, reveal a negative relationship, in opposite to results from the benchmark model. Nevertheless, it should be noted that a robustness check based in a Cholesky Decomposition (with a lower or upper triangular matrix), changing the variables ordering, affects, somehow, the amplitude of shocks and signal typology either. Adding to the previous, it can be observed that significant relationships converge with PVAR estimates. Hence, as it is verified a

switch on signal typology in two significant relationships and on the amplitude of shocks in one significant relationship, it can be argued that the model, in the Global Group and, above all, in the EU-15 Group, shows statistical robustness.

Table 7. Robustness test for the EU-15 Group.

Equation Variable	Excluded Variable	Dynamic Analysis	4 Years	8 Years	10 Years	Sign
MAT_PR						
	GDP_PC	FEVD	0.1197	0.0971	0.0920	-
		COIRF	−0.0748	−0.0822	−0.0835	
	SMKT	FEVD	0.1769	0.1677	0.1683	-
		COIRF	0.0536	0.0025	−0.0181	
FDI						
	SMKT	FEVD	0.0911	0.1194	0.1244	-
		COIRF	−1.4795	−2.5512	−2.9221	
CO_2_PR						
	MAT_PR	FEVD	0.0340	0.0281	0.0268	+
		COIRF	0.0122	0.0161	0.0174	
	FDI	FEVD	0.2106	0.3342	0.3573	+
		COIRF	0.0741	0.1267	0.1451	
	ENV_TECH	FEVD	0.0459	0.0369	0.0351	+
		COIRF	0.0153	0.0132	0.0120	
SMKT						
	GDP_PC	FEVD	0.0202	0.0195	0.0190	-
		COIRF	−0.0716	−0.0845	−0.0866	
	CO_2_PR	FEVD	0.1093	0.1014	0.0996	'
		COIRF	0.1090	0.0800	0.0667	
ENV_TECH						
	MAT_PR	FEVD	0.0297	0.0254	0.0245	+
		COIRF	0.0472	0.0612	0.0659	

Legend: FEVD—forecast error variance decomposition; IRF—cumulative orthogonalized impulse Response function. The causality sign is obtained from the accumulated value of the 10 periods coefficients because from that period coefficients reach the necessary stability (Goux 1996). The direction of causality analyzed presents a significant impact, i.e., over 5% after eight periods (Goux 1996). Source: Own elaboration.

4.3. Discussion

Economies are based on a fossil energy model, with a notable correlation between material consumption and economic activity (Steinberger and Krausmann 2011), which in turn contributes to even greater stimulation of the socioeconomic metabolism (Krausmann et al. 2009), with the driving levers of low energy and material prices (Agnolucci et al. 2017). Nevertheless, the results obtained, in the European context, display a negative effect of the economic activity on material production, in the EU-15 Group, which denote that material production decreases as it ramps the development and income state up of an economy, according to with EKC (Canas et al. 2003) and through environmental policies implemented (Vehmas et al. 2007). Thus, H1 is rejected for Global Group but it is not rejected for the EU-15 Group.

Considering the factual evidence found in some empirical literature, according to which emerging economies are presented as an important factor in the major decoupling of developed countries, due to industries' relocation (Wu et al. 2018) or policies of environmental regulation, there is a notable agreement between the evidence obtained here and the above arguments. Therefore, the rate of population growth becomes the main driver of material and energy consumption (Chen et al. 2018), as well as the growth of gross domestic product reveals to be one of the driving forces of CO_2 emissions (Vo et al. 2019). It turns out that besides government incentives for clean energy consumption, the onset of financial crises as recession cycles can imply an increase in carbon productivity. Thus, H2 is not rejected for the Global Group, but it is rejected for the EU-15 Group.

In turn, referring to previous evidence that precious metal markets emerge as substitutes for stock markets (Batten et al. 2010; Jain and Biswal 2016) or showing a structure of hedging of greater risk (Sadorsky 2014), the results revealed here point to a set of contradictory evidence. Consequently, the evidence obtained may indicate a certain operational efficiency of equity markets, not admitting the adoption of arbitrage practices (Irandoust 2017), which indicates rejection of H3, for both Groups.

Concerning the stock markets of European economies, on one hand these emerge as important drivers of green/renewable energy consumption (Paramati et al. 2016), through listed companies' absorption of green energy technology (Paramati et al. 2017). On the other hand, increased volatility of carbon markets means an unfavorable shock for investment (Reckling 2016), which can contribute to environmental sustainability having a negative impact on European markets. In this context, H4 is rejected both for the Global Group, and for the relationship between carbon productivity and the stock market, for the EU-15 Group. However, H4 is not rejected for the stock market-carbon productivity causality relationship between the stock market and carbon productivity, for the EU-15 Group.

The empirical evidence regarding the FDI and carbon productivity relationship reveals that the trade liberalization increases CO_2 emissions (Lau et al. 2014), even taking into consideration that the FDI ensured by multinational companies, through their more efficient and clean energy technology, leads to reduced CO_2 emissions (Paramati et al. 2016). Notwithstanding, financial crises and expensive clean-related technologies costs arise as constraints to achieve carbon mitigation. Therefore, H5 is rejected for Global Group but it is not rejected for EU-15 Group.

The FDI is a key-driver of investment dynamics especially in developed financial systems (Azman-Saini et al. 2010), which allows greater freedom in capital transactions (Agbloyor et al. 2013) and the adoption of diversification strategies by investors (Lizardo and Mollick 2009). Furthermore, the internationalization of these markets contributes to increased FDI, through greater market capitalization (Claessens et al. 2001). Nevertheless, the empirical evidence of this empirical study only depicts a negative relationship between FDI and stock markets in the European context. Such evidence arises from stock markets volatility and uncertainty fostered by subprime and European sovereign debt crises. Therefore, H6 is rejected for both Groups.

In turn, FDI and economic activity evidence no nexus of causality, justified by the great uncertainty in the European and international economic and political situation, which discourages investment (Herzer 2012). This indicates rejection of H7 for both Groups.

The high level of financial and economic integration, as well as existing bilateral relationships, contribute to a more favorable market performance (Tavares 2009) and economic activity (Levine and Zervos 1998). However, during the sample period of the study, the behavior of the financial markets move according to monetary policies implemented by the Fed and European Central Bank, and deficit and debt structural adjustments in European economies. Thus, H8 is rejected for both Groups.

The results obtained from the current study evidence that green tech has a positive relationship with carbon productivity but no significance which may be justified, on the one hand, due to the low prices of energy-related fossil fuel (Samargandi 2017) and, on the other hand, due to the restrictions in patent applications concerning in technological diffusion and high costs associated (Mensah et al. 2018). Hence, H9 is rejected.

Although no hypothesis is formulated, the results show a positive relationship between green tech and aggregate material production in the context of Global Group, which appoints for as it ramps up CO_2 emissions higher probability that a country develops an environmental-related technology (Su and Moaniba 2017).

Despite the Russian crisis (caused by an emerging market) having a significant impact on emerging and developed financial markets (Dungey et al. 2006, 2007, 2010). However, in the present paper, the dummy Crises EM does not identify such evidence. It can be justified by the fact that emerging market crises are derived from exchange rate crises, and, therefore, the significant and positive effect of the Dummy Crises EM with greater evidence

in European countries can be justified through the appreciation of European currencies. In the global context, the effect is irrelevant because the Global Group includes emerging countries where financial crises were onset.

In turn, Dummy Crises DM, in the European context, has a negative and significant impact only on the stock market. This may indicate that there was contagion through the bond market channel (Dungey et al. 2010), which in this case, means sovereign debt and collateralized debt obligations markets. Furthermore, in the global context, it denotes a positive effect on economic activity, technology, and material production, which are associated with the aggressive monetary policies by FED and ECB (Dungey et al. 2006), smoothing the crises effect and contributing to the boost of the respective economies. Thus, it is determined that the crises are not alike, taking into account that the methodology applied in Dungey et al. (2006, 2007, 2010) is not at all similar to that of the present study. However, financial crises do not reveal a negative effect on energy efficiency and environmental degradation, which is contrasting with previous findings of Mimouni and Temimi (2018) and Pacca et al. (2020).

5. Conclusions

5.1. Empirical Findings and Implications

Considering the empirical findings, concerning the Global Group, material production is found to be the predominant factor in the positive determination of the behavior of FDI, economic activity and green tech. In this context, it is underlined that the industrialization process embarked on in recent decades, in emerging economies, has promoted the creation, acquisition and investment of companies in industrial sectors, contributing to global economic growth (positive relationship from aggregate material production to FDI and economic activity). Mergers and acquisitions among the largest listed metal and mineral companies can be connected to the positive effect on markets. In turn, the greater investment in new, cleaner and more efficient energy can be at the origin of increased carbon productivity (positive relationship from aggregate material production to green tech and positive relationship from economic activity to carbon productivity).

Regarding the EU-15 Group, the empirical findings reveal six significant relationships in which a shock from stock markets induces positive effects on aggregate material production and FDI; a shock from economic activity denotes a negative effect on aggregate material production; a shock from aggregate material production affects positively carbon productivity; a shock from FDI impact negatively carbon productivity; and a shock from carbon productivity denotes a positive effect on stock markets behavior. In addition, the stock market is the predominant factor.

It can be concluded that, in the European context, despite the endeavor by agents to reduce fuel energy dependence, the European economy is still based on a fuel energy model. However, there is a slight tendency to change the paradigm of a fuel energy model, which is observed based on negative relationship between economic activity and aggregate materials production, as well as through a positive relationship between aggregate material production and carbon productivity. An important factor of this scenario may be the launch of the European carbon market. Nevertheless, despite robust investment in R and D for achieving energy efficiency or carbon mitigation processes, it seems not to reach the continuous increase in CO_2 emissions (negative FDI and carbon productivity), which leads to the companies' financing moving forward to the green bond market as a driving force for green development and innovation (negative relationship between the stock market and FDI; positive relationship between carbon productivity and stock market) as well as for financing efficiency processes of production, resulting in a positive contagion toward to the stock market (positive relationship between markets and material production).

In short, the findings from the present empirical study verifies that material production is still a key driver of the global economy because production influences both macroeconomic fundamentals and innovation activities. For its turn, in the European economy context, material production only positively influences carbon productivity, which indi-

cates that this economic block seeks to be adopting an economic environmentally-friendly growth model. It should be noted that the dematerialization process is not detected in this study, in a global context, insofar as the economic activity keeps still based on an energy fuel model because fuel prices are considered lower comparing with the renewable energy prices. To ensure the transition into a complete green growth model, it is important to have a developed financial system that leads to strong incentives for green financing and energy efficiency, such as, for example, green, social and sustainable bond markets. No less important, it is worthy to emphasize the importance of emissions trading systems as important instruments to achieve a significant reduction in CO_2 emissions.

Overall, considering the dummy variables, it is concluded that recession in the most relevant economies leads to a mainly negative effect on the variables studied, whereas the short-term Kitchin cycles produce a mostly positive effect on the same variables. Therefore, it is verified that economies are more likely to react negatively to the economic recessions of the largest economies than to financial crises.

5.2. Limitations and Future Research

This study is not without limitations. Firstly, the period of the sample should be extended in future research, in order to increase the still limited knowledge about the global effects of the current pandemic crisis. Added to this is the limited number of countries analyzed, which needs enlarging in future studies. Secondly, there is the limitation of not being able to add other variables proxies of recycling activities and circular economy. This limitation is due to lack of access to available annual data that would allow us to expand this analysis for a larger set of materials.

In order to address the limitations mentioned above, future research could make an analysis to identify the response of the material supply and demand, in various performance regimes, in relation to the behavior of economic-financial variables, including macroeconomic fundamentals and indices of economies' digitalization and sophistication. Finally, it is also important to devote future research efforts to assessing the influence of recycling activities and of the circular economy on the behavior of carbonic productivity, taking into account the different states of economic activity.

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Institutional, Economic, and Socio-Economic Determinants of the Entrepreneurial Activity of Nations

João Leitão [1,2,3,*] and João Capucho [4]

[1] NECE-Research Center in Business Sciences, Faculty of Social and Human Sciences, University of Beira Interior, 6200-001 Covilhã, Portugal
[2] Centre of Management Studies of Instituto Superior Técnico (CEG-IST), University of Lisbon, 1049-001 Lisbon, Portugal
[3] Instituto de Ciências Sociais (ICS), University of Lisbon, 1649-004 Lisboa, Portugal
[4] Faculty of Human and Social Sciences, University of Beira Interior, 6200-209 Covilhã, Portugal; joao.capucho@ubi.pt
* Correspondence: jleitao@ubi.pt; Tel.: +351-275-319-853

Abstract: This empirical study analyses the effects of institutional, economic, and socio-economic determinants on total entrepreneurial activity in the contexts of developed and developing countries. It fills a gap in the literature, regarding the lack of empirical studies about the relationships among entrepreneurial activity, corruption, commercial freedom, economic growth, innovativeness, inward foreign direct investment, unemployment, households, and non-profit institutions serving households (NPISHs)' final consumption expenditure, age dependency ratio, education index, and life expectancy at birth. The empirical application uses annual panel data for the 2003–2018 period, with a total sample of 21 countries, analysed in a two-stage empirical application, including preliminary analysis and a quantile regression model. New empirical evidence is provided, revealing a significantly positive role played by commercial freedom, innovativeness, inward foreign direct investment, households, and NPISHs' final consumption expenditure and education on entrepreneurial activity. Corruption, unemployment, age dependency ratio, and life expectancy at birth have a significantly negative influence on entrepreneurial activity. In terms of implications, greater government control is recommended, in order to foster the quality of nations' institutional environment. Additionally, suggested is the launch of new incentives to stimulate research and development activities aimed at registering international patents with a global impact, sourced from new ventures and transnational collaboration.

Keywords: corruption; economic factors; entrepreneurial activity; institutional theory; socio-economic factors

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1. Introduction

Entrepreneurial activity is an economic and social phenomenon, on a global scale, where entrepreneurs take on various responsibilities and face the risks inherent to creating a new venture, hoping this attitude will make a difference, in some way, and contribute to higher levels of productivity and income. Entrepreneurs' desire, motivation, and passion for autonomy and independence in their new ventures are of major determining importance (GEM 2019/2020). However, the literature still reveals the need for prosecuting additional empirical studies, at the macro level, on the role of the context and quality of the institutional environment in determining entrepreneurial activity (Honig and Karlsson 2013; Smallbone and Welter 2020).

Bearing in mind that entrepreneurship is one of the factors contributing to structural change in countries (Tiberius et al. 2020), it can be a fundamental lever of economic development and growth (Stel et al. 2005; Stam et al. 2009), especially through strengthening the competitive dynamics and innovative capacity of small and medium-sized enterprises (Nunes et al. 2010; Leitão et al. 2011; Baptista and Leitão 2015; Cubico et al. 2018).

In this line of thought, it is hoped that governments will produce measures to combat institutional weaknesses, aiming to stimulate and increase entrepreneurial activity (Albulescu et al. 2016) and raise the quality of their institutions (Riaz et al. 2018).

The literature addressing the relationships between the institutional environment and entrepreneurial activity, deals with the first concept in terms of stability, restrictions, control, and hardness of measures, while the second is approached alluding to change, the increasing of new agents, creativity, and innovation, being highlighted, in this context, the pioneering contributions of the institutional theory, with regard to the determining factors of entrepreneurial activity (Sine and David 2003). In addition, Sine and David (2010) underline that institutional change has positive effects in terms of exploiting new opportunities for the growth of entrepreneurial activity.

Chowdhury et al. (2019) argue that entrepreneurship is essential for the vitality of economies, stressing that institutions are vital both to the quantity and quality of entrepreneurial activity, so countries need to fight corruption, and thereby improve their institutional environments. Following the institutional theory, the observance of high levels of corruption perception interacts with the level of aspirations and motivations of new entrepreneurs. Thus, as core agents of entrepreneurial activity, entrepreneurs need governments that have the capacity for creating favourable environments, which are able to ensure efficient property rights and to prevent corruption (Estrin et al. 2013).

Returning to the inspiring vision of Acs et al. (2018), increased entrepreneurial activity associated with an efficient institutional environment leads to greater economic growth in countries. By ensuring control of corruption, entrepreneurial and innovative activity becomes more attractive (Anokhin and Schulze 2009). In a related vein, Buchanan et al. (2012) confirm that high quality institutions lead to increased entrepreneurial activity, whereas weaker institutions limit the supply of resources available to entrepreneurs.

Consequently, it is especially relevant for countries to promote greater efficiency in economic activity, as this is usually associated with those having stable macroeconomic fundamentals, which in turn can encourage entrepreneurs to exploit new growth opportunities, through the creation of new ventures, implying greater flows of innovation, technology, and knowledge (Castaño et al. 2015).

At present, a common topic concerns low levels of growth and so-called growth traps, which prevents countries from achieving high levels of macroeconomic performance. In addition, the intense competition in global markets affects economic agents and areas of business in a great variety of ways. Then, the adverse effects of successive global crises have caused a slowing down of countries' economic growth and shown the weaknesses of inefficient measures they have adopted (Pradhan et al. 2020).

Supported by institutional theory, Anokhin and Schulze (2009) signal the presence of limitations and the lack of studies on relations between entrepreneurial activity, corruption, and innovation. Here lies one of the main motivations for carrying out this empirical study, i.e., to determine in an innovative way the relations between entrepreneurial activity, corruption, free trade, innovativeness, economic growth, foreign direct investment, and unemployment.

This article focuses on analysing new entrepreneurial activity, considered as one of the pillars of countries' economic development and growth. This matter is also considered very important in order to define countries' new public policies, oriented towards strengthening the competitiveness and innovative capacity of new ventures. Therefore, the relevance and topicality of the subject justify this research into the unexplored institutional, economic, and socio-economic factors determining entrepreneurial activity in developed and developing countries.

This empirical study makes the distinction between institutional, economic, and socio-economic factors, and how they can influence entrepreneurial activity in 21 countries, 16 of which are developed and 5 developing, in the period between 2003 and 2018. Therefore, a selected specification of a quantile regression model was tested, allowing detailed analysis of the different determinant factors, and taking as a reference total distribution of the explained variable regarding the rate of entrepreneurial activity in the different countries.

This type of model was chosen as it is shown to be very efficient in the presence of heterogeneous panels and high values of the asymmetry statistic (i.e., skewness), providing an appropriate adjustment even in the presence of outliers, and a more robust analysis compared to the ordinary least squares (OLS) model.

As for contributions, regarding institutional factors, the evidence obtained here indicates that when countries control their institutions, fighting corruption and expanding free trade, they achieve better performance in entrepreneurial activity, which ratifies the previous evidence found by Anokhin and Schulze (2009). Regarding economic factors, there is confirmation of the expected positive and significant influence of innovativeness, economic growth, and foreign direct investment on entrepreneurial activity. Concerning unemployment, this has non-linear effects on entrepreneurial activity, corroborating the evidence obtained previously by Faria et al. (2009). In relation to the remaining socio-economic determinants, namely, households and NPISHs' final consumption expenditure, education index, and life expectancy at birth, denote positive and significant effects on the entrepreneurial activity. On the contrary, the age dependency ratio has a negative and significant influence.

The study is structured as follows. First, the theoretical framework is presented, dealing with the institutional and socio-economic determinants of countries' entrepreneurial activity and going on to develop the research hypotheses. Secondly, the methodological design is presented, including the period studied, variables, data sources, and descriptive statistics. Thirdly, a two-stage empirical application is carried out: (i) preliminary analysis; and (ii) estimation of the quantile regression model; followed by presentation and discussion of the results, contrasting developed countries and developing countries. The study ends with the conclusions, limitations, and implications.

2. Theoretical Framework and Hypothesis Development

2.1. Institutional Determinants

2.1.1. Corruption

Using institutional theory, North (1990) states it is important for countries not only to pay attention to institutions and institutional relations but also to monitor the conditions of society's evolution regarding levels of social, cultural, and political development. The same author also underlines the power of institutions, both formal (e.g., laws and regulations) and informal (i.e., culture, practices, customs, pressure groups, etc.), exercised on the quality and movement of the business environment.

The role of institutions is strengthened through the implementation of efficient government with political, civil, and human rights, and through greater control of corruption (Castaño et al. 2015). Economies need strong institutions as pillars supporting their competitiveness, in order to generate innovations and thereby achieve economic development and sustainable growth (Riaz et al. 2018).

Corruption is a social and institutional plague of extreme relevance, and it is up to all national governments to try to control and improve performance regarding institutional quality and the perception of corruption. In order to deepen knowledge of corruption, different aspects should be considered, at the cultural, economic, and political level, and countries' history (Tavares 2004). Corruption in countries is usually associated with abuse of power, in positions of public authority, for private benefits (Rodriguez et al. 2006; Anokhin and Schulze 2009).

Entrepreneurial activity is affected by different institutions: social, political, and economic, but there has been limited study of the institutional environment and the impacts of entrepreneurial activity (Bylund and McCaffrey 2017).

There are two perspectives according to which corruption can have effects of entrepreneurial activity. The first, proposed by Dreher and Gassebner (2013), indicates that corruption can sometimes facilitate entrepreneurial activity and countries' economic growth. The second indicates the contrary, i.e., that corruption harms certain countries'

entrepreneurial activity and economic growth (Glaeser and Saks 2006; Anokhin and Schulze 2009; Albulescu et al. 2016; Ojeka et al. 2019).

Anokhin and Schulze (2009) conclude that the level of corruption influences entrepreneurial activity and innovation in all 64 countries studied. The empirical evidence found by the same authors reveals a negative effect of corruption on entrepreneurial activity and innovation. In stylized terms, corruption restrains the entrepreneurial activity and innovation. Accordingly, the nations that are able to implement more effective measures to combat corruption present greater opportunities to create and exploit more innovative ideas through creating new ventures, aiming to originate unique, efficient, and competitive opportunities.

Entrepreneurship shows more robust results in countries where the institutional environment is more efficient, also presenting better results in relation to the corruption phenomenon (Simón-Moya et al. 2014). As for entrepreneurs, they can introduce new technology and innovations in their production processes to improve their efficiency, as long as the institutional environment they are part of is competent and has the most appropriate government measures. An increased rate of entrepreneurial activity combined with an efficient institutional environment leads to countries increased economic growth (Acs et al. 2018). So high quality institutions increase entrepreneurial activity while weaker institutions reduce the supply of resources available to entrepreneurs (Buchanan et al. 2012).

In order to capture institutional connections and assess the hypothetical effects on entrepreneurial activity, this study will use as an explanatory variable the perception of corruption index, which is considered one of the important institutional variables in explaining entrepreneurial activity. The index has been produced annually since 1995, by Transparency International, with a methodological change in 2012 aiming to make it more robust. This index is comparable, considering the period of time envisaged, and has been subject to analysis in different studies of reference (Anokhin and Schulze 2009; Budsaratragoon and Jitmaneeroj 2020; Erum and Hussain 2019; Ojeka et al. 2019). From the above, the first research hypothesis arises:

Hypothesis 1 (H1). *Corruption has a negative and significant effect on entrepreneurial activity.*

2.1.2. Free Trade

In this study, free trade was included in the institutional approach, despite having adjoining characteristics of a commercial, political, and socio-economic nature. Considering the main focus of the study, i.e., the institutional and socio-economic determinants of entrepreneurial activity, governments are expected to tackle the need to produce norms to combat institutional weaknesses, aiming to ensure improved levels of free trade and thereby encourage increased entrepreneurial activity through strengthening the flows of international trade (Simón-Moya et al. 2014; Albulescu et al. 2016).

The most developed countries usually have strong mechanisms, based on efficient institutions, aiming to ensure greater freedom in international trade, allowing them to reach higher levels of entrepreneurial activity. In turn, effective legislation regarding the creation of new business and high levels of protection of intellectual property rights contributes positively to increased entrepreneurial activity (Simón-Moya et al. 2014).

Summarizing, free trade is associated with eliminating tariff and institutional barriers that can influence relations of economic diplomacy and international trade, involving two-directional flows of exports and imports of goods and services, which can intensify entrepreneurial activity. This leads to the second research hypothesis:

Hypothesis 2 (H2). *Free trade has a positive and significant effect on entrepreneurial activity.*

2.2. Economic Determinants

2.2.1. Innovativeness

Entrepreneurs have a fundamental role in economies, by introducing new knowledge and innovations that favour improved quality and market efficiency (Salman 2016). Innovation is taken to be an idea followed up and subsequently presented and introduced to markets (Shah et al. 2014). Alluding to the pioneering work of Schumpeter (1934), the same authors propose the existence of five types of innovation, namely: (i) introducing new products or services; (ii) improving those products or services; (iii) extending products or services to new markets; (iv) innovation through new machinery to produce those goods or services; and (v) introducing new business models to help both national and international trade. However, in the global economy, it is technological innovations that are focused on more intensely and given greatest prominence (Solow 1956).

Innovativeness is very relevant for all countries in that it lets them attain competitive advantages to compete globally. Therefore, innovation consists of making goods and services more competitive and efficient, allowing introduction in various markets, which is especially important in spreading new knowledge and technology (Galindo and Méndez 2014). Entrepreneurship and innovation are considered important phenomena to ensure countries' sustainable economic growth, through stimulating employment, quality of life, the number of innovations, and entrepreneurial activity (Baumol 2014; Rusu and Dornean 2019; Pradhan et al. 2020).

Stel et al. (2005) show the continuity of less innovative companies in developing countries, whereas the tendency to innovate is greater in firms in developed countries, due to the business sector's growth also being greater in these countries.

Adopting a Neo-Schumpeterian vision, society in different countries has a fundamental role in the evolutionary adjustment of good social, cultural, economic, and institutional climates, which enable the conception of innovations and new business initiatives (cf. Schumpeter 1934).

Concerning countries' innovativeness, the total number of patent applications is generally used to measure the level of economies' innovation and macroeconomic performance (Riaz et al. 2018). This indicator is also used to evaluate countries' innovation intensity, and for that reason, will be used in this study to measure the effects of innovation on entrepreneurial activities in 21 countries.

Countries must evolve and invest in policies that promote research and development, as this produces favourable conditions to originate and absorb more and better innovations, both now and in the future. It is important for those policies to include operational measures that allow the rapid spread of innovations, as the faster innovations are created, the greater the potential to generate countries' entrepreneurial activity and economic growth (Pradhan et al. 2020).

In an empirical study using panel data for countries with great innovative capacity, Salman (2016) shows that policies to help entrepreneurs produce positive effects on economic development and growth, essentially through raising the quality of education, subsidies for research and development (R&D) activities, appropriate tax policies, and stability in monetary policy.

Economic growth refers to increasing the level of economic activity based on the production and consumption of goods and services in a given country, over several years, with long-term economic growth being calculated through the rate of technological progress, considered as an amount determined exogenously (Solow 1956).

When efficient, economic activity in countries corresponds to a stable macroeconomic environment, and so entrepreneurs make the most of opportunities to create business, increasing the flows and quality of innovations, technology, and new knowledge, for better exploitation of growth opportunities (Castaño et al. 2015; Acs et al. 2018).

Various studies in the empirical literature of reference converge in concluding that new knowledge, new technology, and innovations lead to increased entrepreneurial activity and naturally to increased economic growth (Schumpeter 1934; Audretsch and Feldman 1996;

Romer 1997; Turró et al. 2014; Castaño et al. 2015; Acs et al. 2018). Therefore, the third research hypothesis is formulated:

Hypothesis 3 (H3). *Innovativeness has a positive and significant effect on entrepreneurial activity.*

2.2.2. Foreign Direct Investment

Foreign direct investment (FDI) is one of the relevant determinant factors for countries being able to increase entrepreneurial activity, and this is affected by a wide range of variables of both an institutional or commercial, and economic and social nature. Economic analysis of FDI flows implies incorporating variables that may be correlated with entrepreneurial activity (Eren et al. 2019).

In this connection, it should be pointed out that corruption can hinder FDI and increase the costs of employees integrated in the country's government, which together can restrict economic growth, innovative and business capacity, the capacity to collect tax income and actions to regulate and implement public policies (Ojeka et al. 2019). Consequently, in this line of thought, it is argued that countries must focus on improving the quality of institutions and reducing the perception of corruption, in order to increase the attractiveness of the economy as a destination for FDI.

For Herrera-Echeverri et al. (2014), it is also relevant to ensure the design of public policies destined to attract inward FDI. This investment is seen as activating new firm creation and an efficient mechanism of technology transfer (Alfaro et al. 2009) or a technological driver of entrepreneurial activity (Leitão and Baptista 2009; Leitão and Baptista 2011).

Therefore, FDI should be stimulated in order to serve as an activator of entrepreneurial activity and other economic activities, expecting a positive association between this type of investment and firms and countries' economic activity (Teixeira and Heyuan 2012). This investment is also considered as a factor stimulating new technology and innovations (Alfaro et al. 2009). Furthermore, FDI can serve as a driver of technological progress in developing countries (Anokhin and Schulze 2009).

Barbosa and Eiriz (2009) claim that inward FDI causes positive impacts on entrepreneurial activity, but only in the short term, applying this to Portugal. Other authors argue that the impacts of this type of investment on countries and companies are positive but of very little significance (Aitken and Harrison 1999; Konings 2001). However, Eren et al. (2019) found the opposite, revealing that inward FDI has a negative impact on new business creation in the period 1996–2008, in the context of the USA. Barbosa and Eiriz (2009) demonstrated that inward FDI in Portugal discourages increased entrepreneurial activity in the long term, a finding corroborated by Leitão and Baptista (2011), in a comparative study of Portugal and Finland, regarding analysis of technological drivers of entrepreneurial activity in these European countries. This leads to the fourth research hypothesis:

Hypothesis 4 (H4). *Inward FDI has a positive and significant effect on entrepreneurial activity.*

2.3. Socio-Economic Determinants

2.3.1. Unemployment

Studying the impacts of unemployment on entrepreneurial activity is relevant for this research, in that it can be addressed as an activator of the option for self-employment, with the expectation that it can stimulate entrepreneurial activity, despite the risks and uncertainties associated with following this option as a mechanism of job creation (Faria et al. 2009).

Audretsch and Fritscht (1994) analyzed the relation between unemployment and entrepreneurial activity, concluding that unemployment has a negative effect on new firm creation. Other authors conclude precisely the opposite, that unemployment has a positive impact (Evans and Leighton 1990; Cumming et al. 2014). Therefore, the theoretical and empirical literature shows a lack of agreement on the sign of this relation.

Audretsch and Thurik (2000) found that entrepreneurship has negative effects on the unemployment rate. In a study applied to the USA, Beynon et al. (2019) found that less developed states have higher levels of entrepreneurial activity, above all due to the lack of competition in some markets, causing an exponential growth in the number of entrepreneurs, which ultimately favours economic growth in these states.

Faria et al. (2009) concluded that unemployment and entrepreneurial activity show non-linear effects, being a very dynamic phenomenon, which contrasts with the pioneering result obtained by Audretsch and Fritscht (1994), who indicated a negative relation between unemployment and new business creation.

Castaño et al. (2016) highlighted the importance of public policies in countries, focusing on increased rates of economic growth and the creation of economic activities, in order to reduce unemployment and stimulate the population's well-being. Nevertheless, it should be noted that the rate of entrepreneurial activity is significantly higher in countries with more unstable unemployment rates, and where there are greater discrepancies in income and lower levels of development (Simón-Moya et al. 2014). Therefore, the fifth hypothesis is as follows:

Hypothesis 5 (H5). *Unemployment has a negative and significant effect on entrepreneurial activity*.

2.3.2. Age

The ageing of the population in developed countries stems from increases in average life expectancy and decreased fertility rates. One way to combat the inversion of the base of the age pyramid is through the adoption of (pro)active aging policies, which advocate raising the retirement age, promoting senior entrepreneurship, and involving the elderly in social, economic, cultural, religious, spiritual, civic actions, among others (Jackson 2000; Kurek and Rachwal 2011).

The latest trends point to the increase in average life expectancy, as well as the overlap of the dependency ratio of the elderly relative to the ratio of young people's dependency, which puts pressure on national governments to design new reform financing solutions and to consider new ways of integrating the older population into the labor market (Bohlmann et al. 2017; Guimarães and Tiryaki 2020).

The need to promote new forms of senior entrepreneurship should be addressed through the creation of specially designed programs, aiming to ensure that the older population can succeed in exploiting new business opportunities, taking advantage of the experience, career path, and relational capital of seniors (Kinsella and Phillips 2005).

For its turn, the aging of the population also creates the need to develop innovative ideas and entrepreneurial initiatives with regard to the commercialization of goods and services to support this growing segment of the population (Kurek and Rachwal 2011).

Lévesque and Minniti (2006) highlight the existence of a negative relationship between age and entrepreneurial activity, stating that the higher the population's life expectancy and the discrepancy in relation to the age dependency ratio, the lower will be the level of entrepreneurial activity.

Thus, the following sixth hypothesis is considered:

Hypothesis 6 (H6). *The age dependency ratio has a negative and significant effect on entrepreneurial activity*.

2.3.3. Households Consumption

Households and NPISHs' final consumption expenditure (% of GDP) brings together the final consumption of households and expresses the value added of goods and services acquired by national families, both nationally and abroad. This variable is one of the plots that most influences GDP behaviour, about 60% (OECD 2020), therefore, it is considered as a fundamental indicator of a robust economic analysis.

The consumption of goods and services, income and wealth of households are framed as vital elements of the economic well-being of the populations, and it is essential for countries to measure and control these three indicators in order to achieve a state of equilibrium and an optimal point (OECD 2013).

The variable used to measure the final consumption of expenses made by households and NPISHs' final consumption basically corresponds to the consumption associated with the meeting of daily needs, such as food, clothing, housing, energy, transport, automobiles, machinery, health and leisure expenses, among other goods and services (OECD 2020). This consumption variable allows for an interesting analogy, based on the measurement of well-being in relative terms of different countries, so we can analyse and compare the expenditure of final consumption between the different countries.

As far as developing countries, such as South Africa, which is included in this sample taken from WESP (2014), positive developments in structural levels of household income patterns have very significant impacts on their economies, all because a substantial part of the population has reached the level of average incomes, through increased purchasing power and consumer spending (Ligthelm 2010). However, there is a peculiar problem with this group of countries, which relates to the difficulties in measuring much of their economic activity (Aparicio et al. 2021).

Nandamuri and Gowthami (2013) investigate the influence of sociodemographic factors on entrepreneurial activity, concluding that household income has a huge impact on the ability to create new businesses. Therefore, it is expected that increasing household incomes will stimulate consumption and be the source of more entrepreneurial activities in different nations.

From the previous, it results in the seventh hypothesis:

Hypothesis 7 (H7). *Households and NPISHs' final consumption expenditure has a positive and significant effect on entrepreneurial activity*.

2.3.4. Education

Following the view expressed by Boubker et al. (2021), entrepreneurship education takes a key role in the development and creation of new businesses, therefore, it is mainly suggested that universities strengthen and create a more entrepreneurial culture, providing students with training on this theme, in order to amplify the entrepreneurial intentions of the younger community.

Students in developing countries require a structural change in education programmes, which provide the creation of teaching and learning mechanisms tailored to an entrepreneurial culture, in order to strengthen entrepreneurial intent and thus improve students' perception skills in the business sector (Hadi et al. 2015).

Acs et al. (2014) stress that each country has its mechanisms and regulations regarding institutions, so the level of education, the will and motivation of entrepreneurs, take a key role in promoting new entrepreneurial initiatives.

It is vital both for the improvement of education activities and for the increase of entrepreneurial activity, for students to participate in business and trade activities, to acquire new competences and skills (Hadi et al. 2015).

Education is fundamental for entrepreneurial activity, assuming a lever role of regional development, and education is expected to have positive and significant effects on entrepreneurial activity (Galvão et al. 2018).

Thus, from the statements presented above, the eighth research hypothesis is considered:

Hypothesis 8 (H8). *The education index has a positive and significant effect on entrepreneurial activity*.

2.3.5. Life

The ageing of the population is a common denominator for most countries, particularly developed countries. This, combined with the trend of increasing average life expectancy,

and the overlap of the dependency ratio of the elderly in relation to the dependency ratio of young people, makes room for a new generation of public policies promoting the (pro)active integration of the older population into the labour market (Bohlmann et al. 2017; Guimarães and Tiryaki 2020).

In developed countries, there has been an increase in the longevity of the population and a decrease in the infant mortality rate, which is justified by the sharp increase in health expenses (Jaba et al. 2014). Gains related to life expectancy at birth can be justified by several factors, such as access to health services, education, and healthier lifestyles (OECD 2019).

The increase in average life expectancy can also have negative impacts, on the sustainability of public budgets, from the point of view of increasing public spending on health and social security. In turn, entrepreneurs as they age become more risk-averse, and one of the direct consequences is reduced investment volatility and decreased consumption (Aiyar et al. 2016; Guimarães and Tiryaki 2020).

According to the previous, the ninth research hypothesis is formulated:

Hypothesis 9 (H9). *The life expectancy at birth has a negative and significant effect on entrepreneurial activity.*

3. Methodological Design

3.1. Period of Study, Data Sources, and Variables

The period of analysis is between 2003 and 2018, i.e., 16 years. This period was chosen based on data availability for the sample of countries studied (cf. Table 1), which are divided according to the criteria in the report drawn up by the United Nations: World Economic Situation and Prospects (WESP 2014).

Table 1. Distribution of countries according to WESP criteria.

Developed Countries	Developing Countries
Germany	South Africa
Croatia	Argentina
Slovenia	Brazil
Spain	China
United States of America	Mexico
Finland	
France	
Greece	
Hungary	
Ireland	
Italy	
Japan	
Norway	
Netherlands	
United Kingdom	
Sweden	

Source: Own elaboration.

The countries were chosen according to the availability of data, and later divided following the criteria of the World Economic Situation and Prospects (WESP), which employs a wide range of trends in various dimensions of the global economy, being prepared by the Development Policy and Analysis Division (DPAD) of the Department of Economic and Social Affairs of the United Nations Secretariat (UN/DESA) (WESP 2014).

In analytical terms, the World Economic Situation and Prospects (WESP) categorizes countries by the following groups: developed economies; economies in transition; and developing economies, however, from the availability of data, the countries that were chosen for this empirical study fall into the categories of developed economies, and developing economies (WESP 2014).

The largest differences between groups of countries with developed economies, and countries with developing economies, are due to disparities in the percentages of exports and imports of fuel; gross domestic income (countries divided into high income; high middle income; low middle income; and low income (countries under $1035 are considered low-income countries; between $1036 and $4085 are considered countries with low average incomes; between $4086 and $12,615 are countries with high average incomes; and finally countries with incomes higher than $12,615 are high-income countries.

The Crisis Dummy represents the global financial crisis of 2008–2009. This global crisis began with the housing market's bubble, created by an overwhelming load of mortgage-backed securities that bundled high-risk loans. This recessive crisis implied a global economic downturn that negatively impacted world financial markets, as well as the banking and real estate industries. The crisis rapidly spread into a global economic shock, resulting in several bank failures. Economies worldwide slowed during this period since credit tightened and international trade declined. Housing markets deteriorated and unemployment raised. In short, the Crisis Dummy was created for capturing the effects caused by the global economic and financial crisis of 2008–2009. It assumes a value of 1 in the years 2008 and 2009, and a value of 0 for the remaining years 2003 to 2018.

Table 2 describes the variables considered in this study: dependent and independent; to analyse the factors determining countries' entrepreneurial activity; organized in four categories: institutional; economic; socio-economic; and dummies; with the description and the corresponding source. The variables were obtained from the following international data sources: Global Entrepreneurship Monitor (GEM); Transparency International; Heritage Database; WIPO Statistics Database; World Development Indicators; Human Development Data Center; and Unctadstat. The countries and period studied were limited to the availability of data for the variables chosen to measure both institutional, economic, and socio-economic factors.

Table 2. Variables: description and sources.

Variables	Determinants	Description	Data Sources
TEA		Rate of entrepreneurial activity in the initial state.	Global Entrepreneurship Monitor
CPI	Institutional	Corruption perceptions index.	Transparency International
FT		A measure formed by the absence of tariff and non-tariff barriers that affect the import and export of goods and services.	Heritage Database
PATPC_LAG1	Economic	Lagged ratio of total number of patents (direct entries and national PCT) to gross domestic product per capita constant lcu.	WIPO Statistics Database and World Development Indicators
INFDI		Stock of foreign direct investment entries as % of GDP.	Unctadstat
UNEM	Socio-economic	Total unemployment as a % of the total workforce.	World Development Indicators
AGE		People younger than 15 or older than 64 that are dependent of to the working-age population. Proportion of dependents per 100 working-age population.	World Development Indicators
HOUSEHOLD		Households and NPISHs' final consumption expenditure (% of GDP)	World Development Indicators
EDUCATION		Education index is an average of mean years of schooling (of adults) and expected years of schooling (of children), both expressed as an index obtained by scaling with the corresponding maxima.	Human Development Data Center
LIFE		Number of years a new-born infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life.	Human Development Data Center
DCRISIS	Dummies	Crisis dummy.	Own elaboration
DDEVEL		Development dummy.	Own elaboration

Source: Own elaboration.

TEA is the dependent variable in this study and represents the rate of entrepreneurial activity in the initial state, expressed by the percentage of the population between 18 and 64 who are latent entrepreneurs and those who intend to start a business within three years, excluding individuals who are already involved in any stage of entrepreneurial activity (GEM 2019/2020). The remaining variables are considered independent, except for the last two, which are used as control variables. Subsequently, 3 more variables of interest are used: DTEA (lagged dependent variable); CPI2 (squared CPI variable); and CPI3 (cubic CPI variable); tested at the second stage of the empirical application.

3.2. Descriptive Statistics

In a preliminary assessment of the nature of the data used in this empirical application, some consideration is given to the descriptive statistics of the variables studied. These do not show great variability, except for the variable representing countries' innovativeness (PATPC), which is due to analysing a very heterogeneous panel of countries with different capacities for innovation and the creation of national wealth expressed by the real GDP.

Table 3 below presents the descriptive variables studied, namely total observations, mean, coefficient of variation, minimum, maximum, and the results of the Jarque–Bera test and asymmetry and kurtosis statistics.

Table 3. Descriptive Statistics.

Variables	Descriptive Statistics							
	Obs	**Mean**	**Coefficient of Variation**	**Min.**	**Max.**	**Jarque-Bera**	**Skewness**	**Kurtosis**
TEA	336	0.0793	0.51198	0.0148	0.2401	122.933	1.2991	4.425
DTEA	315	0.00104	20	−0.1138	0.0964	708.403	−0.8562	10.1443
CPI	336	0.6175	0.329879	0.25	0.97	28.0846	−0.0681	1.5902
FT	336	0.8133	0.094012	0.506	0.894	183.135	−1.499	5.0232
PATPC_LAG1	315	1.3844	2.278677	0.003028	23.67596	7273.265	4.2321	24.9661
INFDI	336	0.40798	0.981813	0.02014	3.05778	3953.74	3.4576	18.3164
UNEM	336	0.08957	0.660936	0.02445	0.32456	319.187	1.8461	6.0276
AGE	336	0.5121	0.103476	0.364897	0.674291	18.90305	−0.386124	3.918622
HOUSEHOLD	336	0.5568	0.161422	0.310226	0.707723	18.8731	−0.565471	2.601351
EDUCATION	336	0.8073	0.120401	0.522	0.943	35.51182	−0.817561	2.81013
LIFE	336	78.1863	0.068162	53.4	84.5	1149.202	−2.551263	10.8463
CPI2	336	0.42269	0.593106	0.0625	0.9409	27.0296	0.2239	1.6846
CPI3	336	0.31152	0.79706	0.0156	0.91267	28.15	0.5034	2.0014
DCRISIS	336	0.125	2.64968	0	1	426.286	2.2678	6.1428
DDEVEL	336	0.7619	0.55985	0	1	88.0272	−1.2298	2.5125

Source: Own elaboration.

Regarding the values of the coefficient of variation (VC), the variables: DTEA; PATPC_LAG1; and DCRISIS, denote a higher VC, comparing with the remaining one.

The Jarque–Bera test was performed, to determine normality and combine the study of kurtosis with asymmetry. Observation of the results obtained reveals that the variables do not follow normal distribution. In addition, the skewness statistic was calculated, to determine the asymmetry of distribution. In this test, mostly positive values were obtained, so the distribution is single tailed to the right, as the curve on the right is seen to be greater than the curve on the left, showing positive asymmetry. This coefficient allows a comparison to be made between the distribution of the sample and normal distribution, and the greater the value of this coefficient, the greater the distance of the sample distribution from normal distribution.

Calculation of the kurtosis statistic can determine possible excess of kurtosis, i.e., the existence, or not, of outliers. Three possibilities are assessed: (i) leptokurtic variables (values above 3); (ii) platykurtic variables (values under 3); and (iii) mesokurtic variables (i.e., excess kurtosis equal to zero). Consequently, the test allows measurement of the peaks of the series' distributions, confirming that the majority of variables are leptokurtic.

The asymmetry values (skewness) show in some cases a certain bias of the probability distribution of a random variable on its mean, above all when having values above 1 or even less than −1. In turn, kurtosis informs about the height and clarity of the central peak of the distribution, in relation to a standard sine curve, confirmed here by the concentration of values above 4.2321.

4. Empirical Application

The empirical application is in two phases, i.e., the first makes a preliminary analysis of the data, based on the results of calculating the correlation coefficients, variance inflation factors (VIF), unit root tests, specification tests, tests of specific behaviour of the distribution of data, and tests of normality of distribution; aiming to confirm the choice of the most suitable regression model and ensure the likelihood of results. The second phase arises from selection of a quantile regression model, which can cope appropriately with a panel of heterogeneous data, as well as testing hypothetical non-linear effects of the institutional and socio-economic determinants throughout the distribution of the explained variable, i.e., countries' entrepreneurial activity.

4.1. First Stage: Preliminary Analysis

Table 4 presents the correlation coefficient matrix, which allows some preliminary considerations about the variables studied regarding signs, intensities, and statistical significance of the correlations, by pairs of variables. Considering the correlation coefficients, it is possible to observe that all are equal or lower than 0.7720, regarding the EDUCATION and CPI pair, signalling a positive association between education index and the perception of corruption. Thirty-seven statistically significant coefficients are detected, by pairs of variables studied, but there are no signs of potential problems of multicollinearity as they present absolute values under 0.80.

Table 4. Correlation coefficient matrix.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.TEA	1.0000										
2.CPI	−0.4775 *** (0.0000)	1.0000									
3.FT	−0.4668 *** (0.0000)	0.5991 *** (0.000)	1.0000								
4.PATPC_LAG1	0.2257 *** (0.0001)	−0.0464 (0.4118)	−0.1314 ** (0.0197)	1.0000							
5.INFDI	0.0116 (0.8381)	0.2713 *** (0.0000)	0.3125 *** (0.0000)	−01878 *** (0.0008)	1.0000						
6.AGE	−0.2821 *** (0.0000)	0.1968 *** (0.0004)	0.1759 *** (0.0017)	−0.3948 *** (0.0000)	0.0082 (0.8844)	1.0000					
7.HOUSEHOLD	0.0654 (0.2474)	−0.3976 *** (0.0000)	−0.1331 ** (0.0181)	−0.2283 *** (0.0000)	−0.4188 *** (0.0000)	0.3396 *** (0.0000)	1.0000				
8.EDUCATION	−0.4260 *** (0.0000)	0.7720 *** (0.0000)	0.6825 *** (0.0000)	−0.1497 *** (0.0078)	0.3024 *** (0.0000)	0.3232 *** (0.0000)	−0.1544 *** (0.0060)	1.0000			
9.LIFE	−0.3237 *** (0.0000)	0.5017 *** (0.0000)	0.5211 *** (0.0000)	−0.0069 (0.9031)	0.0758 (0.1796)	0.1858 *** (0.0009)	−0.1873 *** (0.0029)	0.5708 *** (0.0000)	1.0000		
10.UNEM	−0.1230 ** (0.0290)	−0.2981 *** (0.0000)	−0.0772 (0.1714)	−0.2120 *** (0.0001)	0.0152 (0.7878)	0.0677 (0.2310)	0.3210 *** (0.0000)	−0.1888 *** (0.0008)	−0.4707 *** (0.0000)	1.0000	
11.DTEA	0.2167 *** (0.0001)	0.0453 (0.4225)	0.0560 (0.3214)	−0.0492 (0.3843)	0.0483 (0.3928)	−0.0192 (0.7339)	−0.0231 (0.6835)	0.0131 (0.8164)	−0.0114 (0.8400)	0.0010 (0.9852)	1.0000

Legend: *** 1% significance; ** 5% significance. All the variables are presented in levels, except for DTEA, which is presented in first differences. Source: Own elaboration.

Table 5 presents the results of the test of the variance inflation factor (VIF), aiming to determine the hypothetical presence of multicollinearity among variables.

Table 5. VIF test.

Dependent Variable—TEA Variables	Variance Inflation Factor (VIF)		
	VIF	**1/VIF**	**Mean of VIF**
DTEA	1.01	0.987490	
CPI	3.38	0.296039	
FT	2.23	0.447789	
PATPC_LAG1	1.33	0.751282	
INFDI	1.56	0.640276	
UNEM	1.56	0.640261	
AGE	1.54	0.650561	
HOUSEHOLD	2.09	0.479042	
EDUCATION	3.68	0.271929	
LIFE	2.09	0.447789	
			2.05

Source: Own elaboration.

Considering the recommendation of Asteriou and Hall (2011), observation of the results presented in Table 5 above allows the conclusion that the variables do not show the presence of multicollinearity, as almost all the VIF values are around 2.

Table 6 presents the results of the unit root tests, which inform about the stationarity of the variables studied. The tests performed are: Levin, Lin, and Chu (LLC), which is usually effective for panel data (Levin et al. 2002); Im, Pesaran, and Shin (IPS) common for heterogeneous and dynamic panels (Im et al. 2003); and Phillips and Perron (PP), which serves as a supplement for greater robustness, the aim here being to detect the presence of unit roots in the time series studied and admitting the possibility of the distribution being heterogeneous (Phillips and Perron 1988; Maddala and Wu 1999). The results indicate that almost all the variables are stationary, at their normal level and in first differences of TEA (DTEA).

Table 6. Unit root tests.

Variables	Tests		
	LLC	**IPS**	**PP**
TEA	−3.3110 ***	−1.476 *	8.0564 ***
DTEA	−11.6089 ***	−10.8180 ***	59.7210 ***
CPI	−3.5521 ***	−1.1299	0.8833
FT	−21.9236 ***	−11.5725 ***	6.7935 ***
PATPC_LAG1	−2.8430 ***	0.4492	3.9858 ***
INFDI	−2.3083 ***	0.4278	3.4800 ***
UNEM	−4.5969 ***	−2.6966 **	0.6624
AGE	−4.1563 ***	1.3029	12.76 ***
HOUSEHOLD	−3.1904 ***	−0.3588	−0.2789
EDUCATION	−5.8857 ***	0.0684	5.4550 ***
LIFE	−10.8124 ***	−4.6781 ***	19.9759 ***

Legend: LLC—Levin, Lin, and Chu unit root test (Levin et al. 2002); IPS—Im, Pesaran, and Shin unit root test (Im et al. 2003); PP—Phillips and Perron unit root test (Phillips and Perron 1988). *** 1% significance; ** 5% significance; and * 10% significance. All the variables are presented in levels, except for DTEA, which is presented in first differences. Source: Own elaboration.

The null hypotheses (*H0*) and the alternative hypotheses (*Ha*) are the following. In the LLC test, *H0*—the panel has unit roots and *Ha*—the panel is stationary. In the IPS test, *H0*—all the panels have unit roots, and *Ha*—some panels are stationary. As for the last one, the PP test, *H0*—all the panels have unit roots, and *Ha*—only the last panel is stationary.

For the LLC test, H0 is rejected for all the variables, this means that all the variables are stationary. In the IPS test, H0 is rejected for the variables of TEA, DTEA, FT, UNEM,

and LIFE so these are stationary and do not have unit roots. Regarding the other variables, CPI, PATPC_LAG1, INFDI, AGE, HOUSEHOLD, and EDUCATION are found not to be stationary and present unit roots. In the last unit root test (PP), the majority of variables do not show unit roots and, therefore, the last panel is stationary. Only UNEM, HOUSEHOLD, and CPI have unit roots.

Table 7 presents the results of some specification tests suitable for the data panel. Considering the significances detected for the different statistics, at a 1% level, the consistency of that panel is confirmed.

Table 7. Specification tests.

Tests	Statistics
Hausman Test	Chi2(11) = 34.77 ***
Modified Wald Test	Chi2(21) = 8972.23 ***
Wooldridge Test	F(1,20) = 74.200 ***
Pesaran's Test	46.57 ***
Breusch–Pagan/Cook–Weisberg Test	Chi2(1) = 59.76 ***

Legend: *** 1% significance. Source: Own elaboration.

Concerning the Hausman test, the null hypothesis (H_0) corresponds to the data panel being better adjusted with random effects, and so H_0, is rejected for a 1% level of significance. It is concluded that the data panel is better adjusted with a fixed effects model, although the fixed effects (FE) and random effects (RE) models will be tested, in order to determine first, the signs and significance level of the explanatory variables of the dependent variable, i.e., entrepreneurial activity (Hausman 1978).

Next, the modified Wald test is performed, as is usual for fixed effects panels, concluding that this data panel presents heteroscedasticity (Goh and King 1996). This result agrees with the empirical literature of reference, which proposes that the quantile regression model admits the presence of heteroscedasticity and outliers (Koenker and Bassett 1978; Koenker and Machado 1999; Koenker and Hallock 2001).

Regarding the Wooldridge test, this was performed to determine the existence of first order autocorrelation, and as H0 is rejected, it is concluded that there is first order correlation in the data panel (Wooldridge 2002).

In determining the existence of the phenomenon of cross sectional dependence, the Pesaran test was performed, as is common in panels with fixed effects, concluding on the existence of cross sectional dependence (Pesaran 2004; Hoyos and Sarafidis 2006).

Another appropriate test for this model, presenting robust results in relation to the phenomenon of heteroscedasticity, is the Breusch–Pagan/Cook–Weisberg test, which as proposed in the corresponding H0, can test for the presence of homoscedasticity (Breusch and Pagan 1980).

Table 8 below presents the results of the test of the specific behaviour of the data distribution, using the Shapiro–Wilk W test (Shapiro and Wilk 1965; Shapiro and Wilk 1968).

According to the results shown in Table 8, all the variables are seen to differ significantly from normal distribution, i.e., data distribution follows a non-normal/non-linear distribution (Shapiro and Wilk 1968).

The test of normality was also performed, i.e., the skewness/kurtosis test (cf. Table 9), in order to determine the effects of normality on a data panel (Bai and Ng 2005) and assess the asymmetry of residuals' normality.

The results of the test of asymmetry of residuals' normality allow the conclusion that the variables have a non-linear distribution, i.e., the distribution of their values does not follow normality (Bai and Ng 2005).

Table 8. Shapiro–Wilk W test.

Variables	OBS	W	V	Z	Prob.> Z
TEA	336	0.88658	26.723	7.754	0.00000
DTEA	315	0.90333	21.507	7.219	0.00000
CPI	336	0.93009	16.471	6.612	0.00000
CPI2	336	0.92226	18.317	6.863	0.00000
CPI3	336	0.90238	23.001	7.400	0.00000
FT	336	0.82514	41.199	8.776	0.00000
PATPC_LAG1	315	0.47466	116.874	11.202	0.00000
INFDI	336	0.65474	81.348	10.381	0.00000
UNEM	336	0.78184	51.402	9.298	0.00000
AGE	336	0.97545	5.784	4.142	0.00002
HOUSEHOLD	336	0.96072	9.256	5.252	0.00000
EDUCATION	336	0.92455	17.777	6.792	0.00000
LIFE	336	0.73162	63.235	9.787	0.00000
DCRISIS	336	0.96230	8.883	5.155	0.00000
DDEVEL	336	0.99026	2.295	1.960	0.02499

Source: Own elaboration.

Table 9. Skewness/kurtosis test.

Variables	OBS	Pr(Skewness)	Pr(Kurtosis)	Adjchi2(2)	Prob > Chi^2
TEA	336	0.0000	0.0003	56.91	0.0000
DTEA	315	0.0000	0.0000	65.01	0.0000
CPI	336	0.6034	0.0000	.	.
CPI2	336	0.0907	0.0000	.	0.0000
CPI3	336	0.0003	0.0000	58.29	0.0000
FT	336	0.0000	0.0000	70.70	0.0000
PATPC_LAG1	315	0.0000	0.0000	.	0.0000
INFDI	336	0.0000	0.0000	.	0.0000
UNEM	336	0.0000	0.0000	.	0.0000
AGE	336	0.0122	0.0125	11.17	0.0038
HOUSEHOLD	336	0.0001	0.6588	15.99	0.0003
EDUCATION	336	0.0000	0.0000	25.00	0.0000
LIFE	336	0.0000	0.0000	.	0.0000
DCRISIS	336	0.0000	0.0000	.	0.0000
DDEVEL	336	0.0000	0.0231	48.05	0.0000

Source: Own elaboration.

4.2. Second Stage: Quantile Regression Model

4.2.1. Method

Koenker and Bassett (1978) were pioneers in presenting the quantile regression model, a method that can analyze the different effects independent variables can cause on the dependent variable's conditional distribution. Subsequently, this model was tested by the same authors in other work to check its accuracy, confirming that it ensures obtaining robust results in the presence of outliers (Koenker and Machado 1999; Koenker and Hallock 2001).

A study of reference for this research, dealing with the relations between corruption, entrepreneurial activity, and innovation, used the same type of method (Anokhin and Schulze 2009), in order to determine the non-linear relations between the variables studied, added to the set of scientific and technical arguments, which help to justify the methodological option to use this type of regression model. Other studies of reference applying this model were also taken into account in this research (Buchinsky 2012; Keho 2016; Zhang et al. 2016; Aldieri and Vinci 2017; Afonso et al. 2019; Moreno-Izquierdo et al. 2020).

According to Koenker and Bassett (1978), a simplified expression of the model can be presented as follows:

$$Y_{it} = X_{it}\beta(\tau) + \mu_{it} \quad (1)$$

where: X_{it}, corresponds to the coefficients of the explanatory variables; and $\beta(\tau)$ contains the regression coefficients by quantile (τ = 0.2;0.4;0.6;0.8;0.98) corresponding to the dependent variable Y_{it}. Regarding μ_{it}, this corresponds to distribution of the error term. It is noted that as increases of τ between 0 and 1 are found, there is development of the conditional distribution of total entrepreneurial activity, the maximum value corresponding to 1, and the minimum to 0.

4.2.2. Model Specification

In this study and to analyse the hypothetical effects of institutional and socio-economic factors on entrepreneurial activity, the following model specification is considered:

$$\begin{aligned} Q(TEA_{it}) = {} & \beta_{0\tau}+\beta_{1\tau}DTEA_{it} +\beta_{2\tau}CPI_{it}+\beta_{3\tau}FT_{it}+\beta_{4\tau}PATPC\_LAG1_{it}+\beta_{5\tau}INFDI_{it} \\ & +\beta_{6\tau}UNEM_{it}+\beta_{7\tau}AGE_{it} + \beta_{8\tau}HOUSEHOLD_{it} +\beta_{9\tau}EDUCATION_{it} +\beta_{10\tau}LIFE_{it} + \mu_{it} \end{aligned} \quad (2)$$

where: $Q(TEA_{it})$: shows the quantile referring to entrepreneurial activity (TEA); the *i* parameter refers to the country in the data panel; and *t* corresponds to the period of time. TEA expresses the dependent variable measured by the rate of entrepreneurial activity; DTEA represents the lagged dependent variable; CPI expresses the corruption perceptions index; FT represents free trade; PATPC_LAG1 corresponds to the ratio of patents to real GDP per capita; INFDI represents the entry flows of FDI; UNEM corresponds to the unemployment rate; AGE represents the age dependency ratio; HOUSEHOLD corresponds to the households and NPISHs' final consumption expenditure; EDUCATION expresses the education index; and LIFE corresponds to the life expectancy at birth.

The equation represents the hypothetical effects associated with the determinant factors of countries' entrepreneurial activity. The interest of this study lies in contributing to advancing the still limited knowledge about the hypothetical non-linear effects of institutional, economic, and socio-economic determinant factors, considering the whole distribution of entrepreneurial activity. This line of reasoning justifies use of the econometric method of quantile regression, as it is considered appropriate to investigate those hypothetical effects of the independent variables on a given dependent variable, assessing different points of that dependent variable, throughout its conditional distribution.

4.3. Empirical Evidence

4.3.1. Results of Estimation of the Models

This sub-section presents the results of the models applied using the quantile regression method. Model 1 (cf. Table 10) considers all the independent variables, including the lagged dependent variable (DTEA), in order to determine the hypothetical effects of the independent variables on entrepreneurial activity, throughout the corresponding distribution. The CPI2 and CPI3 variables are also considered, in order to determine possible non-linear effects of perceived corruption on entrepreneurial activity. Model 2 (cf. Table 10) includes one of the control variables, the dummy referring to the 2008–2009 crisis. Model 3 (cf. Table 11) includes the second control variable, a dummy for developed and developing countries. Model 4 (cf. Table 11) includes all the independent variables and the two control variables.

Concerning the results of Model 1, in relation to corruption, the sign of the coefficient is as expected, being negative and very significant in all the quantiles, except for the Q80.

Free trade has negative and significant effects on entrepreneurial activity only in the last quantile (Q98), i.e., free trade is only significant for higher levels of the distribution of the entrepreneurial activity variable.

Table 10. Results of quantile regression models: 1 and 2.

	Model 1					Model 2				
Dependent Variable: TEA	Quantile					Quantile				
Independent Variables	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**
DTEA	0.3522 ***	0.4578 ***	0.5290 ***	0.5590 ***	0.5840 ***	0.3519 **	0.4662 ***	0.5093 ***	0.5408 ***	0.5228 ***
CPI	−2.0770 ***	−1.9419 ***	−2.0776 ***	−0.8181	−2.2347 **	−2.0287 ***	−1.9954 ***	−2.4926 ***	−1.1001	−2.4623 **
CPI2	3.1368 ***	2.7842 ***	2.9450 ***	0.7033	2.2830 *	3.0583 ***	2.8965 ***	3.6198 ***	1.1862	3.2224 *
CPI3	−1.5430 ***	−1.3041 ***	−1.3688 ***	−0.1264	−1.1220	−1.4983 ***	−1.3727 ***	−1.7156 ***	−0.3758	−1.3290
TF	0.0659	−0.0089	−0.0255	−0.1466	−0.2269 ***	0.0693	−0.0145	−0.0043	−0.1471	−0.2116 ***
PATPC_LAG1	0.0011	0.0011	0.0029 *	0.0055 ***	0.0042 ***	0.0012	0.0011	0.0026	0.0048 ***	0.0037 ***
INFDI	0.0153	0.0181 ***	0.0216 ***	0.0223 ***	0.0323 ***	0.0169 *	0.0186 ***	0.0198 ***	0.0238 ***	0.0300 ***
UNEM	0.0089	−0.0398	−0.1043 ***	−0.1527 ***	−0.2128 ***	0.0213	−0.0390	−0.0974 ***	−0.1525 ***	−0.2177 ***
AGE	−0.0182	−0.0816 **	−0.1278 ***	−0.1871 ***	−0.2826 ***	−0.0380	−0.1053 ***	−0.1502 ***	−0.2080 ***	−0.3001 ***
HOUSEHOLD	−0.0625	−0.0110	0.0662 **	0.0836 **	0.1993 ***	−0.0398	0.0027	0.0630 **	0.1004 ***	0.2133 ***
EDUCATION	−0.0263	0.0133	0.0655	0.0997 **	0.1043 **	−0.0326	0.0225	0.0572	0.0584	0.1014 *
LIFE	−0.0008 *	−0.0009 **	−0.0010 ***	−0.00005	0.0006	−0.0006	−0.0009 **	−0.0011 ***	−0.0003	−0.00008
DCRISIS	–	–	–	–	–	−0.0054	−0.0053	−0.0096 **	−0.0153 ***	−0.0033
DDEVEL	–	–	–	–	–	–	–	–	–	–
Constant	0.5578	0.6073	0.6233	0.4704	0.7860	0.5333	0.6163	0.7095	0.5422	0.8298
N	315	315	315	315	315	315	315	315	315	315
Pseudo R^2	0.2281	0.2991	0.3893	0.4928	0.6409	0.2303	0.3019	0.3977	0.5015	0.6432
Adjusted R^2	0.1975	0.2713	0.3650	0.4727	0.6266	0.1971	0.2718	0.3717	0.4800	0.6278

Legend: *** 1% significance; ** 5% significance; and * 10% significance. Source: Own elaboration.

Table 11. Results of quantile regression models: 3 and 4.

	Model 3					Model 4				
Dependent Variable: TEA	Quantile					Quantile				
Independent Variables	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**
DTEA	0.4830 ***	0.4735 ***	0.5127 ***	0.5571 ***	0.4627 ***	0.4738 ***	0.5184 ***	0.4986 ***	0.5387 ***	0.3696 ***
CPI	−0.5827	−0.3301	−0.0185	−0.4404	0.3074	−0.5288	−0.6176	−0.2156	−0.2753	0.6378
CPI2	0.8982	0.4294	−0.0735	0.5417	−0.6254	0.8013	0.8733	0.2590	0.2691	−1.2928 *
CPI3	−0.4547	−0.1985	0.0473	−0.2432	0.3289	−0.4014	−0.4175	−0.1300	−0.1065	0.7432 *
TF	0.0362	0.0136	0.0355	0.0700	0.0477	0.0372	0.0434	0.0509	0.0631	0.0584 ***
PATPC_LAG1	−0.0002	−0.0002	0.0030	0.0040 ***	0.0023	−0.0001	−0.00004	0.0029	0.0041 ***	0.0039 ***
INFDI	0.0195 ***	0.0219 ***	0.0193 ***	0.0171 ***	0.0122 **	0.0202 **	0.0209 ***	0.0183 ***	0.0188 ***	0.0157 ***
UNEM	−0.0052	−0.0906 **	−0.1447 ***	−0.1735 ***	−0.2638 ***	−0.0067	−0.0954 ***	−0.1517 ***	−0.1821 ***	−0.2662 ***
AGE	−0.0889 **	−0.2014 ***	−0.2029 ***	−0.2358 ***	−0.3172 ***	−0.0843 **	−0.2112 ***	−0.2236 ***	−0.2328 ***	−0.2923 ***
HOUSEHOLD	0.0278	0.0661	0.0819 ***	0.1239 ***	0.1523 ***	0.0305	0.0686 *	0.0797 ***	0.1195 ***	0.1493 ***
EDUCATION	0.0770 *	0.1115 **	0.1466 ***	0.2171 ***	0.2833 ***	0.0786 *	0.1195 ***	0.1456 ***	0.2203 ***	0.2392 ***
LIFE	0.0020 ***	0.0022 ***	0.0022 ***	0.0021 ***	0.0022 ***	0.0020 **	0.0018 ***	0.0021 ***	0.0022 ***	0.0022 ***
DCRISIS	–	–	–	–	–	−0.0025	−0.0064 *	−0.0036	−0.0096 ***	−0.0114 ***
DDEVEL	−0.0782 ***	−0.0913 ***	−0.1010 ***	−0.1118 ***	−0.1216 ***	−0.0779 ***	−0.0887 ***	−0.0998 ***	−0.1010 ***	−0.1182 ***
Constant	0.0197	0.0193	−0.0721	−0.0359	−0.1669	0.0048	0.0815	−0.0222	−0.0752	−0.2075
N	315	315	315	315	315	315	315	315	315	315
Pseudo R^2	0.3416	0.4057	0.4950	0.5992	0.7244	0.3430	0.4097	0.4971	0.6040	0.7342
Adjusted R^2	0.3132	0.3801	0.4732	0.5819	0.7125	0.3123	0.3822	0.4736	0.5855	0.7217

Legend: *** 1% significance; ** 5% significance; and * 10% significance. Source: Own elaboration.

The ratio of patents to GDP per capita has positive and significant effects but shows coefficients with low values. This explanatory variable is more significant for higher levels of the TEA distribution (Q60; Q80; and Q98). Therefore, beneficial results are expected, in terms of entrepreneurial activity, as long as innovations continue.

In relation to FDI, this is found to have positive and very significant effects for all the quantiles of TEA distribution, except for the Q20. This being so, increases in this type of investment in countries is seen to promote increased levels of entrepreneurial activity. This variable is considered an incomplete proxy to represent technology transfer flows, and so the greater the FDI, the greater the technology transfer and higher levels of entrepreneurial activity will be achieved.

Unemployment is seen to have negative and significant effect on entrepreneurial activity, for most distributions, except for Q20 and Q40. These results contrast with the scarce most recent empirical literature regarding this relation but are explained by the sample being mostly formed of developed countries.

The age dependency ratio has negative and significant effects for all the quantiles of entrepreneurial activity distribution, except the Q20. This mean that the higher age dependency ratio, the lower will be the propensity for countries to create entrepreneurial activity.

Households and NPISHs' final consumption expenditure exhibit significant and positive effects on quantile: 60; 80; and 98. The increase in household expenditure in relation to consumption, leads to higher levels of entrepreneurial activity.

The education index has positive and significant effects on large distributions of entrepreneurial activity, that is, the higher the number of years of schooling of the population, the higher will be the level of entrepreneurial activity.

On the contrary, the average life expectancy at birth has negative and significant effects on entrepreneurial activity in the 20, 40, and 60 years. Thus, the higher the life expectancy at birth, the lower will be the level of entrepreneurial activity.

As expected, the pseudo R^2 and adjusted R^2 become higher with increased quantile value. Therefore, for higher levels of the conditional distribution of entrepreneurial activity, the model's explanatory power is reinforced. The model is found to adjust well to the data, and as the sample is of 315 observations, this R^2 can be considered acceptable.

Concerning Model 2, whose differentiating element is the inclusion of the crisis dummy, the results are similar, with small changes in the coefficients and in the loss or gain of significance. Taking quantile 20 as a reference, the INFDI variable is statistically significant to 10% and the LIFE variable became statistically significant at 5%. Regarding quantile 40, gains of significance are found in relation to the AGE variable, which is now significant at 1%. The PATPC_LAG1 variable now shows a non-significance, taking Q60 as a reference. In quantile 80, HOUSEHOLD is significant at 1% and EDUCATION is no longer statistically significant. However, the coefficient of the control variable (DCRISIS) is negative, as expected, and significant for quantile 60 and 80, at 5% and 1%, respectively.

The adjusted R^2 has changed to a slightly higher value, given the inclusion of a control variable showing statistical significance for Q60 and Q80.

Models 3 and 4 (cf. Table 11) include the control variable referring to the condition of developed or developing country, based on the WESP (2014) classification. In order to capture the effects that the different conditions of the countries in the sample can have on the distribution of entrepreneurial activity, a dummy variable was created to represent the status of developed country (value 1) and developing country (value 0).

In Model 3, including the new control variable means a loss of significance in relation to the corruption perceptions index. This index is no longer statistically significant for any quantile. However, the perception of the corruption squared index has negative effects and the cubic transformation of the same index denotes positive effects, both significant at 10%.

Free trade, considered as an institutional determinant factor, has no statistical significance for any of the quantiles of the TEA distribution.

Regarding the PATPC variable, for higher levels of entrepreneurial activity, this ratio shows positive and very significant effects (Q98). FDI has positive and very significant

effects at the 1% level for most quantiles, except for Q98 of the third model, which presents significance at 5%.

Unemployment shows negative and significant effects for most quantiles of the distribution of entrepreneurial activity, except for Q20. The age dependency ratio variable has negative and significant effects across the distribution of TEA. The HOUSEHOLD variable has positive and significant effects for quantiles 60; 80; and 98 of the distribution of entrepreneurial activity.

The education index shows the expected results, for the entire distribution of TEA, there are positive and statistically significant effects. The LIFE variable, with the inclusion of dummy, presents contradictory results compared to the previous models, that is, for all the quantiles of the sample, the average life expectancy at birth presents positive and significant results.

As for the development dummy, this has negative and very significant effects all at 1%, and so the more developed countries are, the less likely they are to increase entrepreneurial activity.

Therefore, the countries under analysis that are grouped according to the criterion provided by WESP (2014), denote interesting results, from which it can be retained that the more developed the countries are, the less prone they will be to develop further entrepreneurial activity flows.

This set of results is aligned with the vision of Minniti et al. (2005), according to which the objectives of countries with high income levels, are essentially to maintain competitiveness levels; support companies with high added value and great growth potential; and develop its innovative capacity. In many of these countries, government policies are created to create efficient mechanisms for companies already installed to survive and grow in their business area, so that they try to increase their export levels. The same authors argue that countries with the average income level must create measures and mechanisms to support the adoption of new technologies and an entrepreneurial culture. Many of these countries choose to create measures to encourage the creation of new entrepreneurial activities; promote adoption measures for new innovations and new technologies, mainly through tax reductions; monetary incentives to create potential businesses; credit facilities; low interest rates, among other measures to encourage the creation of new businesses and an entrepreneurial culture mainly in developing countries.

The adjusted R^2 and the pseudo R^2 improve through including this control variable, shown by the significance and the effects observed in the distributions of entrepreneurial activity. Therefore, in this model, the explanatory variables show greater explanatory power of the dependent variable, as there are increases in the values of the adjusted R^2 and the pseudo R^2.

Referring to the results of Model 4, there are few changes in the coefficients and significances obtained for Model 3. Both control variables were included in this new model.

Taking the CPI variable first, it is still not statistically significant for any quantile of the distribution of entrepreneurial activity. CPI2 and CPI3 are statistically significant for the maximum quantile of the TEA distribution. The HOUSEHOLD in the fourth model becomes significant at 10% for Q40.

The crisis dummy continues to show a negative impact, with statistical significance for Q40, Q80, and Q98, while the development dummy is also negative as in the previous model and always very significant at 1%.

As expected, the pseudo R^2 and adjusted R^2 become higher with increased quantile value. Therefore, for higher levels of the conditional distribution of entrepreneurial activity, the model's explanatory power is reinforced.

Concerning the global results of the four models, it is underlined that DTEA shows positive and significant effects (mostly at 1% significance), and coefficients with considerable values in all quantiles, leading to the conclusion that the greater entrepreneurial activity in the past, the greater it will be in the present. This is recurrent in all the models, so with inclusion of the control variables, the result presented above is ratified.

4.3.2. Results of the Robustness Tests

Tables 12 and 13 present the results of the symmetry and equality tests, in order to assess the robustness of the results obtained for the different quantiles of conditional distribution of entrepreneurial activity (TEA).

In performing the symmetry test, three different pairs of quantiles are considered (2–98; 20–80; and 40–60), for the model without control variables and the model with both control variables.

For the first model, the results indicate that the unemployment variable shows significant and positive effects, only in the symmetry pair (2–98).

In the last model, the INFDI variable has negative and significant coefficient in pairs of symmetry (2–98 and 40–60). The PATPC_LAG1 variable has positive and significant coefficient in the quantile pairs (20–80 and 40–60).

The Wald test is only significant at 10% for the model with the control variables.

Table 13 presents the results of the equality test for the quantile regression model.

Application of the Wald test provides very robust results, all significant at 1%. The equality test shows the differences between the quantile pairs studied, revealing that they are mostly very different.

Table 12. Results of the symmetry tests.

	Symmetry Tests					
Dependent Variable: TEA	**Quantile**					
Independent Variables	**Q2 = Q98**	**Q20 = Q80**	**Q40 = Q60**	**Q2 = Q98**	**Q20 = Q80**	**Q40 = Q60**
DTEA	−0.0782	−0.1060	−0.0304	−0.3152	−0.0192	−0.0147
CPI	0.8650	1.3432	0.2188	0.5952	0.3976	0.3686
CPI2	−1.5376	−2.2022	−0.3131	−1.1453	−0.5989	−0.5370
CPI3	0.9204	1.1479	0.1443	0.6913	0.2788	0.2392
TF	−0.1839	−0.0993	−0.0529	0.0266	−0.0033	−0.0092
PATPC_LAG1	0.0022	0.0017	−0.0009	0.0035	0.0037 **	0.0025 *
INFDI	0.0134	−0.0033	−0.0012	−0.0177 *	−0.0067	−0.0066 *
UNEM	0.2071 *	−0.0177	−0.0181	0.0840	0.0533	−0.0050
AGE	−0.0395	−0.0139	−0.0180	−0.1044	0.1080	−0.0096
HOUSEHOLD	0.1292	−0.0397	−0.0055	−0.0709	−0.0429	−0.0446
EDUCATION	−0.0217	0.0003	0.0057	0.1034	0.0753	0.0416
LIFE	0.0002	0.0007	0.00007	−0.0005	−0.0002	−0.0005
DCRISIS	–	–	–	−0.0052	−0.0037	−0.0017
DDEVEL	–	–	–	−0.0038	−0.0022	−0.0016
Constant	−0.0556	−0.1956	0.0067	−0.0702	−0.1607	−0.0311
Nº of tests	5	5	5	5	5	5
Wald test	35.17	35.17	35.17	60.97 *	60.97 *	60.97 *

Legend: ** 5% significance; and * 10% significance. Source: Own elaboration.

In the model without control variables, in the equality pair (20–40), the age shows positive and significant coefficient. In the next pair (40–60), the unemployment variable presents positive and significant effects and HOUSEHOLD variable must negative and significant effects at 5%, respectively. In the pair (60–80), CPI3 and PATPC_LAG1 show negative and positive significant effects. High−lighted in the last equality pair are the positive effects at 10% of AGE. The HOUSEHOLD and THE INFDI presents negative and significant effects at 1% and 10%, respectively.

In the last model with the control variables, in relation to the first equality pair (20–40), unemployment and AGE presents positive effects at 5% and 1%, respectively. In the pair (40–60), PATPC_LAG shows a negative and significant effect and UNEM presents positive and significant effects at 5%. In the pair (60–80), HOUSEHOLD shows negative and significant effects and DCRISIS presents positive and significant effects, both at 10%.

Table 13. Results of the equality tests.

Dependent Variable: TEA Independent Variables	Equality Tests							
	Quantile							
	Q20 = Q40	**Q40 = Q60**	**Q60 = Q80**	**Q80 = Q98**	**Q20 = Q40**	**Q40 = Q60**	**Q60 = Q80**	**Q80 = Q98**
DTEA	−0.1056	−0.0712	−0.0300	−0.0251	−0.0446	0.0198	−0.0401	0.1690 *
CPI	−0.1350	0.1356	−1.2595	1.4166	0.0887	−0.4020	0.05971	−0.9130
CPI2	0.3526	−0.1608	2.2417	−2.1265	−0.0720	0.6143	−0.0101	1.5619
CPI3	−0.2389	0.0648	−1.2425 *	0.9956	0.0161	−0.2875	−0.0235	−0.8497
TF	0.0747	0.0166	0.1212	0.0802	−0.0062	−0.0075	−0.0122	0.0047
PATPC_LAG1	0.00005	−0.0019	−0.0026 *	0.0012	−0.00009	−0.0029 *	−0.0012	0.0001
INFDI	−0.0028	−0.0034	−0.0007	−0.0101 *	−0.0007	0.0026	−0.0006	0.0031
UNEM	0.0487	0.0645 **	0.0484	0.0601	0.0887 **	0.0563 **	0.0304	0.0840 ***
AGE	0.0634 *	0.0462	0.0593	0.0955 *	0.1269 ***	0.0124	0.0093	0.0594
HOUSEHOLD	−0.0515	−0.0772 **	−0.0174	−0.1157 ***	−0.0381	−0.0111	−0.0398 *	−0.0299
EDUCATION	−0.0397	−0.0521	−0.0343	−0.0046	−0.0410	−0.0261	−0.0747	−0.0189
LIFE	0.0001	0.0002	−0.0006	−0.0005	0.0001	−0.0003	−0.0002	0.00004
DCRISIS	–	–	–	–	0.0039	−0.0028	0.0060 *	0.0018
DDEVEL	–	–	–	–	0.0107	0.0111	0.0102	0.0082
Constant	–	–	–	–	–	–	–	–
Nº of tests	5	5	5	5	5	5	5	5
Wald test	259.70 ***	259.70 ***	259.70 ***	259.70 ***	328.92 ***	328.92 ***	328.92 ***	328.92 ***

Legend: *** 1% significance; ** 5% significance; and * 10% significance. Source: Own elaboration.

In the last equality test (80–98), DTEA presents positive and significant effects at 10%. The unemployment variable shows positive and significant effects at 1%.

4.3.3. Estimates with Confidence Intervals

Now, the estimates of the parameters of the quantile regression of the fourth model are presented, with confidence intervals of 95%, for the determinant factors: institutional; economic and socio-economic; of entrepreneurial activity.

Axis *x* presents the quantile studied in relation to the distribution of entrepreneurial activity, and axis *y* shows the values of the coefficients of the independent variables and the control variables for the respective quantiles. Therefore, the blue lines represent the estimates of the model's parameters and the red lines correspond to the area of the 95% confidence interval (Figure 1).

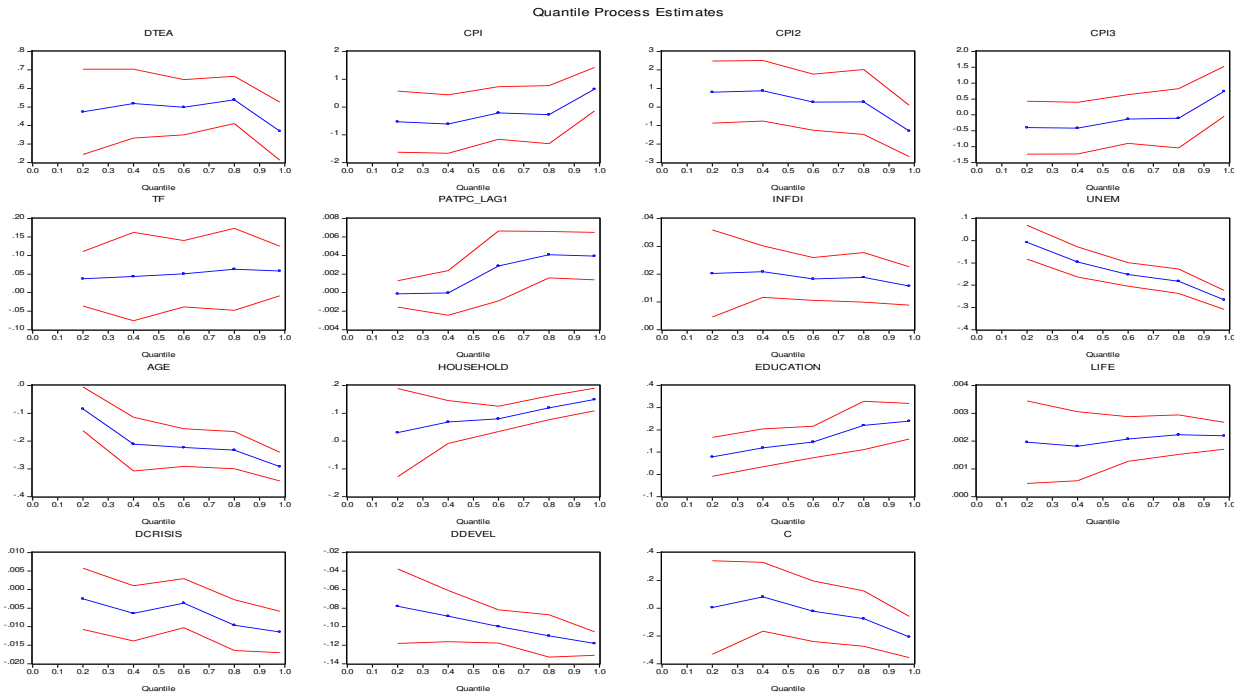

Figure 1. Behavior of the variables in the model with the two control variables and a confidence interval of 95%. **Source:** Own elaboration.

4.4. Discussion and Summary of the New Evidence

The results obtained in relation to institutional factors agree with previous empirical evidence. However, there is new evidence of the negative and significant effects of the corruption and positive and significant effects of the free trade, meaning that H1 and H2 cannot be rejected. This indicates that more efficient state control will allow reaching higher levels in these indicators, leading to improvements in the business environment and an increased rate of entrepreneurial activity in countries, in the line defended by Glaeser and Saks (2006), Anokhin and Schulze (2009), and Ojeka et al. (2019).

Free trade and the corruption perceptions index present robust results, in that when flexibility is increased and barriers to international trade are lowered (Simón-Moya et al. 2014; Albulescu et al. 2016), together with greater efficiency in controlling corruption, it is possible to achieve higher levels of entrepreneurial activity. Countries should therefore combat the corruption phenomenon, to improve the efficiency of institutional channels of information transmission and ensure greater transparency of institutions (Glaeser and Saks 2006; Ojeka et al. 2019).

With expansion of the free trade index, it is possible to improve the economy's effectiveness, obtain and introduce innovations, increase technological progress and thereby make countries more stable and sustainable in macroeconomic terms (Simón-Moya et al. 2014; Albulescu et al. 2016; Youssef et al. 2017).

The strong and significant evidence obtained here corroborates the expected positive effect of the patent to real GDP per capita ratio on entrepreneurial activity, also leading to non-rejection of H3. Therefore, the State should ensure the adoption of new, improved measures, so as to attract even more and better innovations, to increase entrepreneurial activity and originate more economic growth. This being so, the interconnection between innovations and economic growth contributes to increased entrepreneurial activity in countries (Castaño et al. 2015; Acs et al. 2018; Tunali and Sener 2019).

It is very important for companies to have competitive advantages in relation to entrepreneurial activity and innovations. However, for countries and their companies to achieve advantages, in comparative terms, it is necessary to optimize strategies and public policies that can contribute to greater effectiveness of governments and countries' ecosystems (Pradhan et al. 2020). Innovation has an essential role in the vitality of global economies, but it is necessary to implement the most effective measures to promote greater benefits for the population. Innovations allied to entrepreneurship can create more jobs, a higher quality of life and improve countries' competitiveness in global terms.

Concerning the results obtained for INFDI, this is found to have positive effects on entrepreneurial activity in the 21 countries studied in the period 2003–2018, which also means non-rejection of H4. This type of investment is used as a mechanism of technological progress, but it is up to governments to create measures with high quality information to try to capture greater flows of this investment (Alfaro et al. 2009; Anokhin and Schulze 2009; Herrera-Echeverri et al. 2014). In the line proposed by Stiglitz (2000), increased FDI is a strong mechanism to improve international trade, being positively correlated with institutions' quality.

As for unemployment, this has a negative effect on entrepreneurial activity, i.e., with increased unemployment, entrepreneurial activity is expected to diminish (Audretsch and Fritscht 1994), meaning H5 is not rejected. The result obtained here may be explained by the data panel containing mostly developed countries (71%), as sometimes in these more advanced countries rates of entrepreneurial activity are not so high, due to the co-existence of good social protection and strong aversion to risk, with the effects of unemployment being apparently unlike those experienced in less developed countries (Audretsch and Fritscht 1994; Simón-Moya et al. 2014).

The age dependency ratio leads to the non-rejection of the H6 hypothesis, since it presents the expected results, that is, negative and significant effects on entrepreneurial activity, which is in line with the studies conducted by Lévesque and Minniti (2006), Kurek and Rachwal (2011), and Guimarães and Tiryaki (2020). The larger the proportion of younger or elderly

population depends on the active population, the lower will be the entrepreneurial activity. However, there are still gaps to be addressed in the areas of public policies that lead to greater social inclusion of older populations, making them more proactive and integrated into society, promoting the entrepreneurial activity of this age group.

As regards to the variable that controls the final expenditure stemming from household consumption, it denotes positive and significant effects on entrepreneurial activity, as happened with Ligthelm (2010). Therefore, H7 is not rejected for the sample under study.

Education is a significant determinant factor for the emergence of new entrepreneurial activities. Therefore, the increase in the schooling of the population has positive effects on entrepreneurial activity (Boubker et al. 2021). This result points in the sense of non-rejection of H8.

Life expectancy at birth has a negative and significant effect on entrepreneurial activity. Lévesque and Minniti (2006) point out that as the elderly population increases, labour productivity and the emergence of new entrepreneurs tend to decline. Guimarães and Tiryaki (2020) argue that the increase in average life expectancy has negative impacts on the sustainability of public budgets, through increasing public spending on health and social support. It should be noted that H9 is not rejected, bearing in mind the results obtained in this quantile regression model.

Regarding the control variables, it is noted that the crisis dummy shows a negative coefficient, as expected, but it is not significant for any distribution of TEA. However, the developed/developing country dummy shows negative and very significant effects. This leads to the conclusion that the more developed a country, the less likely it is to develop entrepreneurial activity, as was expected.

It is also expected that with the creation of new companies in countries which already have some diversity of business, positive externalities arise for new firms, and so they can benefit from the existing knowledge, technology, and innovation in those already established. These externalities will bring about various benefits for market competition; the quality of products and the companies themselves (Stel et al. 2005; Pradhan et al. 2020).

In relation to countries' competitive advantages, these must exist in order to allow positive effects on the quality and efficiency of business environments, contributing to stronger information channels, a more qualified workforce and increased technological progress (Pradhan et al. 2020). Therefore, countries must be able to generate added value in various areas of entrepreneurial activity and in this way have competitive advantages over rivals.

Table 14 presents a summary of the research hypotheses, contrasting previous and new evidence.

Table 14. Summing-up of research hypotheses and evidence.

Hypotheses	Description	Evidence
H1	Control of corruption has a negative and significant effect on entrepreneurial activity.	Negative & S
H2	Free trade has a positive and significant effect on entrepreneurial activity.	Positive & S
H3	Innovation intensity has a positive and significant effect on entrepreneurial activity.	Positive & S
H4	FDI has a positive and significant effect on entrepreneurial activity.	Positive & S
H5	Unemployment has a negative and significant effect on entrepreneurial activity.	Negative & S
H6	Age dependency ratio has a negative and significant effect on entrepreneurial activity.	Negative & S
H7	Households and NPISHs' final consumption expenditure have a positive and significant effect on entrepreneurial activity.	Positive & S
H8	Education index has a positive and significant effect on entrepreneurial activity.	Positive & S
H9	Life expectancy at birth has a negative and significant effect on entrepreneurial activity.	Negative & S

Legend: S: Significant. Source: Own elaboration.

4.4.1. Contrasting Developed vs. Developing Countries

For contrasting purposes, several empirical findings are presented concerning the different types of countries include in the sample, for the 2003–2018 period.

In order to control and observe the effects that the different conditions of the countries in the sample can have on the distribution of entrepreneurial activity, a dummy was created to represent the status of developed country (value 1), and developing country (value 0).

Tables 15 and 16 show the three models, divided from the perspective of the institutional, economic, and socio-economic determinant factors, incorporating the interaction terms related to each group of factors, i.e., the explanatory variables to be multiplied by the dummy of developed country and developing country status.

In relation to model 5, with the inclusion of terms of interaction referring to the two institutional factors, corruption perception index and freedom of trade, it can be concluded that the condition of developed country only accelerates the positive effect of freedom of trade on the total entrepreneurial activity, in quantile 20 and 40, both at 10% significance.

Table 15. Results of quantile regression models: 5 and 6.

	Model 5					**Model 6**				
Dependent Variable: TEA	**Quantile**					**Quantile**				
Independent Variables	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**
DTEA	0.4732 ***	0.5272 ***	0.5082 ***	0.5322 ***	0.4096 ***	0.4379 ***	0.4581 ***	0.4525 ***	0.5070 ***	0.3696 ***
CPI	−0.5548	−0.4752	−0.4366	−0.6368	0.8971 *	−0.8834 *	−0.6598 *	−0.3137	−0.1155	1.1336 ***
CPI2	0.9510	0.9703	0.9140	1.0518	−1.8665 *	1.3460	0.9925	0.3564	−0.0815	−2.2213 ***
CPI3	−0.4777	−0.4845	−0.4613	−0.5368	1.0415 *	−0.6699	−0.4842	−0.1523	0.1114	1.2367 ***
TF	0.0421	0.0137	0.0637	0.0970 *	0.0471	0.1108 ***	0.1105 ***	0.1302 **	0.0922	0.0366
PATPC_LAG1	−0.0007	−0.0012	0.0021	0.0039 **	0.0038 ***	−0.0009	−0.0017	−0.0024 **	−0.0023 ***	0.0007
INFDI	0.0160 *	0.0192 ***	0.0176 ***	0.0169 ***	0.0147 ***	−0.1674 *	−0.1901 ***	−0.1290 **	−0.0846	−0.0980
UNEMP	−0.0820	−0.3282 **	−0.4140 ***	−0.3559 **	−0.2454 ***	−0.0143	−0.0676 **	−0.1033 ***	−0.1128 ***	−0.1970 ***
HOUSEHOLD	−0.0085	0.0542	0.0722 ***	0.1071 ***	0.1484 ***	0.0614	0.0807 **	0.0488 *	0.0138	−0.0171
AGE	−0.0672	−0.1550 ***	−0.1560 ***	−0.2013 ***	−0.3040 ***	−0.0910 **	−0.1628 ***	−0.1913 ***	−0.2280 ***	−0.2629 ***
EDUCATION	0.1022 *	0.1338 ***	0.1524 ***	0.2105 ***	0.2416 ***	0.0995 **	0.0492	0.0944 **	0.1824 ***	0.2413 ***
LIFE	0.0017	0.0008	0.0001	0.0003	0.0022 ***	0.0007	0.0004	0.0015 **	0.0023 ***	0.0033 ***
DCRISIS	−0.0016	−0.0059	−0.0061 *	−0.0091 **	−0.0131 ***	−0.0023	−0.0047	−0.0051	−0.0084 **	−0.0107 ***
DDEVEL	−0.0581	−0.0509	−0.0542	−0.1046	−0.1562 *	−0.1263 ***	−0.1387 ***	−0.1416 ***	−0.1438 ***	−0.1003 ***
CPI*DDEVEL	−0.0795	−0.1748	−0.1845	−0.0653	0.1009	–	–	–	–	–
TF*DDEVEL	0.0928	0.2849 *	0.3331 *	0.2429	−0.0204	–	–	–	–	–
PATPC_LAG1*DDEVEL	–	–	–	–	–	−0.0011	0.0003	0.0075 ***	0.0109 ***	0.0094
INFDI*DDEVEL	–	–	–	–	–	0.1853 **	0.2134 ***	0.1480 **	0.0983	−0.0855
Constant	0.1870	0.1195	0.1310	0.0528	−0.1175	0.1397	0.2001	0.0649	−0.0110	−0.2964
N	315	315	315	315	315	315	315	315	315	315
Pseudo R^2	0.3539	0.4316	0.5116	0.6129	0.7380	0.3726	0.4403	0.5331	0.6233	0.7497
Adjusted R^2	0.3192	0.4011	0.4854	0.5921	0.7239	0.3389	0.4102	0.5080	0.6031	0.7363

Legend: *** 1% significance; ** 5% significance; and * 10% significance. Source: Own elaboration.

With regard to the model with economic factors, it should be noted that the dummy referring to the status of developed countries and developing countries, catalyses the intensity of innovation for the quantile 60 and 80 to 1% significance, as well as it accelerates the inward FDI for the quantile 20 and 60 to 5% of statistical significance, and for the quantile 40 to 1% of significance.

In the latter model, it is important to highlight the accelerating effects that developed country status causes on the age dependency ratio, in all quantiles, mostly at 1% significance,

except for quantile 80. The same condition as a developed country restrains the behaviour of the education index for quantile 40, to 5% of statistical significance. Furthermore, the country-condition dummy also restrains the relationship between life expectancy at birth and entrepreneurial activity in the generality of quantiles, with the exception of Q98.

Thus, it can be concluded that the more developed, the economies of the countries have a lower propensity for the development of entrepreneurial activity.

For countries whose economies are developing, these have positive effects in capturing higher rates of entrepreneurial activity, as expected. For example, countries such as South Africa; Argentina; Brazil; China; and Mexico, need to develop new generation public policies aimed at enhancing the competitiveness of their entrepreneurial and innovative ecosystems, as well as the quality and efficiency of business environments, thereby ensuring sustainable competitive advantages over countries with more developed economies.

Table 16. Results of quantile regression model: 7.

	Model 7				
Dependent Variable: TEA	**Quantile**				
Independent Variables	**Q20**	**Q40**	**Q60**	**Q80**	**Q98**
DTEA	0.4696 ***	0.4465 ***	0.4480 ***	0.4983 ***	0.4951 ***
CPI	−0.7743	−0.7114 **	−0.8254 **	−1.2895 *	−0.5908
CPI2	1.2951	1.2263 **	1.4334 **	2.1860 **	0.8792
CPI3	−0.6883	−0.6727 **	−0.7857 ***	−1.1735 **	−0.4908
TF	0.0840 ***	0.1078 **	0.1090 **	0.1082 *	0.0451
PATPC_LAG1	−0.0028 ***	−0.0040 ***	−0.0035 ***	−0.0002	0.0042
INFDI	0.0190 ***	0.0210 ***	0.0204 ***	0.0184 ***	0.0101 **
UNEM	−0.0360	−0.0623	−0.1200	−0.0671	−0.2768 ***
HOUSEHOLD	0.1675 **	0.0247	0.0430	0.1162	0.2389 ***
AGE	−0.7703 ***	−0.5985 ***	−0.5761 ***	−0.5320 **	−0.4867 ***
EDUCATION	0.1601	0.2723 ***	0.2680 ***	0.2129 *	0.2919 ***
LIFE	0.0018	0.0029 *	0.0023 *	0.0030	0.0008
DCRISIS	−0.0026	−0.0047	−0.0052	−0.0053	−0.0064 *
DDEVEL	−0.0710	0.1379	0.1279	0.2073	−0.0227
UNEM*DDEVEL	0.1034	0.0650	0.0785	−0.0103	0.1208
HOUSEHOLD*DDEVEL	−0.1115	0.0733	0.0678	0.0452	−0.1940
AGE*DDEVEL	0.8467 ***	0.6695 ***	0.5958 ***	0.4764 **	0.2937 ***
EDUCATION*DDEVEL	−0.0357	−0.1628 **	−0.1578 **	−0.0026	0.0314
LIFE*DDEVEL	−0.0048 **	−0.0067 ***	−0.0061 ***	−0.0075 ***	−0.0061
Constant	0.2507	0.0804	0.1335	0.1478	0.1217
N	315	315	315	315	315
Pseudo R^2	0.4851	0.5364	0.5836	0.6592	0.7596
Adjusted R^2	0.4519	0.5065	0.5567	0.6373	0.7441

Legend: *** 1% significance; ** 5% significance; and * 10% significance. Source: Own elaboration.

4.4.2. Evaluating the Quantile Regression

The quantile regression model allows analysing the different types of effects of explanatory variables, along the distribution of the explained variable. Thus, this empirical study contributes in a differentiated way to the advancement of knowledge about the effects of institutional, economic, and socio-economic determinants, along the distribution of entrepreneurial activity.

According to the results obtained in Tables 1–4 of the quantile regression, it is possible to observe that the effects of independent variables along the distribution of the dependent variable (TEA) are very robust, that is, when the distribution of TEA increases from quantile to quantile, the significance and effects obtained from explanatory variables are relevant, being in line with the expected results (cf. Table 14).

In summary, for higher levels of the TEA distribution, the evidence shows to have a high explanatory power and robustness, which provides an extensive basis of empirical findings, of a global dimension, applicable to both developed and developing countries. Overall, in order

to increase entrepreneurial activity, countries should stimulate innovative capacity, household income and the quality of their institutional and business environments.

5. Concluding Remarks

5.1. Empirical Findings

Regarding the first of the institutional factors studied here, countries should control corruption, to be more effective institutionally and convey more trust. When countries' institutions are more efficient, this will give rise to higher levels of entrepreneurial activity and more new firm creations. It is therefore up to economic policy-makers to focus on this area and implement the most correct measures, in order to make countries less corrupt (Glaeser and Saks 2006; Anokhin and Schulze 2009; Ojeka et al. 2019).

Addressing the second institutional factor linked to economic diplomacy and international trade, it is concluded that the higher the free trade index, the greater countries' entrepreneurial activity. However, the State must strive to improve this index, creating norms to try to attract even more trade, originate more entrepreneurial activity and more firm creation, thereby creating more innovation flows and economic growth (Simón-Moya et al. 2014; Albulescu et al. 2016; Youssef et al. 2017).

Regarding the variables selected to measure the institutional environment, as institutional determinants were selected, corruption and free trade, mainly due to the lack of data for the 21 countries under study, in the 2003–2018 period.

The study of socio-economic factors is in line with what is set out in the most recent global report from the Global Entrepreneurship Monitor (GEM 2019/2020), indicating as a guideline the stylized fact that entrepreneurial activity is a powerful enabler of countries' sustainable economic growth, as a viable solution to combat poverty and social inequality. Another fact to retain is that entrepreneurial activity, in some countries, is extremely innovative (for example, in Canada, Colombia, Guatemala, Ecuador, Panama, Chile, and the United Arab Emirates), i.e., one in twenty adults in these countries begins a business based on innovative products or services (GEM 2019/2020).

Taking as a reference the empirical findings presented here, the ratio of patents to GDP per capita increases entrepreneurship, and so the more innovative countries are, the more they will grow, sustainably, and more entrepreneurial activity will be created (Castaño et al. 2015; Acs et al. 2018; Tunali and Sener 2019).

Concerning inward FDI, this produces positive and very significant effects on entrepreneurial activity (Herrera-Echeverri et al. 2014), and for that reason, this type of investment is essential for economic growth, being considered as a driver of technological transfer between countries. Therefore, the more FDI attracted, the more technology and innovations will be produced (Anokhin and Schulze 2009), attaining higher levels of technological progress and expanding the technological frontier of possibilities for countries' production and consumption.

Unemployment restricts entrepreneurial activity, and the explanation for this arises from the fact that the data panel is made up mostly of developed countries (Audretsch and Fritscht 1994). More developed countries do not tend to achieve high levels of entrepreneurial activity, and so this result is expected considering the total of 16 developed and 5 developing countries in the data panel used here.

The upward trend of life expectancy and the age dependency ratio play an important role in the sense that countries need to create policy measures for (pro)active ageing, that is, promoting senior entrepreneurship and ensuring inclusion of the elderly in social, cultural, civic, and citizenship participation (Jackson 2000; Kurek and Rachwal 2011).

The importance of education along life is one of the key-factors for countries to create and develop their entrepreneurial activity capacity (Boubker et al. 2021).

5.2. Implications and Recommendations

In terms of the implications of this study, most of the evidence converges on revealing the need to develop a new generation of public policies and operational measures, ori-

ented towards improving the quality of institutions and raising countries' institutional effectiveness. One of the most imperative measures is to control corruption, to ensure greater entrepreneurial activity, flows of innovation and technological progress. In this way, countries can increase their rates of economic growth and harmonize levels of well-being.

In a related vein, Aidis et al. (2008) studied the effects of institutional weaknesses on entrepreneurship. The same authors concluded that there are low levels of entrepreneurship in Russia, especially due to institutional weaknesses. Therefore, those who benefit and take advantage of these effects are entrepreneurs already installed in their different business areas, because the opportunities and motivations for the increase of new entrepreneurs in the business system of Russia is quite scarce, however it is essential that the government establishes efficient measures that can stimulate new entrepreneurs to exploit new business opportunities (Radosevic and Yoruk 2013). There is a need to design and implement new public policies focused on different valences, such as resources, liaisons, dynamic capabilities, competences, and skills for entrepreneurship, because some countries that intend to create an efficient entrepreneurial ecosystem face a number of limitations in terms of these valences (Junior et al. 2020).

In developing countries, economic policy-makers should be aware of the adversities and discrepancies of indicators, and create supporting measures, thereby stimulating entrepreneurial activity, technological progress, and innovations, which can contribute to more sustainable creation of wealth.

From the empirical evidence found here, it is recommended that governments should improve the regulation and control of countries' institutional environments. Besides this need for improvement, new incentives should be created, aiming to stimulate R&D activities and in this way, develop activities oriented towards creating new forms of qualified entrepreneurship (e.g., knowledge-based firms), registering new patents from new firms and the essential introduction of innovations.

Policy-makers play a vital role in ensuring the sustainable growth of their economies, and typically analyse and take action on production, for providing an increase in well-being to the population and thus leading to increases in household consumption (OECD 2020).

However, there are persisting gaps in addressing policies that lead to the rates of employability and entrepreneurial activity of older people, making them more (pro)active and integrated in society, and thus contributing to the increase in the rate of entrepreneurial activity of this age group (Kurek and Rachwal 2011; Guimarães and Tiryaki 2020).

With this new evidence, it is also recommended that developing countries should concentrate on measures to promote innovation, giving more incentives especially to female entrepreneurs, in order to stimulate new business creation and the adoption of new technology, to improve the population's standard of living and combat social and gender inequality, which is still prevalent and becomes more obvious at times of serious economic, political, social, and public health crises.

5.3. Limitations

This study has several limitations, arising fundamentally from the data-collecting process. Some of these refer to the GEM data, which in some countries studied and others that could have been included present shortcomings in some years. Another is the number of explanatory variables, which could be greater, but sometimes the model's explanatory power reveals greater weakness and is therefore less viable. This study analyses the direct effects of a limited number of determinant factors, both institutional, economic, and socio-economic, on entrepreneurial activity in developed and developing countries. It is therefore suggested that this limitation can be addressed in the future, including other types of factors: cultural; historical; political; geographical; demographic; financial; ethnic; religious; etc. For example, the use of socio-cultural variables could contribute to better explanation and clarification of the effects on entrepreneurial activity. Furthermore, the sample in this study is not particularly large, in terms of the number of countries and years,

and so it would be interesting to use other variables and from other countries to be able to explore empirically a longer period of time.

Adding to the previous, it should be noted that, in an embryonic analysis of the present investigation, the variable Human Development Index was included as an explanatory variable, but it raised some problems regarding the correlation matrix (high correlation pairs with the variables trade freedom and corruption). This index would be very relevant to contrast the countries in the sample, especially, in terms of economic policy choices and regulatory actions, through its three dimensions: (i) average life expectancy; (ii) number of years of schooling; and (iii) standard of living; however, it was not possible to operationalize it in the context of the present empirical study, which is here addressed as a limitation that could be surpassed in future research using disaggregated data.

5.4. Future Research

The proposals for future research arise from the limitations of this study and could lead to different empirical conclusions related to entrepreneurial activity and its central element, i.e., the entrepreneur.

At present, the world is facing a sudden economic, financial, social, and sanitary crisis with many effects on our lives, all due to a mutating virus (Covid-19), which has already claimed thousands of human victims worldwide. Therefore, various studies will be necessary to capture the impacts of this virus on different determinant factors and in many countries. A proposal for future study following on from this one would be to use a variable to control and capture the impacts on entrepreneurial activity. At this moment, there are many measures to help companies' financial health, but not all firms will manage to survive the major economic and social crisis that has arisen in a short period of time. Indices linked to entrepreneurship will show very negative impacts, and a suggestion is to study the determinant factors of survival and exit, especially regarding micro-firms.

Consequently, new research is suggested, attempting to address the following questions:

- What are the effects of rising unemployment rates and the difficulties already felt in attracting FDI on entrepreneurial activity and technological innovation?
- What are the effects of government measures implemented in the course of the pandemic and the post-pandemic to help the survival of micro-firms and ensure new innovation clusters?

Considering the inspiring research line followed by Radosevic and Yoruk (2013), in future studies, it would be interesting to be able to operationalize, empirically, an approach of structural equations of the PLS-SEM type, to measure, in alternative terms, the nonlinear effects of different categories of determining factors, incorporating a higher level of disaggregation and detail to the institutional factors of flexible environments versus non-flexible environments for the development of entrepreneurial activity, in the context of entrepreneurial, innovative, and sustainable ecosystems.

Finally, this study provides a range of scientific evidence that can be used in decision-making processes and in designing efficient policies to promote institutional quality and good business environments, resorting to effective mechanisms to diminish corruption and increase free trade. If these factors are effective and countries are more competent institutionally, it is hoped they can become more efficient in socio-economic terms. It is necessary to create a new generation of public policies, to attract more friendly, quality FDI, and thereby promote new venture creation, technology transfer, new management practices, training, and qualification of human capital. This will lead to a fall in unemployment and allow development and sustainable economic growth.

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Spatial and Sectoral Determinants of Productivity: An Empirical Approach Using an Entropy Lens

Sónia de Brito [1,*] and João Leitão [2,3,4]

1 Research Center in Business Sciences (NECE), University of Beira Interior, 6200-209 Covilhã, Portugal
2 Department of Management and Economics, Faculty of Social Sciences and Humanities, Research Center in Business Sciences (NECE), University of Beira Interior, 6200-209 Covilhã, Portugal; jleitao@ubi.pt
3 CEG-IST—Centre for Management Studies of Instituto Superior Técnico, University of Lisbon, 1049-001 Lisbon, Portugal
4 ICS—Instituto de Ciências Sociais, University of Lisbon, 1049-001 Lisbon, Portugal
* Correspondence: sonia.rosana.brito@ubi.pt

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Abstract: This study analyzes the productive structure of Portugal in the period 2013–2017, using indicators of localization and specialization applied to 308 Portuguese local authorities. From an empirical approach using a threshold model, the following indicators are used: (i) localization quotient; (ii) specialization coefficient; (iii) Theil entropy index; (iv) rate of industrialization; and (v) the density of establishments by business size. The selected period 2013–2017 is due to the available data concerning firms located per local authority, and the choice of threshold model is justified through the possibility of assessing the non-linear effects of specialization and diversification on productivity, considering, in simultaneous terms, different regimes per business size. Estimation of the threshold model identified a positive, statistically significant relation between industrialization and productivity. Similarly, the terms of interaction between exports and diversification, and between the former and higher education institutions, shows a catalyzing effect of productivity. In addition, the most specialized micro-firms affect productivity significantly and positively, while the least specialized have the opposite effect. Small, less specialized companies have a significant and negative effect on productivity, contrasting with less specialized, medium-sized companies, which affect productivity positively. For large firms, the impact on productivity is negative for both high and low levels of specialization, reinforcing the need to fill existing gaps in strategic diversification, as well as the vertical and horizontal integration of the activities of production chains with high value added.

Keywords: concentration; diversification; entropy; specialization

1. Introduction

The relation between spatial concentration and sector specialization, which began to be studied in the field of regional science, in recent years has emerged in the field of entrepreneurship and innovation, with it being a well-established fact that business undertakings are susceptible to geographical concentration [1–3], together with clear evidence that entrepreneurial activity varies considerably between countries and regions [4,5] and this phenomenon is shown to be persistent over time [6,7]. According to Aiginger and Rossi-Hansberg [8], spatial concentration and sector specialization have been studied as intrinsically related economic phenomena. Therefore, most empirical studies deal with both processes as parallels, meaning that concentration dynamics are accompanied by the same specialization dynamics. This being so, it is necessary to present the difference between spatial concentration and sector specialization, since there are always ambiguities arising from the fact that concentration is sometimes presented as equivalent to specialization. Spatial concentration is the extent

to which in one country a given industry or sector is concentrated in a limited number of regions; sector specialization is the extent to which a country concentrates its industrial activity in a limited number of sectors, so that a region has a profile of a highly specialized production structure when regional production is distributed mainly over a small number of sectors [9]. In turn, unlike sector specialization, Chowdhury et al. [10] refer to sector diversification as corresponding to a concentration of production activities not in a small number of sectors but in diverse sectors.

In the literature on this topic, the concept of industrial district formulated by Marshall [11] and Becattini [12] as well as the concept of cluster popularized by Porter [13] are predominant. In addition, industrialization, representing the process by which industrial sectors come to play a dominant role in a national economy, is also closely related to phenomena of spatial agglomeration and concentration. For Chenery et al. [14], the most widespread characteristic of industrialization is that corresponding to transformation of the production structure, whereby industrial sectors typically grow more quickly than agriculture. Fujita et al. [15] mention that one essential characteristic of industrialization is spatial concentration, and that indeed industrialization is frequently accompanied by the spatial agglomeration of industrial activities.

Industrialization greatly improved productivity [16], which has a relevant role in determining a country's economic well-being [17]. According to the OECD [18], there are different ways to measure productivity and the choice depends on the purpose of measuring it, and in many cases, the data available. Among alternative measures of productivity, such as multi-factor productivity or capital productivity, work productivity is particularly important in the economic and statistical analysis of a country. Work productivity equals the ratio between a measure of the output volume, in this case gross value added (GVA), and a measure of the use of inputs, in this case, the population employed. Therefore, the measure of the output volume reflects the goods and services produced by the workforce, while the measure of the use of inputs reflects the workforce's time, effort, and skills.

Aiming to advance knowledge about the relation between industrialization and productivity, using the Sales Index database, this study uses indicators of localization and specialization applied to all 308 local authorities in Portugal, intending to make a generic analysis of the dynamics of their production structure in the period 2013–2017. More specifically, a threshold model is estimated, in order to test the effect of industrialization on productivity as well as other research hypotheses arising from the literature review.

In this vein, the current study uses a concept of entropy operationalized through the Theil Index, developing an economics approach focused on the analysis of both spatial and sectoral determinants of productivity. This approach aims to assess the non-linear effects of specialization and diversification on productivity, considering, in simultaneous terms, different regimes per business size. Toward this empirical application, we contribute to advancing the existent knowledge on determinants of productivity, using an Entropy index and also unveiling distinct signals and significances of the determinants studied in different specialization regimes.

To achieve the objectives proposed, the following sections present firstly a literature review, originating in industrial districts and moving toward the cluster approach, and resulting in the research hypotheses. This is followed by the empirical approach, namely the methodology, and presentation, analysis, and discussion of the results. The study ends with the conclusion, limitations, and implications.

2. Literature Review

2.1. From Industrial Districts to Clusters

The concept of the industrial district was originally presented in the *Principles of Economics* by Marshall [11], proposing that the geographical agglomeration of companies in the same or similar branches of industry leads to organizational growth and development, allowing firms to obtain economic advantages expressed by external economies. From the pioneering work by Marshall [11], and after lying dormant for decades, the concept of industrial district was only taken up again in

the 1970s, in Italy, by Becattini [19], who defined it as a socio-territorial entity characterized by the active co-presence, in a limited, natural, and historically determined territorial area of a community of people and a population of industrial companies, differentiated from the traditional economic region by having industry as the dominant activity. One of the main characteristics of industrial districts is firms' flexible specialization, i.e., the social division of work between firms, based on tasks and their interconnections [20].

Both Marshall [11] and Becattini [12,21] refer to the division of the production process among firms, but this is not viable for all products. For the social division of work among firms to be viable, it must be possible to decompose this process in terms of space and time [22]. For Becattini [21], specialization of the local workforce has the nature of a public good and is a key factor for the district's productivity and competitiveness. Homogeneity among production units allows a great mobility of workers between companies. Another aspect recognized by Becattini [21] in industrial districts, and also mentioned earlier by Marshall [11], is that knowledge is spread both formally, referring to the teaching process or learning at work, and informally, referring to personal contacts among the various agents.

Other concepts have emerged in the literature, considering the spatial agglomeration of companies and its relation with other variables such as innovation. Highlighted here are the concept of innovative milieux, innovative systems, and the concept of learning regions. Developed by the *Groupe de Recherche Européen sur les Milieux Innovateurs* (GREMI), the concept of innovative milieux corresponds to how a company is regarded not as an isolated agent of innovation but as being inserted in a milieu with innovation potential [23]. Authors such as Aydalot [24], Ratti [25], Camagni [26,27], and Camagni and Maillat [28] state that the concept of innovative milieu has explored networks between innovation activities and space. Making a comparison between countries, states, and metropolitan areas, Jaffe et al. [29] argue that knowledge spillovers are geographically located and concentrated, meaning that the smaller the geographical area, the more significant the location and incidence of spillovers. A city can also be a rich context for the development of networks, and supporting this, Capello [30] concludes that cities that are not too large facilitate environmental balance, efficient mobility, and the possibility of maintaining a sense of belonging in the population. However, the city concept does not have the same characteristics as the notion of an innovative milieu [31,32]. In the perspective of Maennig and Ölschläger [32], if there is exchange and interaction between the city and the milieu, first of all, the whole city forms the physical basis and the milieu is formed through urban relational capital and collective learning processes, and secondly, a single specialized industry in a city forms a milieu.

Regarding the concept of innovation systems, this emerges in the literature with a focus on the national level of analysis, namely through building the theory of national innovation systems (NIS). The oldest versions of the NIS concept go back to Freeman [33], Nelson [34], and then Edquist [35], with the concept of innovation systems seeking to contemplate various factors determining the innovative process, based on the systemic nature of innovation. In the innovation system, innovation is systemic, multi-functional, and inter-organizational, being related to industrial dynamics and the relations between innovative firms and their milieu. Furthermore, at the national level, there are different possibilities for the organization of markets. In this connection, Lundvall [36] mentions that the interaction between universities, the types of interaction cultivated between specialists, and financial markets, which were analyzed separately in the literature, have gradually been considered and inserted in the perspective of systems. In recent decades, the regional issue has gained relevance due to the problem of asymmetric development and regional divergence. The accelerated globalization process and technological progress have clarified the need to deal with the matter of innovation in regions, and in this connection, it was Cooke [37] who introduced the concept of regional innovation systems (RIS), which is widely used in studies about innovation processes in regional economies [38–42].

An RIS can be defined as a system in which companies and other organizations are systematically concentrated in interactive learning through an institutional means characterized by immersion [40]. Added to this is the concept of learning regions developed by Cooke [43], Morgan [44], and Asheim [45], which can be considered as an attempt to synthesize the spatial models of innovation, but by

highlighting the importance of the role played by institutions in regional development, it ends up being distinguishable from the other spatial models of innovation [44].

More recently, Porter [13], inspired by the work already mentioned by Marshall [11] and Becattini [19] to explain the nature of the competitiveness in industrialized countries, introduced the concept of clusters, defining them as geographical concentrations of inter-related firms, specialized suppliers, service companies, firms in related industries, and cultural and teaching institutions—for example, universities, agencies and business associations—in a given area, that promote simultaneously cooperation and competition: (i) cooperation between related firms and local institutions; and (ii) competition between rival firms, in terms of attracting and holding on to customers. Clusters correspond to the solid set of related firms located in a small geographical area, which are sometimes centered on a country's scientific basis [46]. According to Porter [47], clusters have an important role in companies' competitiveness, above all through the increased productivity of companies and industries, through increased innovation capacity, and through the intermediary of promoting new businesses that support innovation and give clusters scale. Firms' productivity is increased through access to specific production factors and a specialized workforce, information, complementarities, institutions, public goods, and performance incentives. These factors bring about advantages such as a larger qualified workforce, increased specialization among suppliers, access to global markets, and reduced costs [47]. Studies have been made to define the context in which firms operate, namely using models reflected in the industrial concentration described by Krugman [48,49] and Fujita et al. [15], showing the advantages and success stories in various countries [50], as regards economic development [51] and learning processes [52,53]. Therefore, industrial concentrations result in growth through the results and advantages arising from spatial proximity [54], as is the case of the effect of the production function associated with transport costs, increasing productivity with a fixed number of production factors [55].

Clusters present benefits in the form of increased capacity for innovation and learning, technological externalities and increased flexibility and effectiveness of production and distribution systems [56], vertically disintegrated sub-contracting relations between firms specialized in different phases of production and interaction between small firms [20], local production networks [50], and interdependence [57] and firm networks that facilitate imitation and improvement [58], contributing to the development of competitive advantages for the firms located in these clusters [13,59] with a view toward cooperation rather than competition [60]. In a context of inter-connections, some researchers emphasize the importance of local learning [52,53], while others give importance to the links between market processes and institutional and cultural factors [61,62]. The literature shows that strong cooperation networks between firms and support agencies within clusters are characteristics of successful clusters [61,63], presenting differences in the importance of cooperation and competition in their environment [64].

2.2. Spatial Concentration and Sector Specialization: Research Hypotheses and Conceptual Model

Rodrick [65] indicates explicitly that the transition to modern industrial activities acts as a driver of growth, arguing that structural transformation is the only explanation of growth in a rapidly developing world. Later, Rodrick [66] also reveals that industry is the only sector of the economy that achieves unconditional convergence in productivity. The study by McCausland and Theodossiou [67] confirms the positive impact of industrialization on growth, also underlining that the role of the service sector in determining economic growth is not comparable to that of the industrial sector. Kathuria and Natarajan [68] analyze the determinant factors of regional growth, concluding that more industrialized regions grow more quickly. Güçlü [69] also finds evidence that the industrial sector has a positive impact on economic growth. Szirmai and Verspagen [70] assess the impact of the industrial sector on economic growth and find it has a moderately positive effect, not finding the same effect for the service sector. A study by Haraguchi et al. [71], in the context of developed and developing countries, revealed that growth stimulated by industrialization is still powerful for

developing countries, despite recent allegations of reduced industrial development and the reduced relevance of industry for economic development and structural change in the economy.

More recently, Zhao and Tang [72] examined the sources of economic growth in China compared to Russia in the period between 1995 and 2008, finding that increased economic growth in Russia was stimulated largely by the service sector, which was followed by the primary sector. On the contrary, in China, increased economic growth was largely achieved through the contribution of the industrial sector and to a lesser extent by the service sector. In addition, the hypothesis of a non-linear relation between industrialization and economic growth is not rejected, according to the evidence found in the study by Ortiz et al. [73], who argue that every society should strive to achieve a minimum level of industrial technological integration before being able to reap the benefits of industrialization in the form of economic growth. If the hypothesis was rejected, it would imply that countries enjoy the benefits of industrialization in economic growth once they go beyond a certain threshold of technological integration in the industrial sector. Although the empirical evidence reflects the impact of industrialization on economic growth and not directly on productivity, with the proviso that productivity can be an indicator revealing various economic indicators, in that it provides a measure of economic growth, the above results in the following research hypotheses:

Hypothesis 1. *Industrialization is positively related to productivity.*

Hypothesis 2. *Increased industrialization has a non-linear relation with productivity.*

The impact of agglomeration on productivity can be seen according to two theories that best explain specialization and diversification, these being Marshall-Arrow-Romer (MAR) theory and Jacobs theory. Beginning with the theory of Marshall [11], Arrow [74] and Romer [75], formalized by Glaeser et al. [76] as Marshall–Arrow–Romer (MAR), which predominates in specialized environments and defends that the concentration of an industry in one region promotes knowledge spillovers between companies and facilitates innovation in a specific industry within a region. According to Saxenian [50], specialization stimulates the transmission and exchange of knowledge, ideas, and information, whether tacit or coded, about products and processes through imitations, commercial interactions, and qualified workers' circulation among companies, without monetary transactions. However, knowledge externalities among companies only occur between firms in the same or similar industries, and so, they can only be supported by regional concentrations of the same or similar industries. Consequently, it is also assumed there can be no knowledge spillovers between industries. Frenken et al. [77] mention that MAR externalities tend to emerge when the industry the company's main activity belongs to is relatively large. Mukkala [78] argues that workers are consequently better protected from business uncertainty and demand shocks if located in a region with a major local base of their own industry. Glaeser et al. [76] conclude that a local monopoly is better for growth than local competition, since a local monopoly restricts the flow of ideas to others, and therefore allows externalities to be internalized by the innovator. Those spillovers of an intra-industrial nature are known as externalities of location or specialization or MAR.

The theory of Jacobs [79], which prevails in diversified environments, proposes that the most important sources of knowledge spillovers are outside the industry in which a given firm operates. As the diversity of these sources of knowledge is greater in cities, Jacobs [79] also concludes that cities themselves are a source of innovation. This theory emphasizes that the variety of industries in a given geographical region promotes knowledge externalities, and consequently, innovative activity and economic growth. Furthermore, a more diversified business community in close proximity promotes opportunities to imitate, share, and recombine ideas and practices in all sectors. For Harrison et al. [80], a more diversified economy favors the exchange of necessary skills for the emergence of areas of economic activity. In this connection, for Combes [81], this assumes that technologically related sectors can come to be incorporated in the production activities of other industries. Moreover, transport and communication infrastructure that works well, proximity to markets, and better access to specialized services are additional sources of Jacobs externalities that Jacobs argues facilitate firms' operations.

Jacobs [79] uses the example of Manchester as a city specialized in textiles that failed, in contrast to the success of Birmingham, which was structurally diversified to argue that the diversification of industries in the same place, and not specialization, can promote knowledge-related externalities and lead to innovation and economic growth. Therefore, it is indicated that a diversified local production structure originates diversification externalities.

In the empirical literature, the results obtained by De Lucio et al. [82] show that MAR externalities affect productivity growth, the same not occurring with regard to Jacobs externalities. The same authors defend that below a certain threshold of specialization, MAR externalities have a negative effect on growth, and above that threshold, the opposite is true, i.e., greater specialization is better for productivity growth. Frenken et al. [77] do not find evidence of the effects of specialization on productivity, and their measurement of diversification reveals a negative impact on productivity growth, despite causing a strongly positive impact on employment growth. Mukkala [78] and Almeida [83] find evidence of specialization externalities in productivity. Beardsell and Henderson [84], Black and Henderson [85], and Henderson [86], using data on productivity, conclude that firms benefit from a more specialized industrial environment, thereby rejecting the theory of Jacobs. Dekle [87] compares the effect of MAR and Jacobs externalities on the growth of total factor productivity and employment growth and finds evidence of MAR in the former but not in the latter. Cingano and Schivardi [88] also find evidence of MAR externalities in the growth of total factor productivity but not in employment growth. None of these studies found that Jacobs externalities influence productivity growth, and Capello [89] and Henderson et al. [90] obtained similar results. Capello [89] separates large and small firms and reveals that economies of specialization have a positive impact on small firms' productivity. Henderson et al. [90] reveal that productivity increases in high-tech sectors when there is a greater concentration of the sector. Forni and Paba [91] give support to both MAR and Jacobs externalities when they analyze empirically the effects of specialization and industrial diversification on the growth of Italian industry, arguing that the effect of industrial agglomeration is vital in regional industrial growth, also concluding that industrial specialization and diversification have a significant facilitating function for most industries. Simonen et al. [92] indicate that both moderate specialization and diversification have a positive role in regional economic growth, despite being subject to the influence of the scale of the city, the agglomeration structure, and other conditions. Yuan et al. [93] show that MAR externalities increase technical efficiency, reducing pure technical efficiency and accelerating technological progress, while Jacobs externalities increase scale efficiency and technological progress, despite contributing to diminished pure technical efficiency. According to Groot et al. [94], a more recent view of the role of MAR externalities is based on the concepts of related and non-related industries. This vision shares the idea of the positive effect of inter-sector spillovers of the Jacobs type. However, the difference lies in the fact of even knowledge spillovers being linked and flowing geographically between sectors, with the effect on growth depending on the extent to which knowledge flows through complementary or non-complementary sectors. A region specialized in a particular composition of complementary sectors will experience higher rates of growth than one specialized in sectors that do not complement each other [95]. According to this point of view, results provided by Greunz [96], Bochma et al. [97,98], and Cainelli et al. [99] indicate that companies and start-ups should agglomerate in regions where there is close technological proximity between firms. Concerning diversification, Glaeser et al. [76] argue that a local industry prospers if it faces a diversified surrounding economic structure. The results found by Batisse [100] when studying the relation between the local economic structure and the growth of Chinese provinces show that specialization has a strong negative impact on growth, whereas a more diversified industrial community has a positive impact. Capello [89] studies small and large companies, revealing that diversification externalities are more advantageous for large ones. Frenken et al. [95] assess whether the diversification of related or non-related industries favors stability and regional growth, finding that the related diversification of industries contributes to increasing employment. Considering the above, the following research hypothesis is formulated:

Hypothesis 3. *Diversification is positively related to productivity.*

According to Aw and Hwang [101], there is consensus regarding the primary role of exports in determining high levels of growth in production and productivity. Aw and Hwang [101], Bernard and Wagner [102], Bernard and Jensen [103], Aw et al. [104] and Delgado et al. [105] analyze empirically how exports and productivity are related to company structure, with the evidence revealing that exporting firms perform better than non-exporting ones, not only in terms of survival, salaries, capital intensity, and technological sophistication, but also in productivity. Now, the question raised here is if exports have a positive moderating effect on the relation between diversification and productivity. In this connection, according to Jacobs [79], in the case of a country, city, or region, these grow through a process of gradual diversification and differentiation of their economy, being stimulated by production oriented to the external market and by work efforts directed to exports. During the process of economic growth, through adding new work to the economy, it is essential that internal products come to be exported and that new products are created, for both the internal and external markets.

Returning to the vision of Jacobs [79], if a serious problem arises in the economy, this can only be solved by adding new goods and services. Considering the multiplying effect of exports, specialization of the internal production of certain goods and services for local consumption allows the latter to be exported, as the greater the specialization, the easier it becomes to export the goods, which in turn creates wealth, stimulates local employment, and makes increased imports viable.

The capacity to develop new goods and services for export is essential in this growth process, as in the same line of argument as Jacobs [79], the capacity to develop new goods and services for export is essential for the process of strengthening productivity, in that generating new exports gives room for the local expansion of work, due to the multiplying effect of exports, and puts pressure on the increased efficiency of the productive structure. In this connection, Prebisch [106] argues that diversification of the productive structure also benefits economic growth, in that it can make the country less dependent on more sophisticated imports and can therefore contribute to reducing the external imbalance and to combating low levels of economic growth. Moreover, diversification of the productive structure could lead to diversifying the export structure, reducing the dependence on income from exporting few goods, normally commodities. Imbs and Waczarg [107] consider that structural change responds basically to the commercial policy followed and economic growth, which agrees with the line taken by Chenery et al. [14], who indicate that economies that follow growth strategies guided by exports industrialize earlier, register higher rates of total factor productivity and are faster to reach the productive structure of an advanced economy. Therefore, the following research hypothesis is considered:

Hypothesis 4. *Exports have a moderating effect between diversification and productivity.*

Considering the literature review and the research hypotheses formulated, the operational model presented in Figure 1 is proposed.

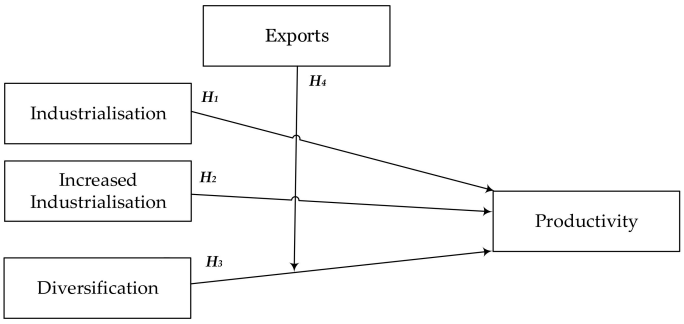

Figure 1. Determinants of concentration and specialization of productivity: Model and hypotheses. **Source:** Own elaboration.

3. Methodology

3.1. Concentration and Specialization: Indicators and Metrics

For Delgado and Godinho [108], the indicators of localization and specialization are measures of a descriptive nature that can characterize the production structure of each region, aiming to analyze the degree of geographical concentration/dispersion and the degree of specialization or diversification. According to Paiva [109], in calculating these indicators, the variable used should be the one ensuring the least possibility of bias in the results and also presenting the greatest possible number of sub-sectors, as the greater the sectoral disaggregation, the better the identification of regional specialization. In this context, the variable most commonly used in the literature, particularly in the classic studies by Isard [110] and later in the study by Dion [111], is the one corresponding to the number of employees by sector, and for that reason, this variable is used here. After defining the variable to be used, the sectors of economic activity considered here are primary, secondary, and tertiary. Based on the Portuguese Classification of Economic Activities, 3rd review, abbreviated to CAE-Rev.3 (Table 1), the primary sector is considered to include sections A and B of CAE-Rev.3; the secondary sector covers sections C, D, and E of CAE-Rev.3; and the tertiary sector includes sections F, G, H, I, J, L, M, N, O, P, Q, R, and S of CAE-Rev.3. Sections K, O, T, and U are not considered due to the lack of available information.

Table 1. Portuguese Classification of Economic Activities: CAE-Rev.3.

CAE-Rev.3	
Section	**Designation**
A	Agriculture, livestock, hunting, forestry and fishing
B	Mining industry
C	Manufacturing industry
D	Electricity, gas, steam, hot and cold water and cold air
E	Water storage, treatment and distribution; sanitation, waste management and depollution
F	Construction
G	Wholesale and retail commerce; car and motorcycle repair
H	Transport and storage
I	Accommodation, restaurants, and similar
J	Information and communication activities
K	Financial and business activities
L	Real estate activities
M	Consultancy, scientific, technical and similar activities
N	Administrative activities and support services
O	Public administration and defense; obligatory social security
P	Education
Q	Human health activities and social support
R	Artistic, performance, sporting, and recreational activities
S	Other service activities
T	Activities of families employing domestic staff and family production activities for own consumption
U	Activities of international bodies and other foreign institutions

Source: Adapted from the National Statistics Institute (INE). https://www.ine.pt/ine_novidades/semin/cae/CAE_REV_3.pdf.

After choosing the variable to be used and the area of analysis for calculation of the indicators, the following coding is defined: x represents employment; i represents each sector of activity; I represents the set of sectors in an economy; r represents each of the local authorities in which the area of analysis is sub-divided; R represents the set of local authorities according to NUTS II, i.e., Algarve, Alentejo, Metropolitan Area of Lisbon, Centre, North, Autonomous Regions of the Azores and Madeira; j represents manufacturing industry; PE represents the employed population; A represents area in Km^2; $E \leq 9$ represents the number of establishments with no more than nine employees; $E \leq 49$ the

number of establishments with no more than 49 employees; $E \leq 249$ the number of establishments with no more than 249 employees; and $E \geq 250$ the number of establishments with 250 or more employees.

$$x_{ri} = \text{employment for the local authority } r \text{ and the sector of activity } i \quad (1)$$

$$x_i = \sum_{r=1}^{R} x_{ri} = \text{employment by NUTS II for the sector } i \quad (2)$$

$$x_r = \sum_{i=1}^{I} x_{ri} = \text{employment for the local authority } r \text{ in all sectors} \quad (3)$$

$$\sum_{r=1}^{R} \sum_{i=1}^{I} x_{ri} = \text{employment registered by NUTS II, in all sectors of activity} \quad (4)$$

$$x_{rj} = \text{Employment for the local authority } r \text{ and in manufacturing industry} \quad (5)$$

$$PE_R = \text{Population employed by NUTS II} \quad (6)$$

$$A_r = \text{Local authority area } r, \text{ in Km}^2 \quad (7)$$

$$E \leq 9_r = \text{No of establishments with up to 9 employees in the local authority } r \quad (8)$$

$$E \leq 49_r = \text{No of establishments with up to 49 employees in the local authority } r \quad (9)$$

$$E \leq 249_r = \text{No of establishments with up to 249 employees in the local authority } r \quad (10)$$

$$E \geq 250_r = \text{No of establishments with 250 or more employees in the local authority } r \quad (11)$$

$$i = 1, \ldots, 3 \quad (12)$$

$$r = 1, \ldots, 308 \quad (13)$$

Table 2, below, from expressions (1) to (13), presents the indicators of localization and specialization. The indicators of localization and specialization calculated are the following: Quotient of Localization (QL_{ri}); Coefficient of Specialization (CE_r); Rate of Industrialization (TI_r); Density of Establishments by Business Size ($Micro_r$, $Small_r$, $Medium_r$,$Large_r$); and the Theil Index included in the indices of generalized entropy (IT_r).

Table 2. Indicators of Localization and Specialization.

Indicators	Metrics	Reference
Quotient of Localization (QL_{ri})	$QL_{ri}=\frac{\left(\frac{x_{ri}}{x_r}\right)}{\left(\frac{x_i}{x}\right)}$, $QL_{ri \geq 0}$	$\left(\frac{\frac{Loc.Authority}{Loc.Authority}}{\frac{NutsII}{NutsII}}\right)$
Coefficient of Specialization (CE_r)	$CE_r=\frac{\sum_{i=1}^{I}\left\lvert\frac{x_{ri}}{x_r}-\frac{x_i}{x}\right\rvert}{2}$, $CE_r \in [0,1]$	$\left\lvert\frac{Loc.Authority}{Loc.Authority} - \frac{NutsII}{NutsII}\right\rvert$
Rate of Industrialization (TI_r)	$TI_{r=\frac{x_{rj}}{PE_R}}$	$\left(\frac{Loc.Authority}{NutsII}\right)$
Density of Establishments by Business Size ($Micro_r$, $Small_r$, $Medium_r Large_r$)	$Micro_{r=}\ \frac{E\leq 9_r}{A_r}$, $Micro_r \geq 0$ $Small_{r=}\ \frac{E\leq 49_r}{A_r}$, $Small_r \geq 0$ $Medium_{r=}\ \frac{E\leq 249_r}{A_r}$, $Medium_r \geq 0$ $Large_{r=}\ \frac{E\geq 250_r}{A_r}$, $Large_r \geq 0$	$\left(\frac{Loc.Authority}{Loc.Authority}\right)$
Theil Index (IT_r)	$IT_r = -\sum_{i=1}^{I}\left[\frac{xri}{xr} * log\left(\frac{xri}{xr}\right)\right]$, $0 \leq IT_r \leq \log I$ Normalize Theil Index (IT_r) $IT_r = \frac{logI - IT_r}{logI}$, $0 \leq IT_r \leq 1$	$\left[\frac{Loc.Authority}{Loc.Authority} * log\left(\frac{Loc.Authority}{Loc.Authority}\right)\right]$

Source: Elaborated by the authors, based on Cerejeira [22] and Simões Lopes [112].

The localization quotient (QL_{ri}) is the most widely used indicator in the literature, being explicitly recommended by Isard [110] to measure the relative level of concentration of the sector of activity i in local authority r and identify the relative centers of localization and specialization of activity i in the national territory. The indicator takes positive or null values and will be higher the higher the concentration of activity i in local authority r. The indicator has the value of 0 when sector i is not present in the local authority r; if the value is under 1, the weight of sector i in the local authority is relatively less than that of the area of reference. For values of 1, the relative importance of sector i in the local authority r is the same as the relative importance of the sector nationally, i.e., the regional and national concentration of sector i are identical. When the value of the indicator is above 1, this means that sector i is relatively concentrated in local authority r. A low value of the localization quotient reflects the absence of regional competitive advantage in that sector or simply lost opportunities [110]. The degree of regional specialization is analyzed through calculating the specialization coefficient (CE_r), with the (CE_r) of local authority r being a relative measure of the degree of regional specialization, which compares the regional sector structure with the sector structure of the area of reference. The indicator takes a null value (extreme situation), when the regional sector structure coincides with that of the area of reference. In this case, the local authority is not considered specialized. The closer to 1 the value of the indicator, the greater the distancing from the regional sector structure from that of the country, with the local authority being considered specialized. This indicator has the great advantage of summarizing in a single value the degree of relative specialization, compared to the localization coefficient, with the disadvantage of not indicating the sectors in which the region is specialized, but this failing can be overcome through complementary analysis of the localization quotient. The rate of industrialization (TI_r) measures the percentage of the population employed in the manufacturing industry in relation to the total population employed in the local authority [113], and it can have positive or null values, being higher the greater the local authority's industrialization. The density of establishments by business size ($Micro_r$, $Small_r$, $Medium_r$, $Large_r$) measures the number of establishments according to business size by km^2. Employer size is according to the European classification, i.e., up to 10 employees refers to micro-firms, while small firms have between 10 and 49 employees, medium-sized ones have between 50 and 249 employees, and large ones have 250 or more employees. The Theil Index (IT_r) is a compound index that can measure a local authority's degree of specialization/diversification, as explained in the following section, which gives a brief description of the origin of the concept of entropy and the indices derived from generalized entropy.

Entropy and Its Measures

The concept of entropy, which in general terms is a measure of the dispersion of material in a given space, was developed and applied to a variety of subjects, including thermodynamics [114], kinetic theory [115], classic statistical mechanics [116], quantum statistical mechanics [117], and the theory of information [118]. Derived from information theory, measures of generalized entropy serve to measure the distribution of wealth, and according to Mussard et al. [119], different metrics such as the Herfindahl–Hirschman Index (HHI), Atkinson Index, Gini Index, and Theil Index, are particular cases of the class of measures of generalized entropy.

The Herfindhal Index, known as the Herfindahl–Hirschman Index, or HHI, which was proposed independently by Hirschman [120] and Herfindahl [121], includes the family of generalized indices of entropy. Later, Hirschman [122] claimed authorship of the index. HHI measures the concentration of industry using the data of all companies in a given industry and is written as follows:

$$\text{HHI} = \sum_{i=1}^{N} S_i^2 \tag{14}$$

where N is the number of companies; and S_i is the market quota of company i in the market. The index varies from $1/N$ (lower limit) to 1 (upper limit)

The Atkinson index, also known as the Atkinson measure or Atkinson's measure of inequality, proposed by Atkinson [123], represents the percentage of total income that a given group should have to give up for more partitions of equal income to be viable. The index varies from 0 (perfect equality) to 1 (maximum inequality) and is represented by:

$$A_\varepsilon = 1 - \left[\frac{1}{n} \sum_{i=1}^{n} \left(\frac{y_i}{\overline{y}} \right)^{1-\varepsilon} \right]^{\frac{1}{(1-\varepsilon)}} \tag{15}$$

where $\overline{y}$ is average income, y_i is individual income, i is the number of individuals or families, and ε indicates the degree of aversion to disparity.

The Gini Index, also known as the Gini coefficient, was developed by Gini [124] to express inequality of wealth and is based on the Lorenz curve, which is the curve of accumulated frequencies that compares the distribution of income with uniform distribution representing equality. Application of the Gini coefficient in measuring inequalities can be limited to a part of the distribution, in this case, the part corresponding to the lower or upper extreme of income distribution. Considering x_i as a point on the axis of x (representing the accumulated percentage of the population) and y_i as a point on the axis of y (axis of the accumulated percentage of income), the Gini coefficient can be expressed as follows:

$$\text{Gini} = 1 - \sum_{i=1}^{N} (x_i - x_{i-1})(y_i + y_{i+1}). \tag{16}$$

When there are equal intervals on the axis of x, this is simplified

$$\text{Gini} = 1 - \frac{1}{N} \sum_{i=1}^{N} (y_i + y_{i+1}). \tag{17}$$

The Theil Index, proposed by Theil [125], belongs to the family of generalized indices of entropy. This measure serves fundamentally to analyze the distribution of wealth, and in this article, the Theil notion of entropy serves to analyze the diversity of sectors of economic activity present in a local authority, meaning here a measure of diversification of a given local authority. The degree of specialization/diversification obtained through the Theil index (IT_r) depends only on the sectoral structure of the local authority analyzed. The limits of this indicator vary between 0 (indicating situations of maximum specialization) and the logarithm of the number of sectors of activity retained for analysis (signaling situations of total diversification). The result of the Theil Index (IT_r) can also be normalized to vary between 0 and 1, representing maximum diversification and maximum specialization, respectively.

It is interesting to remember that the choice of index to use is directly related to the specific aspect to be studied. It is emphasized that use of the Theil Index is important, since it allows assessment of the specific structure of a region (or local authority), immediately classifying the position of regions (or local authorities). Using it for only one region (or local authority) diminishes the capacity to interpret the results, and so it is advantageous to analyze the results of this index in comparison with other regions (or other local authorities) presenting a relevant common reference framework such as geographical proximity, location, spatial concentration of related companies, similar development strategies, etc.

3.2. Threshold Regression Method

The regression model with the threshold effect, originally proposed by Tong [126] and Tong and Lim [126], emerged applied to the context of time series, allowing individual observations to be divided in regimes based on the value of an observed variable. This model divides the sample in classes based on the value of an observed variable, irrespective of exceeding any limit. Later, Hansen [127] introduced appropriate techniques for the threshold regression with panel data. Allowing fixed individual effects, the regression model with the threshold effect with panel data divides the observations in two or more

regimes, depending on whether a threshold variable is below or above a threshold value and whether those regimes are distinguished by different regression slopes. Therefore, from panel data, the equation of the model of the single threshold type is expressed by the following equation:

$$y_{it} = \mu + \boldsymbol{X}_{it}(q_{it} < \gamma)\boldsymbol{\beta}_1 + \boldsymbol{X}_{it}(q_{it} \geq \gamma)\boldsymbol{\beta}_2 + u_i + e_{it} \tag{18}$$

where $i = 1 \ldots N$; $t = 1 \ldots T$; y_{it} is a scalar-dependent variable; X_{it} is a regression vector; q_{it} is a scalar threshold variable; and γ is the threshold parameter that divides the equation in two regimes with coefficients $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$. In addition, the parameter u_i corresponds to the individual effect and e_{it} corresponds to the error term. With γ given, the ordinary least squares estimator of $\boldsymbol{\beta}$ is expressed by the following equation:

$$\hat{\boldsymbol{\beta}} = \left\{\boldsymbol{X}^*(\gamma)'\boldsymbol{X}^*(\gamma)\right\}^{-1}\left\{\boldsymbol{X}^*(\gamma)'\,\boldsymbol{y}^*\right\} \tag{19}$$

where $\boldsymbol{X}^*$ and y^* belong to the group of deviations. The residual sum of squares is equal to $\hat{e^*}'$ and $\hat{e^*}$. To estimate γ, a search can be made of the subset of the threshold variable q_{it}, since instead of the search being made for the whole sample, this can be restricted to the interval $\left(\overline{\gamma},\ \underline{\gamma}\right)$, which are quantiles of q_{it}. When γ is known, the model is not different from a common linear model, but in the case of γ being unknown, there is a parameter problem, which makes distribution of the estimator γ outside the standard. Given the above, Hansen [127] proved that $\hat{\gamma}$ is a consistent estimator for γ, arguing that the most suitable way to test $\gamma = \gamma_0$ is respecting a confidence interval using the method of non-rejection of the region with a likelihood ratio statistic expressed as follows:

$$LR_1(\gamma) = \left\{\frac{LR_1(\gamma) - LR_1(\hat{\gamma})}{\hat{\sigma^2}}\right\} \xrightarrow{P_r} \xi P_r(x < \xi) = \left(1 - e^{\frac{-x}{2}}\right)^2. \tag{20}$$

Therefore, for a level of significance α, the lower limit corresponds to the maximum value, which is less than the quantile α, and the upper limit corresponds to the minimum value, which is less than the quantile α. For example, for a $\alpha = 0.1$, 0.05 and 0.01, the quantiles are 6.53, 7.35, and 10.59, respectively. If $LR_1(\gamma_0)$ is more than c (α), then H_0 is rejected. In turn, the test for the threshold effect is identical to the one used to test whether the coefficients are the same in each regime. The null hypothesis (H_0) and the alternative hypothesis (H_a) are expressed as:

$$H_0\text{: } \beta_1 = \beta_2 H_a\text{: } \beta_1 \neq \beta_2. \tag{21}$$

The F statistic is given by:

$$F_1 = \frac{\left(S_0 - S_1\right)}{\hat{\sigma^2}} \tag{22}$$

where S_0 is the sum of squared errors obtained through estimating Equation (18) with the null hypothesis of the non-existence of any threshold; S_1 is the sum of squared errors obtained from estimating the equation of the single threshold model of panel data (see Equation (18)); and $\hat{\sigma}^2$ is the residual variance of the regression of the single threshold model of panel data (see Equation (18)). As in H_0, the threshold γ is not identified, and F_1 has a non-standard asymptotic distribution, Hansen [128] suggests using a bootstrap procedure for the critical values of the F statistic in order to test the significance of the threshold effect. If there are multiple thresholds, i.e., various regimes, Hansen [127] suggests estimation of a double threshold model, which can be expressed as follows:

$$y_{it} = \mu + \boldsymbol{X}_{it}(q_{it} < \gamma_1)\boldsymbol{\beta}_1 + \boldsymbol{X}_{it}(\gamma_1 \leq q_{it} < \gamma_2)\boldsymbol{\beta}_2 + X_{it}(q_{it} \geq \gamma_2)\boldsymbol{\beta}_3 + u_i + e_{it} \tag{23}$$

where γ_1 and γ_2 are the thresholds that divide the equation in three regimes with coefficients $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, and $\boldsymbol{\beta}_3$. The general approach of the threshold model to test multiple thresholds is similar to what is performed in the case of the single threshold model, albeit with some differences. The first difference

concerns the estimating procedure, which can be a three-stage sequenced estimate (when there are only three regimes) of two limiting parameters. Here, the first stage involves the same estimating procedure as presented for the single threshold model, which produces the first estimate $\hat{y}_1$. By fixing this threshold parameter, in the second stage, the second threshold parameter $\hat{y}_2^r$ is estimated, minimizing the sum of the squared errors of the equation (see Equation (23)). In the third and final stage, the first threshold parameter is re-estimated, keeping the second threshold parameter fixed. This sequential three-stage estimate results in the asymptotically efficient estimator of the threshold parameters, $\hat{y}_1^r$ and $\hat{y}_2^r$. It is noted that these estimators have the same asymptotic distributions as the threshold estimate obtained from a single threshold model, which means that confidence intervals should be considered, similarly to what was mentioned above. The second difference concerns the inference about the threshold estimates. When the null of no threshold is rejected with the F_1 statistic, it is necessary to make an additional test to discriminate between one and two thresholds. This test is carried out through application of a bootstrapping procedure, but now simulating the distribution of the F_2 statistic, which is expressed as follows:

$$F_2 = \frac{\left\{S_1\left(\overline{\hat{y}}_1\right) - S_2^r\left(\overline{\hat{y}}_2^r\right)\right\}}{\hat{\sigma}_{22}^2} \tag{24}$$

where S_1 is the sum of the squared errors obtained from the estimate in the first stage; $\hat{y}_2^r$ is the sum of the squared errors obtained from the estimate in the second stage; and $\hat{\sigma}_{22}^2$ is the residual variance of the estimate in the second stage.

Variables and Specification of the Model

Using localization and specialization indicators, as well as other variables referring to the 308 Portuguese local authorities, for the period 2013–2017, a balanced panel was constructed. Table 3 presents the variables used and the corresponding description.

Table 3. List and description of variables.

	Variable	Description
Dependent variable	$Logproduct_r$	Logarithmic transformation of productivity
Independent variables	TI_r	Rate of industrialization
	${TI_r}^2$	Squared rate of industrialization
	${TI_r}^3$	Cubic rate of industrialization
	IT_r	Theil Index (diversification)
	$Export_r * IT_r$	Term of interaction between the weight of exports and the Theil Index
Control variables	IES_r	Number of higher education Institutions, by local authority
	$Clusters_r$	Variation in number of clusters [1]
Threshold variable	CE_r	Coefficient of specialization
Variables in dependent regime	$Micro_r$	Density of micro-firms
	$Small_r$	Density of small firms
	$Medium_r$	Density of medium firms
	$Large_r$	Density of large firms

[1] The variation in the number of clusters for 2013, 2014 and 2015 obtained from the sums of centres of competitiveness identified by the programme of Compete 2007 and 2013 and the clusters identified by the same programme for 2003–2015 less the clusters that had been identified by Porter in 1992 and for the years 2016 and 2017 the variation was obtained through the clusters of competitiveness recognised by IAPMEI in 2015 less the centres of competitiveness identified by the Compete programmes 2007 and 2013 less the clusters identified by the same programme for 2003–2015. **Source:** Own elaboration.

In this study, the dependent variable corresponds to the logarithmic transformation of productivity ($Logproduct_r$). The independent variables used are associated with the research hypotheses raised:

rate of industrialization (TI_r); squared rate of industrialization ($TI_r{}^2$); cubic rate of industrialization ($TI_r{}^3$); diversification measured by the Theil Index (IT_r); and the term of interaction between exports and the Theil Index ($Export_r * IT_r$). Concerning the control variables, these are the number of higher education institutions (IES_r) and a variation in the number of clusters ($Clusters_r$) that can influence productivity in some way.

According to Conceição and Heitor [129], the low level of productivity in Portugal may be justified partly by the structure of the economy, which has a relatively high quota of non-specialized workers in sectors with intensive incorporation of the work production factor. This low level of education of the majority of the population is one of the main reasons why many companies continue in activities of low productivity and do not adopt more new technology [130]. Consequently, there is growing recognition that a more educated population can generally be more innovative and more able to absorb technological changes [130]. Therefore, HEIs create knowledge that they supply to the economy, leading to increased productivity and simultaneously to a better provision of human capital [131]. Regarding clusters, according to Porter [63], these can increase productivity in various ways, namely through better access to inputs and specialized workers. Porter [63] mentions that clusters typically allow better access to institutions, public goods, and infrastructure; provide greater incentives to achieve high productivity; and make it easier for companies to measure the performance of internal activities. Various empirical studies reveal the positive effect of clusters on productivity, as in the case of the study by Martin et al. [132], which shows that French companies benefit from localization externalities that increase productivity, and the study by Cainelli et al. [99] exploring the impact of agglomeration and diversity on total factor productivity, suggesting that clusters have a significant effect on companies' total factor productivity.

In this empirical approach, the type of model used also allows definition of a threshold variable concerning specialization (CE_r), as well as variables in a dependent regime that correspond to the density of firms by business size: ($Micro_r$); ($Small_r$); ($Medium_r$); and ($Large_r$). Therefore, the threshold model is adopted to estimate the level of the specialization threshold (CE_r) and analyze its influence on the logarithmic transformation of productivity ($Logproduct_r$). The specification of the econometric model, with indication of the threshold equation regression, is given by the equation:

$$\begin{aligned} Logprodut_{r_{it}} = {} & \mu + TI_{r_{it}} + TI_{r_{it}}{}^2 + TI_{r_{it}}{}^3 + IT_{rit} + Export_r * IT_{r_{it}} + IES_{r_{it}} + Clusters_{r_{it}} + \boldsymbol{X}_{it}(CE_{r_{it}} < \gamma_1)\boldsymbol{\beta}_1 \\ & + \boldsymbol{X}_{it}\left(\gamma_1 \leq CE_{r_{it}} < \gamma_2\right)\boldsymbol{\beta}_2 + \boldsymbol{X}_{it}\left(CE_{r_{it}} \geq \gamma_2\right)\boldsymbol{\beta}_3 + u_i + e_{it} \end{aligned} \quad (25)$$

where i =1, ... , 308; t =2013, ... , 2017; μ = Constant; X_{it} = Regression vector (Micro, Small, Medium and Large); γ_1 and γ_2 = Threshold parameters that divide the equation; $\boldsymbol{\beta}$ = Coefficients; u_i = Individual effect; and e_{it}= Error term.

4. Results

A double threshold model was tested, using a bootstrap method with 300 replications. First, for the single threshold model (Th-1), the results indicate that the estimator is 0.348 with a confidence interval of 95% [0.343; 0.352] (see Table 4).

Table 4. Threshold estimator.

	Threshold	Confidence Interval for 95%
Th-1	0.348	[0.343;0.352]
Th-21	0.348	[0.343;0.352]
Th-22	0.023	[0.017;0.023]

Source: Own elaboration.

Furthermore, the results show that in the test for the single threshold model (with H_0: linear model; H_1: single threshold model), the F_1 statistic of 78.040 is greater than its critical value of 64.294 for a level of significance of 1% (see Table 5). Therefore, the F_1 statistic is significant with a bootstrap p value of 0.003, indicating that H_0 is rejected. In other words, the relation between specialization (CE_r) and productivity ($Logproduct_r$) is not linear, and there is the threshold effect. For the double threshold model, the F_2 statistic (with H_0: single threshold model; H_1: double threshold model) is highly significant with a bootstrap p value of 0.000 (F_2 = 48.570 > Crit 1 = 38.295). This results in rejecting H_0, suggesting the detection of a double threshold model with the estimates of 0.348 (Th-21) and 0.023 (Th-22) (see Table 4).

Table 5. Effect of the threshold test.

Test of the Threshold Effect (Bootstrapping; n.º of Replications = 300)							
Threshold	**RSS**	**MSE**	**F**	**P**	**Crit10%**	**Crit5%**	**Crit1%**
Single	235.237	0.191	78.040	0.003	46.118	51.730	64.294
Double	226.314	0.184	48.570	0.000	28.581	32.006	38.295

Source: Own elaboration.

The results of the fixed effects regression and threshold effect are presented in Table 6.

Table 6. Regression estimates: double threshold model.

Variables	**Fixed Effects**	
	Coefficients	**P > |t|**
$Logproduct_r$		
TI_r	0.423	0.000 ***
${TI_r}^2$	−0.044	0.000 ***
${TI_r}^3$	0.001	0.000 ***
IT_r	0.881	0.000 ***
$Export_r * IT_r$	3.446	0.000 ***
IES_r	0.021	0.000 ***
$Clusters_r$	−0.019	0.005 ***
	Threshold effect	
	Coefficients	**P > |t|**
$Micro_r$		
$CE_r (CE_r < 0.023)$	0.003	0.009 ***
CE_r $(0.023 \leq CE_r < 0.348)$	0.000	0.747
CE_r $(CE_r \geq 0.348)$	−0.042	0.000 ***
$Small_r$		
$CE_r (CE_r < 0.023)$	−0.167	0.001 ***
CE_r $(0.023 \leq CE_r < 0.348)$	0.002	0.891
CE_r $(CE_r \geq 0.348)$	0.415	0.219
$Medium_r$		
$CE_r (CE_r < 0.023)$	1.232	0.000 ***
CE_r $(0.023 \leq CE_r < 0.348)$	−0.263	0.000 ***
CE_r $(CE_r \geq 0.348)$	1.910	0.092 *
$Large_r$		
$CE_r (CE_r < 0.023)$	−2.786	0.000 ***
CE_r $(0.023 \leq CE_r < 0.348)$	0.063	0.828
CE_r $(CE_r \geq 0.348)$	−80.844	0.000 ***
constant	1.203	0.000
F test of all u_i = 0: F(4.152) = 3.06Prob < F = 0.016		

* significance 10%| *** significance 1%. **Source:** Own elaboration.

The F statistic of 3.06, for a level of significance of 5% with the null hypothesis of all u_i=0 confirms that the fixed effect model is appropriate. Considering that the model is appropriate and that the

regression estimates in the double threshold model indicate the effect of specialization in three regimes, the summarized description of the most significant variables found follows, with subsequent reference to the tests of the research hypotheses.

The parameters displayed in Table 6 for the variables TI_r, ${TI_r}^2$, ${TI_r}^3$, IT_r, $Export_r * IT_r$, IES_r, and $Clusters_r$ have been estimated through panel data regression with fixed effects, as well as considering the admission of the threshold effect, which provides the calculation of the estimators relating to business size: $Micro_r$, $Small_r$, $Medium_r$, and $Large_r$, which vary according to the three specialization regimes, in corresponding terms.

It is worth pointing out that the rate of industrialization (TI_r), cubic transformation of the rate of industrialization (${TI_r}^3$), the Theil Index representing diversification (IT_r), the term of interaction between the weight of exports and the Theil Index ($Export_r * IT_r$), and higher education institutions (IES_r) have a positive and significant (1%) influence on productivity ($Logproduct_r$). In addition, with a significance of 1%, the squared transformation of the rate of industrialization (${TI_r}^2$) and the variation in the number of clusters ($Clusters_r$) have a negative influence on productivity ($Logproduct_r$).

In addition, when considering the increased rate of industrialization, performing, firstly, a squared transformation of the rate of industrialization and then calculating the first order partial derivative given by $\frac{\partial Logproductr}{\partial TI_r} = 0.4234 - 0.0884x + 0.0039x^2 = 0$, it is possible to identify 6.874 as the maximum and 15.792 as the minimum rate of industrialization. Explicitly, $x = \frac{-(-0.0084) - \sqrt{(-0.0884^2) - 4 \times 0.0039 \times 0.4234}}{2 \times 0.0039} = 6.874$ and $x = \frac{-(-0.0084) + \sqrt{(-0.0884^2) - 4 \times 0.0039 \times 0.4234}}{2 \times 0.0039} = 15.792$, which correspond to red points in Figure 2.

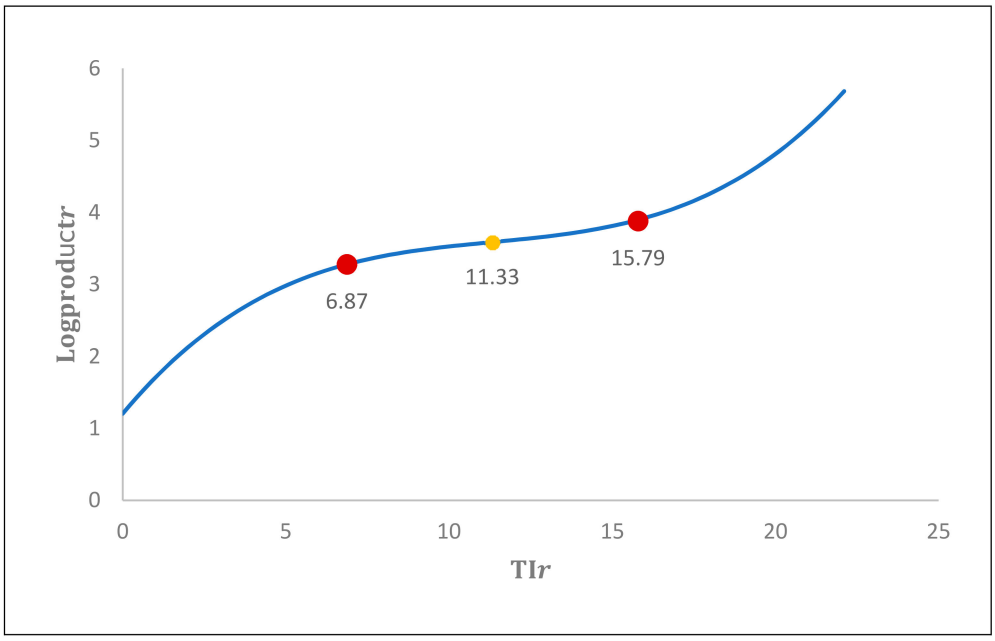

Figure 2. Relation between industrialization and productivity. **Source**: Own elaboration.

The result obtained implies that for a given rate of industrialization up to 6.874, industrialization is a determinant factor restricting productivity, while above this figure, increased industrialization is found to be a determinant factor with a positive effect on productivity. Consequently, the empirical results obtained now indicate the existence of a non-linear relation between the rate of industrialization and productivity. In turn, calculation of the second-order partial derivative given by $\frac{\partial Logproductr^2}{\partial {TI_r}^2} = -0.0884 + 0.0078\,x = 0$ identifies 11.333 as the point of inflection from which industrialization stimulates productivity. In more detail, $x = \frac{0.00884}{0.0078} = 11.333$, which corresponds to the yellow point in Figure 2.

When the analysis is made considering the density of establishments by business size, for a specialization (CE_r) < 0.023, a positive coefficient of 0.003 is detected, which implies a significant (1%) and positive relation between micro-firms ($Micro_r$) and productivity ($Logproduct_r$); when the specialization is $0.023 \leq CE_r < 0.348$, the positive coefficient of 0.000 suggests a positive but non-significant relation between micro-firms ($Micro_r$) and productivity ($Logproduct_r$), and when specialization (CE_r) is ≥ 0.348, the negative coefficient of −0.042 suggests that micro-firms ($Micro_r$) cause a negative and significant (1%) effect on productivity ($Logproduct_r$). Concerning small firms ($Small_r$), only for a specialization (CE_r) < 0.023 do we find a negative and significant (1%) effect on productivity ($Logproduct_r$). For higher levels of specialization for small firms ($Small_r$), there is no significant effect on productivity ($Logproduct_r$). As for medium-sized firms ($Medium_r$), when the specialization (CE_r) is <0.023, they produce a positive and significant (1%) effect on productivity, the same occurring for a specialization (CE_r) ≥ 0.348 but for a level of significance of 10%. For a specialization $0.023 \leq CE_r < 0.348$, a negative and significant (1%) effect on productivity ($Logproduct_r$) is found. Concerning large firms ($Large_r$), only for levels of specialization (CE_r) < 0.023 and ≥0.023 do we find a negative and significant (1%) effect on productivity. The results obtained when considering the density of establishments according to different business size—micro, small, medium, and large—are explained by the Portuguese business sector being formed mainly of micro and small firms, and it should be underlined that firms of this size show structural shortcomings regarding the quality of management and organization of processes and production that tend to improve productivity.

5. Discussion

Considering Hypothesis 1, proposing a positive relationship between industrialization and productivity, this cannot be rejected, since a significant and positive effect on productivity is found. This result agrees with the study by Rodrick [66], which found, using a large sample of countries, that industry is the only sector of the economy that achieves unconditional convergence in productivity. More evidence is obtained in previous studies—for example, McCausland and Theodossiou [67], Kathuria and Natarajan [68], Güçlü [69], and Szirmai and Verspagen [70], where it is concluded that the industrial sector causes a positive impact on economic growth, underlining in this connection the perspectives of Kathuria and Natarajan [68] and Szirmai and Verspagen [70], according to whom the role of the service sectors is not comparable to that of the industrial sector.

Hypothesis H_2 proposing a non-linear relation between an increased rate of industrialization and productivity is not rejected. Therefore, for squared transformation of the rate of industrialization, its effect is significant, but it has a negative impact on productivity. On the other hand, for cubic transformation of the rate of industrialization, its impact is significant and positive. Although there is no previous empirical evidence to directly corroborate the non-linear relationship between industrialization and productivity, considering the set of evidence obtained previously by Ortiz et al. [73], taking economic growth as the dependent variable, the non-linear relation between economic growth and industrialization is confirmed, which is in line with these authors' argument indicating that each society should strive to achieve a minimum level of industrial technological integration before being able to reap the benefits of economic growth arising from industrialization.

Concerning Hypothesis H_3, proposing that diversification is positively related to productivity, a positive and significant influence is found, meaning the hypothesis is not rejected. In this connection, Jacobs [79] argues that a diversification of industries in one place promotes knowledge-related externalities and leads to innovation and economic growth. Added to this is the view of Batisse [100], according to whom specialization has a strong negative impact on growth, contrasting with the positive impact associated with a more diversified industrial basis.

Regarding Hypothesis H_4 aiming to test the hypothetical moderating effect of exports on the relation between diversification and productivity, a positive, significant effect on productivity is found. This evidence agrees with the results of previous empirical studies by Aw and Hwang [101], Bernard and Wagner [102], Bernard and Jensen [103], Aw et al. [104], and Delgado et al. [105], which indicate that

exporting companies will have better performance than non-exporting ones, not only in terms of survival, salaries, capital intensity, and technological sophistication, but also in productivity. In addition, regarding exports affecting the relation between diversification and productivity, Prebisch [106] claims that diversification of the productive structure is beneficial for economic growth by making the country less dependent on more sophisticated imports, and therefore reducing the tendency toward external imbalance and a low level of economic growth in such economies.

6. Conclusions

The empirical evidence obtained indicates a non-rejection of the research hypotheses, and so industrialization is revealed to have a significant and positive relation with productivity. There is also evidence of non-linearity in the relation between increased industrialization and productivity, considering the line previously proposed by Ortiz et al. [73], which indicates the need to intensify industrial technological integration before being able to reap the benefits of industrialization for productivity, corresponding to increased economic growth. The moderating effect of exports on the relation between diversification and productivity is also found to be positive and significant, corroborating the existence of an acceleration effect of the "competitive productivity kit" type on the positive relation between the rate of industrialization and productivity. HEIs are also seen to have a positive and significant effect on productivity, and in this connection, it is true that HEIs create knowledge that they supply the economy with, leading to increased productivity and simultaneously a better provision of qualified human capital [131]. The control variable relating to the variation of clusters is also significant, but its impact on productivity is negative, which warrants continuous reflection by political decision-makers, planners, business people, and higher education institutions, toward the design and implementation of new practices and policies to strengthen the industrial critical mass, with the ultimate aim of raising productivity. Considering different regions of specialization by business size, the results obtained reveal that when it is a question of micro-firms and low levels of specialization, the impact of productivity is positive and significant, but for higher levels of specialization, the impact is negative. Small companies have a negative and significant effect on productivity when specialization is low. For high levels of specialization, small companies are found not to cause an impact on productivity. For a very low level of specialization, medium-sized firms have a positive and significant impact on productivity, and for an intermediate level of specialization, their impact on productivity is negative and significant. For higher and lower regimes of specialization, large companies have a negative and significant effect on productivity, which is not unrelated to the persistent gaps in terms of management quality and the need to update productive structures with greater technological intensity. This diversity of results according to business size is justified by the weight of micro, small, and medium-sized firms, accounting for around 99% of the Portuguese business sector. It is important to note that micro, small, and medium-sized companies differ from large ones in various ways [133]. For example, they have limited resources in terms of management, workforce, and finance [134], and they seem to be more flexible and accompanied by less formalized processes than in large firms, which can facilitate innovation.

One of the main limitations of this study arises from the unavailability of disaggregated data at the local authority level. For example, the rate of industrialization was calculated by considering the employed population in each NUTS II, according to data available in the 2011 census. Another limitation concerns the shortage of empirical studies on the relation between industrialization and productivity, it being more usual to analyze economic growth as a dependent variable, although productivity can be considered as a factor stimulating economic growth or even a proxy to measure the performance of the unit analyzed.

This study gives rise to a number of implications. In the first place, considering the results obtained, which aim to study the Portuguese productive structure at the local authority level, it is suggested that political decision-makers should somehow encourage regions to increase the industrial critical mass, as well as the diversity of their productive activity through clusters, as by doing so they

will contribute to regions becoming more resilient and competitive, given the major opening up of the Portuguese economy and the likely impacts of external shocks. The creation of new instruments is also suggested, aiming for a more vertical structure of industry that is directed complementally toward crossed fertilization between different stages of the chain and between different industries, which should also be based on seeking stronger connections of horizontal integration within industries themselves and in establishing open innovation relations with universities, incubation structures, laboratories, and research units.

Finally, considering the urgent need to strengthen the diversification of productive activities, one suggestion for future research is extending this study to the level of European NUTS II and NUTS III regions for the better mapping of sectors of economic activity and Key-Enabling Technologies (KETs), which can contribute to reinforcing productivity and competitiveness, following a sustainable logic of strategic diversification of sectors of economic activity and considering the spatial heterogeneity of the European regional chessboard.

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Article

Inbound and Outbound Practices of Open Innovation and Eco-Innovation: Contrasting Bioeconomy and Non-Bioeconomy Firms

João Leitão [1,2,3,4,*], Dina Pereira [2,3] and Sónia de Brito [2]

1 Faculty of Social and Human Sciences, NECE–Research Center in Business Sciences, University of Beira Interior, 6200-001 Covilhã, Portugal
2 Research Center in Business Sciences (NECE), University of Beira Interior, 6200-209 Covilhã, Portugal; dina@ubi.pt (D.P.); sonia.rosana.brito@ubi.pt (S.d.B.)
3 Centre for Management Studies of Instituto Superior Técnico (CEG-IST), University of Lisbon, 1649-004 Lisboa, Portugal
4 Instituto de Ciências Sociais, ICS, University of Lisbon, 1649-004 Lisboa, Portugal
* Correspondence: jleitao@ubi.pt; Tel.: +351-275-319-853

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Abstract: Generating innovation with environmental impact is crucial for firms to achieve sustainable eco-innovative performance. In the reference literature on open innovation, gaps still persist at the level of scarce and limited knowledge on the use of knowledge sources and flows, for the purpose of strengthening the eco-innovative performance of the bioeconomy sector. To address these caveats, this study analyses the effects of open innovation on eco-innovation, based on inbound and outbound support practices. Specifically, it aims to analyse the effects of these practices on the eco-innovative performance of bioeconomy and non-bioeconomy firms, using secondary data gathered from the Community Innovation Survey—CIS 2010 for a sample of moderately innovative countries, namely Slovakia, Spain, Hungary, Italy, Portugal and the Czech Republic. The conceptual model proposed is tested using multivariate tobit regression models, in order to ensure the accuracy and reliability required to validate empirical tests. Overall, the empirical evidence allows the conclusion that inbound and outbound practices and public policies have a positive and significant influence on the eco-innovative performance of the firms studied. The contribution provided is two-fold: (i) in theoretical terms, an operational model of open innovation inbound and outbound practices is extended, crossing financial flows and innovation directions; and (ii) in empirical terms, new light is shed on the still limited knowledge about the positive and significant effects of open innovation outbound practices on the eco-innovative performance of companies belonging to a global strategic sector—that is, the bioeconomy sector, which has renewed strategic importance in the face of global climate change.

Keywords: bioeconomy; eco-innovation; inbound; open innovation; outbound

1. Introduction

Creating innovation with a sustainable environmental impact is of great importance for firms, which use open eco-innovation to raise performance and create economic and environmental value [1–4]. Every innovation strategy provides a clear direction for addressing strategic issues, the selection of the market where the company wants to enter and abilities to be developed [5]. Although in the past firms adopted mainly internal research and development activities to create technology and products, this process being known as the closed innovation model [6], in recent decades, the innovation

framework has changed considerably, with many companies adopting an open innovation model, in which they use internal and external paths to develop and exploit new technology and products [6].

Open innovation was stimulated predominately by Chesbrough [6] and since then it has been subject to wide debate and extensive study in the literature of reference on innovation, with a special focus on innovation management [7]. It corresponds to a model of organisation that includes the commercialization of firms' internal and external ideas, following internal and external paths towards the market. This implies the search for knowledge flows from and to the firm environment, taking advantage of potential sources of ideas in third parties [8–10]. This process resorts to complex networks of partners and external stakeholders, who cooperate through open innovation systems with inbound and outbound practices, to address the challenges posed by eco-innovation.

Concerning the challenges raised by eco-innovation, environmental deterioration is one of the most urgent ones and has led to firms' increased interest in investing in sustainable innovations to allow sustainable production [3,11]. Therefore, eco-innovation emerges as the result of integrating the philosophy of sustainability in the context of the business innovation process, and is a type of innovation that in each phase of the life-cycle ensures solid reduction of risks, pollution and energy consumption/use compared to other alternatives [12].

Eco-innovation occurs at the micro level, i.e., at the individual level, where capturing value is characterised by the position of power, unique experiences and absorptive capacity, and also at the macro level, i.e., in the ecosystem. At the same time, open innovation, besides occurring at the micro level also occurs at the meso level, the network level characterised by knowledge-sharing and building partnerships. Consequently, open innovation towards eco-innovation, i.e., open eco-innovation, is related to generating innovations that use inbound and outbound knowledge flows to stimulate internal innovation created with external stakeholders, aiming to have an impact on and create value for society and the environment, thereby working at the micro and macro levels and requiring a flow of knowledge from various actors [4,13–15].

The complexity of knowledge that is an integral part of many eco-innovations stimulates the need to work with partners through open innovation [16], but the development of eco-innovations using open innovation has not yet been well studied [17]. The literature also shows a gap regarding the knowledge sources used in eco-innovation, since it requires a multiple and heterogeneous set of sources, larger and more diverse that other technologies [18]. Therefore, those industries are forced to go far beyond their core competences and the acquisition of external knowledge is a basic factor [19]. This perspective leads to the importance of understanding the channels and sources of information through which eco-innovative firms benefit from external flows [20].

It is extremely important to clarify those channels and how companies absorb and exploit them, for different reasons: first of all, the need to give scientific support to political decision-makers in elaborating instruments to maximize the use of open innovation systems in the environmental domain, stimulating firms' interaction, capacities and learning; secondly, the fact that firms can open up to external sources of knowledge, helping them to overcome their internal limitations and the lack of resources and intangibles to support the creation of eco-innovations; and thirdly, the possibility of guiding these firms, in collaboration with external stakeholders responsible for the environment, to be more sustainable [21–26]. Therefore, this article contributes to analysis of the effects of open innovation and public policies oriented to generating eco-innovations in companies, based on assessment of inbound and outbound practices. Specifically, it also contributes to extending the very limited knowledge about the effects of inbound and outbound practices of open innovation and public policies on the eco-innovative performance of bioeconomy and non-bioeconomy firms, by using secondary data from the Community Innovation Survey (CIS)—CIS 2010. To do so, samples of firms from Slovakia, Spain, Hungary, Italy, Portugal and the Czech Republic are studied, considered moderately innovative countries by the Innovation Union Scoreboard 2010.

The article is structured as follows. It begins with a review of the literature on the inbound and outbound practices of open innovation, and eco-innovation, resulting in the proposal of a conceptual

model. This is followed by the methodology, database, sample, the variables used and the method of estimation. Then the results are analysed and discussed. Finally, the conclusions, limitations and implications are presented.

2. Literature Review

2.1. Open Innovation: Inbound and Outbound Practices

The basic idea for the appearance of open innovation lies in the fact that organisations are not able to innovate in isolation, having to engage with different types of partners in order to acquire new ideas and resources to be able to become competitive [27,28]. Stimulated by Chesbrough [6] and contrasting with the conventional view of innovation as an activity within the firm's limits, open innovation refers to the flow of valuable ideas originating inside or outside the firm, and this can reach the market also from inside or outside the firm. In other words, open innovation assumes that firms should make use of not only external sources for innovation and external paths to the market, but also internal knowledge through external paths to the market [29].

Reflecting on what had been learnt from practising open innovation and trying to emphasize the intentional nature of knowledge flows leaving and entering the firm [30], the concept was revised by Chesbrough, Vanhaverbeke and West [13], and open innovation came to be regarded as the intentional use of internal and external knowledge flows to accelerate internal innovation and expand markets for the external use of innovation. For Vrande et al. [31], the intentional exit of knowledge or exploitation of technology causes innovation activities to raise existing technological capacities outside the organisation's limits, while intentional entry or exploration of technology is related to innovation activities which capture and obtain benefits arising from external sources of knowledge to improve current technological developments. In other words, exploitation involves undertakings based on internal knowledge, internal licensing of intellectual property and involvement with employees, while exploration implies customer involvement in the process of innovation, external licensing of intellectual property and tertiarization of R&D.

Dahlander and Gann [27] argue that open innovation deals with ideas that arise and can be commercialized inside or outside the firm, since this implies firms using multiple sources of knowledge, accelerating the advantages of developing internal ideas that are not immediately launched on the market. Later, Chesbrough and Bogers [32] say that open innovation is a distributed process of innovation and based on knowledge flows managed through organisational borders. Open innovation is a concept in evolution and is no longer the linear and bilateral process of transactions and collaborations within the innovation process, but a wider, dynamic process with network and multi-collaborative participation in an ecosystem of open innovation (European Commission, 2016) [33].

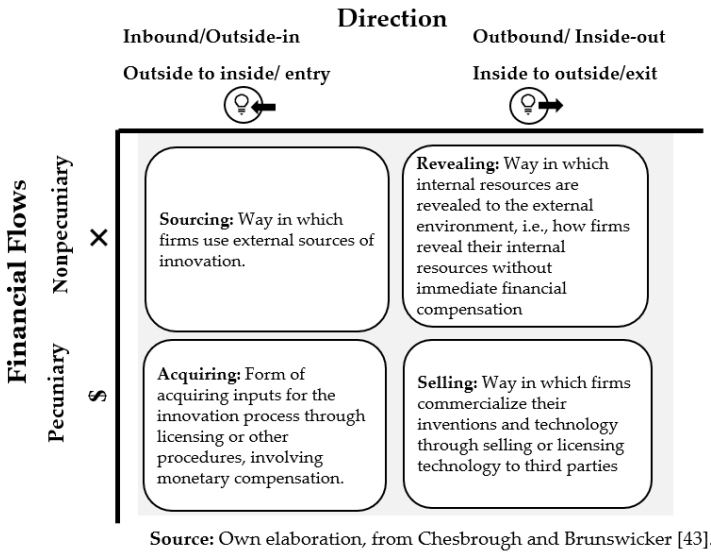
According to Dahlander and Gann [27], open innovation presents advantages such as: (i) reflecting social and economic changes in work patterns where professionals seek a portfolio of careers, rather than a job for life with a single employer, meaning firms must find new ways to access talents who perhaps do not want to be employed by others exclusively and directly; (ii) exploitation of the benefits of globalization, which has expanded the size of the market, allowing a greater division of work; (iii) improved market institutions, such as intellectual property rights, risk capital and technological standards, allowing the organisation to exchange ideas; and (iv) new technology allows new forms of collaboration and coordination, contributing to reducing geographical distances. On the other hand, Manzini et al. [34] also mentioned the potential disadvantages of open innovation, which include the loss of control, increased managerial and organisational complexity, and consequently, increased costs.

In addition, various studies, highlighted among them Laursen and Salter [35], Rothaermel and Deeds [36], Rohrbeck et al. [37] and Chiang and Hung [38], draw attention to the positive and negative effects of open innovation systems. As positive effects, Laursen and Salter [35], Rothaermel and Deeds [36] and Chiang and Hung [38] mention increased profit, R&D performance, product innovation, greater access to sources of knowledge and the success of new products on the market. Concerning

negative effects, Laursen and Salter [35], Rothaermel and Deeds [36] and Torkkeli et al. [39] highlight excessive costs of exploration for external flows of knowledge, the struggle to control knowledge assets and negative attitudes towards open innovation.

Open innovation practices are in accordance with the diversity of forms used in knowledge transfer, i.e., inbound and outbound, also known as outside-in and inside-out, respectively. In inbound OI, knowledge flows from the external environment towards the focal firm; vice versa, in outbound OI, knowledge internally developed flows in the direction of the external environment [40]. In the literature on open innovation, inbound and outbound are designated in various ways, for example: principal processes of open innovation in R&D management [41]; dimension as to the direction of the knowledge flow in relation to the firm [27]; and also typology of open innovation [42].

The systematization proposed by Dahlander and Gann [27] concerning open innovation presents two main dimensions: direction of the knowledge flow in relation to the firm (inbound x outbound) and the involvement of monetary exchange (non-pecuniary vs. pecuniary), and consequently of the main types of openness: sourcing; acquiring; revealing; and selling; is among the most commonly used and is therefore adopted in this study as the operational model of the components of inbound and outbound practices (Figure 1). Inbound practices are types of openness in which external resources can be provided to the internal environment with firms being able to do this via sourcing and acquiring. Sourcing corresponds to an entry that does not involve non-pecuniary exchanges, with an implicit synergy between internal processes and open information available without strict financial liabilities. On the other hand, acquiring is an entry that involves pecuniary exchanges, including all forms of purchasing technology and R&D efforts. Regarding outbound practices, these are types of openness whereby internal resources can be provided to the external environment. Firms can do this via revealing and selling. Revealing is an exit that does not involve pecuniary exchange and concerns knowledge-sharing with the partner network without immediate financial benefit, whereas selling corresponds to an exit involving monetary exchange, allowing total leverage of the R&D investment in partnership with actors able to bring those results to the market.



Source: Own elaboration, from Chesbrough and Brunswicker [43].

Figure 1. Operational model of forms of inbound and outbound practices.

It is noted that Chesbrough and Brunswicker [43] use these same forms of inbound and outbound practices for a different purpose, i.e., to classify explicitly the range of open innovation activities, and not to propose and operationalize forms of inbound and outbound practices as is done in this study. With the due difference, it is noted that taking as reference the first column of Figure 1, the inbound activities including non-pecuniary exchanges characterised by the supply of ideas and external knowledge from suppliers, clients, the competition, consultants, universities, research organisations

and others, also require the development of synergistic relations, understood as indispensable for internal innovation and mutually beneficial management of open information flows with the partners involved, competitors or otherwise [44]. Here, activities involve, for example, client and consumer co-creation processes, crowdsourcing, consortia financed by the public sector in R&D or informal networking. In addition, inbound activities that cover pecuniary exchanges involve acquiring a typology of openness, through the acquisition of inventions and inputs via informal and formal monetary connections, involving an accumulation of competences. These activities include entry licensing of intellectual property, R&D contracts, intermediaries specialized in open innovation, competitions for ideas and start-ups, innovation awards for suppliers or university research grants.

Moving to the second column of Figure 1, non-pecuniary outbound practices imply a revealing strategy, through which the firm reveals its internal resources to the external environment, sharing knowledge with external partners, but without any financial benefit, with this generally occurring in situations where there are highly uncertain regimes of appropriability and where the protection of inventions is too costly. This practice includes participation in public norms or donations to common goods or non-profit organisations. In relation to pecuniary outbound practices, these are characterised by a form of selling that can involve both out-licensing of intellectual property and the sale of products on the market, assuming total leverage of investment in R&D collaboration with partners able to spread the results [45]. These strategies can cover a number of activities, namely joint-ventures, spin-offs, incubation and the sale of market-ready products.

Among the activities presented above are firms that will choose which activities are more convenient for their purposes, i.e., inbound, transmitting internal use of external knowledge; outbound, external use of internal knowledge, and also mixed open innovation, requiring active collaboration between partners to innovate, resulting from orchestrating inbound and outbound activities. Firm activities aiming to make efficient use of inbound and outbound activities need consideration, not only concerning how to absorb resources, but also the use of solutions to enable sustainable actions on firms' internal and external borders. Moreover, the success of open innovation practices is generally associated with increased efficiency in the general performance of the firm's innovation, where the gain mechanics, regarding performance, include the internal and external increase of a set of competences and access to external sources of knowledge, as well as the internal resource economy and the generation of profits from internal intellectual property which is not directly incorporated in market products [43].

In an environment of open innovation, it is essential for firms to develop various dynamic resources to manage their resources effectively, both internally and externally. Conventionally, in the inbound context, there is emphasis on absorption capacity, as suggested by Cohen and Levinthal [46], but as firms began to be increasingly interested in selling their technology as a form of outbound innovation, research on open innovation has evolved to mainly consider the inbound process, study the outbound process and emphasize the need for knowledge capacities [47,48]. The inventive capacity in technology exchange markets, as well as the desorptive capacity of licensors is reflected in the studies by Shin et al. [47] and Hu et al. [49] on outbound open innovation.

Inventive capacity refers to firms' internal capacity to create innovative knowledge, after identifying unsatisfied needs in the market, influenced by the firm's existing knowledge stock in the form of its patent portfolio and citations of patents and technological range [50]. The protection of patents is therefore a strategic advantage for firms to benefit from outbound open innovation, especially in certain technological domains, for example, the pharmaceutical or biotechnological sectors, since this can reduce transaction costs in technological markets. As technological knowledge is of an intangible nature, its licensing is characterised by its complexity, with greater disturbances due to being involved in technology-intensive environments. Furthermore, the licence of a contract with external partners is highly complex due to information asymmetry [51,52]. In this competitive scenario, the firm's inventive capacity is related to licensors' fame and the firm's set of competences and resources owned. That resource stock makes firms' inventive capacity more interesting for licensees, including firms'

patent stock and high-level researchers, and contributes to better collective awareness of potential partners and collaborators. In addition, licensees are interested in increasing their own prestige by establishing partnerships with this type of licensor who has strong inventive capacities, ensuring a relationship of mutual trust. Briefly, licensees with greater inventive capacity also have a greater chance of out-licensing their technology [53,54].

Desorptive capacity refers to firms' capacity to indicate and exploit opportunities for technology transfer, based on their outbound strategies [47]. This capacity is linked to the firm's dynamic capacities, meaning that they intentionally generate, increase and change their resource bases. It is also related to the firm's previous experiences with out-licensing contracts, which in a market characterised by high turbulence, is a major advantage in obtaining lower transaction costs. These competences learned from the firm's previous technological trajectories are extremely important in turbulent and competitive environments [47].

According to Shin et al. [47], and Nonaka [54], knowledge management processes are differentiated by exploitation, exploration and retention of knowledge so that for firms to be able to retain knowledge from inter-firm collaboration, there must be connection capacity. Connection capacity is related to the alliance and firms' relational capacities, ensuring licensors' priority access to external sources of knowledge without complete acquisition. The larger the set of connections and collaborators firms have, the easier the process of managing relations between these external parties tends to be, achieving greater benefits from maintaining external knowledge [47,55].

Firms are coming under increased pressure to combine resources from multiple stakeholders due to growing innovation rates, highly complex global supply chains and in a growing context of catastrophes and environmental problems. Moreover, environmental problems can limit the firm's growth, leading to the attractiveness of sustainable innovations requiring diverse interactions and sources of knowledge [47,54]. In addition, in the area of sustainable, environmentally friendly innovation, in particular, to create eco-innovation, the role of the main users and suppliers is crucial. This arises from the basic assumption that eco-innovation results from highly complex, systemic and interlinked processes involving a set of different stakeholders, as well as the interactions of multiple internal and external factors, transmitting practices of inbound, outbound and combined innovation [56].

2.2. Eco-Innovation

Given the growing concern about the environmental impact of products and their resource-intensive production, a greater number of companies have considered introducing eco-innovation to create simultaneously economic and environmental value [2,3,57]. The concept of eco-innovation relates to organizational sustainability and circular economies [58]. Fussler and James [59] were the first to use the term eco-innovation, defining it as a new product or new process that adds value for the business or the client, with a significant reduction in environmental impacts.

The most widely accepted definition of eco-innovation is the one proposed by Kemp and Pearson [12] and complemented by Horbach et al. [15], according to whom eco-innovation is the production, application or exploitation of goods, services, production processes, organisational structures or management methods that represent something new for the firm or user over their life-cycle, representing the reduction of environmental risks and pollution, implying the limitation of negative impacts resulting from intensive use of resources, for example, energy, compared to relevant alternative options. Consequently, eco-innovation directed to openness, i.e., open innovation, is related to the creation of innovations that use inbound and outbound flows of knowledge to stimulate internal innovation created with external stakeholders, aiming to have an impact and create value for society and the environment, thereby working at both the micro and macro levels and requiring a flow of knowledge from various actors [4,13–15].

In the scenario of open eco-innovation, the mentality shared between partners is the entry and exit of knowledge and its exploitation to attain objectives intrinsically connected with the ecosystem [60].

Consequently, at the macro level, i.e., the ecosystem, capturing environmental value involves a broad and complex set of stakeholders, besides producers and consumers, i.e., eco-systemic performance, the global impact, the regional environment and social value [61]. Here, value includes not only the generation of economic value, but also social and ecological value, for example, improvement in the quality of air and water, preservation of resources, employment growth, reduced pollution and others [62,63]. In this connection, at the meso level, i.e., the network level characterised by sharing knowledge and forming partnerships, there is a diversity of organisational cultures, network structures in development and unbalanced power conflicts that can affect decision-making processes at the micro (firm) level, which in turn can also influence the macro level, the environmental and social level [14].

The systemic nature of eco-innovation requires a multi-faceted knowledge base which is unlikely to exist in one company [15]. It also needs a network of stakeholders to satisfy the permeability between the firm and the external environment, with each stakeholder having the role of bringing knowledge to be exploited and generating value added for all the partners involved [60]. This is not just a question of how each stakeholder creates and captures value added, but mainly how the group of partners acts as a knowledge base for the purpose of generating and capturing value among partners linked through a collaborative scheme of open innovation focused on a common context and mission, so as to contribute to an agenda of industrial sustainability [64,65].

As eco-innovation is of a multi-faceted nature, the literature has witnessed the emergence of an approach centred on the determinant drivers of eco-innovation, structured in three main branches: (i) market attraction; (ii) technological impulse; and (iii) regulatory effects.

Concerning the perspective of market attraction, previous studies indicate that eco-innovation results from expectations of turnover, the search for new eco-innovations; previous economic performance; and benefits for the consumer [66–69].

In relation to the technological impulse, the literature has concentrated on firms' R&D activities, amount of knowledge capital, organisational systems and management focused on environmental innovations [66,70–72].

Concerning regulatory effects, previous studies were concentrated on the roles of environmental policies and standards for the adoption of eco-innovation [73]. Regarding this last aspect, this study has a particularly relevant role, in that it contributes to enriching the analysis of the effects of adopting public policies on eco-innovative performance.

Not only the determinants, but also the enablers of eco-innovation have been subject to much debate. For example, the industrial innovation links and inter-firm networks can enable eco-innovation, providing firms with resources that disguise the lack of scale economies [74]. In addition, partnerships formed with stakeholders outside firms' supply chain, such as knowledge-intensive business services (KIBS), research institutions, universities and competitors, are even more important for eco-innovation than for other types of innovation [75]. The same effect is noted in cooperation for innovation in R&D [76], where universities and business suppliers are indicated as the main partners when considering the impact of eco-innovations.

Of great importance is how firms practising eco-innovation look for external sources of knowledge to be able to innovate, which can be characterised by the extent and depth of the search for knowledge [35]. The extent corresponds to the set of sources available to firms, noting that eco-innovative firms have wider, more diversified sources, since they need more external sources of knowledge than other innovative firms [77,78].

Eco-innovative companies are therefore forced into different regulatory frameworks, which means preparation to cope with knowledge requirements; for example, the need to have scientific knowledge from universities and R&D laboratories about the materials and processes to use, the set of environmental norms to consider when innovating in collaboration with agencies and suppliers' ability to provide sustainable production inputs. All this diversity in the supply of knowledge reveals the necessary extent of eco-innovation, which cannot be found in just a few knowledge suppliers. Moreover, eco-innovation is polyvalent, requiring a combination of various objectives and their internal

harmonization. These diverse objectives cover production efficiency, quality, environmental standards and others, requiring additional sources of knowledge from diverse origins [18,19,79].

It is also important to address the depth of eco-innovations that involve providing depth to external knowledge sources. In the specific case of eco-innovations, external knowledge sources are generally distant from firms' core business, having access to alternative knowledge, which can be an obstacle to its implementation. So firms must undertake deeper interaction with the acquisition of knowledge, in order to enable absorption and exploitation of viable knowledge [78]. Eco-innovative companies also have difficulty in finding the right cooperation partner, needing a deeper, sustainable inter-connection after forming the collaboration, which increases the importance of selection and maintenance processes for these firms [80].

Not only can eco-innovative firms' search for knowledge sources be difficult, but also management and exploitation of these sources can be complex and costly, in that not only distance is important but also that the shortage of green management competences to exploit them. Here, the absorption capacity of eco-innovative firms, i.e., the innovator's capacity to detect, acquire and exploit knowledge sources, is fundamental. Social integration mechanisms increase the absorption capacity of eco-innovative firms, through use of their organisational capacities, as occurs with the capacity for connection and socialization, which stimulate communication flows and favour the external spread of knowledge and its very socialization [8,81].

2.3. Design of the Research Hypotheses and the Conceptual Model

Based on the discussion present in the literature reviewed above, a renewed research framework was designed regarding inbound and outbound open innovation practices and also public policies, as explanatory variables of eco-innovative performance as the dependent variable. Concerning inbound open innovation practices related to the transmission and internal use of external knowledge, these practices are measured through the intermediary of various (non-pecuniary) sources and also through (pecuniary) acquisition. As for outbound open innovation practices corresponding to external use of internal knowledge, these are measured either through (non-pecuniary) revealing or (pecuniary) selling. The dependent variable is product innovation and process innovation, resulting in eco-innovative performance. In addition, company size and whether in 2010 it belonged to a group of companies are included in the study as control variables.

Returning to inbound practices, concerning sourcing, the empirical study by Ketata et al. [82] with data on 1.124 German companies reveals that the extent and depth of knowledge sources improve sustainable innovations. Ghisetti et al. [60], using the CIS 2006–2008 for 11 European countries, obtain similar results, confirming that knowledge sources (extent and depth) are positively associated with the introduction of eco-innovation, but they do not distinguish between the influences of different sources of information.

The interests and needs of all partners in a highly uncertain and complex environment make external knowledge sources particularly important [82]. According to Laursen and Salter [35], actors such as suppliers, users and competitors are seen as market sources providing a soft opening, with the share of information without entering into bonding, juridical agreements. Market sources help companies to gather and absorb information about customers' needs and demand, as well as exploiting information about their competitors' eco-innovation programmes. Authors such as Geffen and Rothenberg [83] and Kammerer [68] mention that knowledge coming from suppliers and customers is relevant for eco-innovation. Regarding the effect of these sources, in both process and product innovation, Marzucchi and Montresor [84] find that the knowledge coming from suppliers, clients, competitors, industrial associations, fairs and conferences is highly relevant for all types of eco-innovation, but especially for process innovations related to reducing material or energy, as far as end-of-pipe technology or the implementation of ecological products is concerned.

For institutional sources of information based on knowledge arising from science and related more directly to national innovation systems (universities, governments and public research institutes),

Bönte and Dienes [85] detected a significantly positive influence of institutional sources (universities) on eco-innovation. Despite the empirical evidence of a positive influence of knowledge from institutional sources on innovation, only Marzucchi and Montresor [84] and Del Río et al. [86] differentiate its effects in terms of process innovation and product innovation. Marzucchi and Montresor [84] show that these sources influence environmentally efficient technology, such as processes to reduce material or energy consumption, but not the introduction of environmental products. In contrast, Del Río et al. [86] only find positive influences of knowledge from institutional sources on product innovation.

By forming partnerships with other firms or non-commercial organisations, companies improve their capacity to introduce new processes or products. Those that engage in cooperation gain access to the knowledge or synergistic skills of complementary partners and capitalize on entry spillovers [87–89], so that they can have access to technology which otherwise could not be acquired on the market [90], aiming to reduce the multiplication of R&D efforts; lessen the risks and costs associated with innovation projects [91]; and obtain economies of scale [88]. Firms can contribute to creating a strong and densified network of multilevel cooperation and alliances involving all the stakeholders [92]. Studies on the influence of cooperation in R&D on eco-innovation produce converging results. For example, for De Marchi [76], cooperation is more important for the introduction of eco-innovations than for any other type of innovation. Collaborative networks with universities and public institutions are also essential stimulants of all types of eco-innovation [93,94]. Horbach et al. [18] observe a significant influence of cooperation in R&D, but only for processes with an environmental benefit for firms related to dangerous substances.

Still in relation to inbound practices, but now concerning acquiring, which is pecuniary entry of innovation, Rouvien [95] states that the acquisition of new equipment, as a form of incorporated knowledge, should mainly stimulate process innovations. Companies can also gain access to an external knowledge base through developing external R&D sub-contracting operations or acquiring technology from external partners, i.e., via licensing. These operations involve pecuniary exchanges for ideas acquired externally, but can also complement the firm's internal knowledge, increasing the likelihood of successful exploitation and exploration. Unlike the acquisition of patented licences, external acquisition of R&D is beneficial only if it shows some complementarity to the focal firm's internal knowledge [89].

However, empirical evidence of the influence of external R&D on eco-innovation is contradictory. The longitudinal study by Horbach [67] shows that improved technological capacities through R&D activities triggers eco-innovations. Later, Horbach et al. [15,18] find a slightly negative influence, but only in process innovations with environmental benefits in related areas, such as energy, dangerous material and recycling. De Marchi [76] and Marzucchi and Montresor [84] do not find a significant influence of acquiring external knowledge, in the form of patents or licences, on eco-innovation. According to Bönte and Dienes [85] and Li-Ying et al. [96], firms involved in external R&D are less likely to introduce process innovations regarding energy and material efficiency. That theoretical statement is corroborated by transversal results obtained at the company level which reveal significant complementarities between internal and external R&D for products, but not for process innovations [97]. In the light of these considerations and previous empirical results, the following research hypothesis is considered:

Hypothesis 1 (H1). *Inbound open innovation practices have a positive relation with eco-innovative performance.*

Hypothesis 1a (H1a). *Non-pecuniary flows of inbound open innovation practices have a positive relation with eco-innovative performance.*

Hypothesis 1b (H1b). *Pecuniary flows of inbound open innovation practices have a positive relation with eco-innovative performance.*

Concerning outbound open innovation practices, previous empirical evidence is very scarce [98], with this being a neglected issue [99]. Nuvolari [100] proposes that companies reveal their ideas to their competitors without any identifiable negative consequence. Through revealing, using a marketing lens, firms can increase their reputation [101], goodwill [102], brand recognition [103] and their target-public [104].

From the technological point of view, revealing can be beneficial when companies use crowdsourcing as a source of knowledge, instead of trying to solve problems internally or hiring a specialist supplier [105,106]. Revealing is also used to obtain feedback from customers [107], manufacturers and even competitors [108].

Still, in relation to inbound practices, but regarding selling, which involves pecuniary exchanges and activities such as licensing, Inauen and Schenker-Wicki [109] find a significant impact on the performance of innovation accompanied by a greater probability of radical innovations that can be critically important for R&D managers. Mazzola et al. [110] also underline the fact that external licensing produces a positive impact on innovation performance. This leads to the following research hypothesis:

Hypothesis 2 (H2). *Outbound open innovation practices have a positive relation with eco-innovative performance.*

Hypothesis 2a (H2a). *Non-pecuniary flows of outbound open innovation practices have a positive relation with eco-innovative performance.*

Hypothesis 2b (H2b). *Pecuniary flows of outbound open innovation practices have a positive relation with eco-innovative performance.*

Study of the literature on the determinant factors of eco-innovation has highlighted the assumed importance of public policies in designing incentives able to promote strategic conduct and practices tending to reinforce eco-innovation [15,111]. Popp [112] found empirical evidence that firms' decisions on innovation were stimulated mainly through national regulations, but eco-innovations can also be motivated by international regulations, as in the case of air pollutants in Japan, where the catalyst of eco-innovation was regulations in the United States of America [113].

Horbach [67] concluded that public policies and the motivation to make cost savings are the main determinant factors of eco-innovation. Jänicke [111] argues that intelligent regulations have an important role in political competition for eco-innovation and can be identified as a driver of eco-innovation. The study by Khanna et al. [114], making a distinction for environmental regulation, proposes that anticipated regulation and the presence of complementary assets are important vehicles for the creation of incentives to innovation. Another important contribution to this debate was made by Kammerer [68], by revealing that the effects of regulations on innovation vary according to the area of environmental impact. Therefore, a distinction should be made between eco-innovations aiming to improve the energy efficiency of materials and the reduction of greenhouse gas emissions (GGE), contributing to improved recycling or reducing negative environmental impacts on the water and the soil. More recently, Ghisetti and Rennings [115] and Triguero et al. [116] indicate the positive effect of public support in the form of subsidies for firms adopting environmental innovation. Leitão et al. [117], in the context of Portuguese high-tech companies, also find a positive effect of public policies. This leads to the following hypothesis:

Hypothesis 3 (H3). *Public policies have a positive relation with eco-innovative performance.*

Considering the complexity of the theoretical references reviewed and the set of previous empirical evidence, Figure 2 proposes a conceptual model of analysis, which aims to simplify the analysis framework developed in the following section of this study, exploring the relations between the inbound and outbound practices of open innovation, public policies and eco-innovative performance.

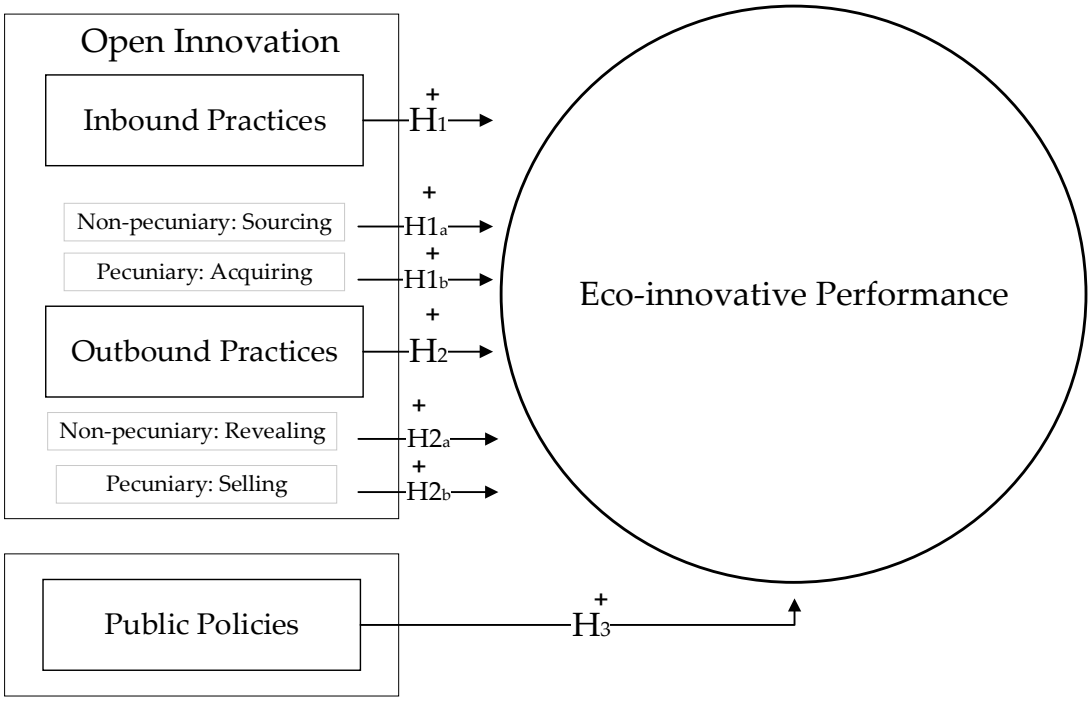


Figure 2. Inbound and Outbound Practices of Open Innovation, Public Policies and Firms' Eco-Innovative Performance: a proposed conceptual model. **Source:** Own elaboration.

3. Methodology

3.1. Database and Sample

The database used for this research corresponds to the Community Innovation Survey 2010, which provides information about sectors' innovation capacity according to firm type, about the different types of innovation and various aspects of an innovation's development, such as objectives, information sources, public financing, expenditure on innovation, etc. The data available are used to produce samples for European Union (EU) member states considered moderate innovators, according to the results of the 2010 edition of the Innovation Union Scoreboard. In the empirical test, only the available data from CIS 2010 were used, for a group of moderate innovators (cf. Figure 3), namely: Slovakia (SK); Spain (ES); Hungary (HU); Italy (IT); Portugal (PT); and the Czech Republic (CZ). For that reason, it was not possible to include the other countries in the group, namely: Greece (GR); Malta (MT); and Poland (PL).

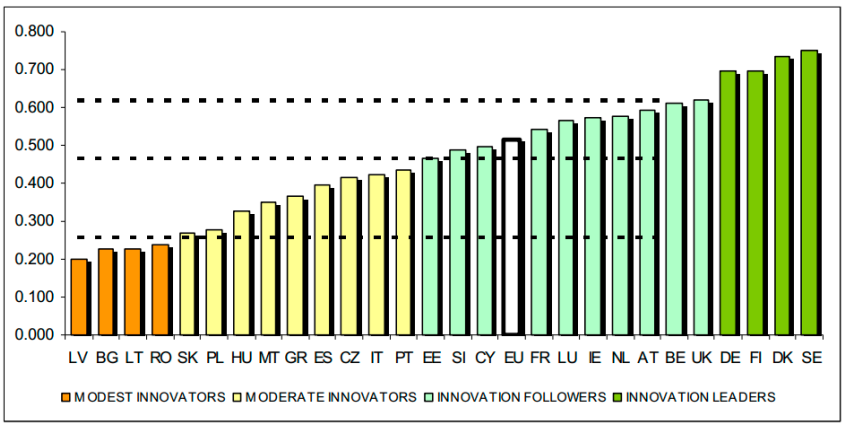


Figure 3. Innovation Performance of European Union Member States. **Source:** Innovation Union Scoreboard 2010.

Analysis of the bio-economy has attracted growing interest among academics [118–120] policy-makers [121,122] and institutions of international reference, including the European Commission [123]. This justifies the focus of the present empirical study on the bioeconomy sector, with the available data being used to produce six samples of firms related to the bioeconomy, located in: Slovakia; Spain; Hungary; Italy; Portugal; and the Czech Republic. Following the official statistical classification of economic activities in the EU (NACE rev. 2), the total sample was divided into "bioeconomy firms"; and "non-bioeconomy firms" (see Table A1, in Appendix A). It is noted that bioeconomy covers the production of renewable biological resources and the conversion of these resources and waste flows into products with value added, such as food, animal fodder, biological-based products and EU bio-energy [123]. The bioeconomy requires vast amounts of biomass that current value chains cannot provide [124].

For better understanding of the total samples and the sub-samples of bioeconomy and non-bioeconomy firms, Table 1 shows the number of "bioeconomy firms" and "non-bioeconomy firms", as well as presents their composition in relation to firm size. The Slovakian sample contains 2363 companies of which 343 are bioeconomy firms and 2050 non-bioeconomy firms; the Spanish sample is made up of 34,550 firms, 6279 being bioeconomy and 28,271 non-bioeconomy; the Hungarian sample contains 4683 firms, 1228 being bioeconomy and 3410 non-bioeconomy; the Italian sample contains 18,328 firms, 2280 being bioeconomy and 16,048 non-bioeconomy; and the Portuguese sample contains 6060 firms, 1223 being bioeconomy and 4937 non-bioeconomy. The sample of 5151 Czech firms is made up of 1435 bioeconomy firms and 3716 non-bioeconomy. In general, both bioeconomy and non-bioeconomy firms are small or medium-sized.

Table 1. Distribution of firms according to bioeconomy and non-bioeconomy and their distribution by size for total samples and sub-samples.

Country	Sample	Firms		Size (Total Employees)					
		N°	%	<50	%	50–249	%	250 e +	%
Slovakia	Total	2363	100	1169	49.47	836	35.38	358	15.15
	Bioeconomy	313	100	110	35.14	123	39.30	80	25.56
	Non-Bioeconomy	2050	100	1059	51.66	713	34.78	278	13.56
Spain	Total	34,550	100	21,438	62.05	9753	28.23	3359	9.72
	Bioeconomy	6279	100	3992	63.58	1872	29.81	415	6.61
	Non-Bioeconomy	28,271	100	17,446	61.71	7881	27.88	2944	10.41
Hungary	Total	4638	100	2455	52.93	1618	34.89	565	12.18
	Bioeconomy	1228	100	585	47.64	498	40.55	145	11.81
	Non-Bioeconomy	3410	100	1870	54.84	1120	32.84	420	12.32
Italy	Total	18,328	100	12,991	70.88	3540	19.31	1703	9.29
	Bioeconomy	2280	100	1447	63.46	554	24.30	279	12.24
	Non-Bioeconomy	16,048	100	11,544	71.93	2986	18.61	1424	8.87
Portugal	Total	6160	100	3956	64.22	1684	27.34	520	8.44
	Bioeconomy	1223	100	706	57.73	400	32.71	104	8.50
	Non-Bioeconomy	4937	100	3237	65.57	1824	26.01	416	8.43
Czech Republic	Total	5151	100	2806	54.47	1373	26.66	972	18.87
	Bioeconomy	1435	100	805	56.10	427	29.76	203	14.15
	Non-Bioeconomy	3716	100	2001	53.85	946	25.46	769	20.69

Source: Own elaboration based on data collected from the Community Innovation Survey-CIS 2010.

The sub-samples of "bioeconomy firms" and "non-bioeconomy firms" were tested empirically, using multivariate tobit regression models, considering the research hypotheses resulting from the previous literature review and the subsequent design of the conceptual model proposed here.

3.2. Variables and Model Specification

This study focuses on the effects of inbound and outbound practices of open innovation and public policies on eco-innovative performance. Therefore, the variables of "Reduce the material and energy used by unit produced" (ORME) and "Reduce the environmental impact" (OREI), with the original designation (in brackets) of the variables of CIS 2010, are the dependent variables resulting in eco-innovative performance. These are polytomous variables that analyse the importance, in the period 2008 to 2010, of the firm introducing innovative products and processes, i.e., equal to 0, if the introduction of new or significantly improved products or processes was irrelevant; equal to 1 if the introduction of product or process innovation was of low importance, and 2 if the introduction of new or significantly improved products or processes was of medium-high importance.

As for the independent variables, this research used the variables associated with inbound and outbound practices of open innovation as well as public policies. Besides the dependent and independent variables, included as control variables were: size (SIZE_3); and group (GP). For the size variable (SIZE_3), firms with up to 50 employees are small firms, those with between 50 and 249 employees are medium-sized and those with 250 or more employees are large firms. The group variable (GP) can determine the influence of belonging to a group of firms.

As already mentioned, to estimate the proposed model and test empirically the research hypotheses and the conceptual model, this study adopted the tobit regression model. The tobit regression model developed by Tobin [125] belongs to a class of econometric techniques traditionally considered as censored regression models [126], having been projected to estimate relations between variables when there is censor on the left or right of the dependent variable. The tobit model can be written as a latent regression model $y = x\beta + \varepsilon$ with a continuous result that is observed or not observed. Following Cong [127], the result observed for the observation i is defined as:

$$y_i^* = \begin{cases} y_i \ se\ a < y_i < b \\ a\ se\ y_i \leq a \\ b\ se\ y_i \geq b \end{cases} \quad (1)$$

where: a is the lower censor limit and b is the upper censure limit. The tobit model assumes that the error term follows normal distribution; $\varepsilon \sim N(0; \sigma^2)$. Depending on the issue in question, the amount of interest in a tobit model can be the censored result y_i^* or the result without censor y_i.

Amemiya [128] extended the univariate tobit model to the multivariate model, creating the MVTOBIT, its usefulness lying mainly in that dependent variables are determined as a whole. In this study, the tobit multivariate model is used to explain two types of eco-innovation: process eco-innovation: y_{1i}^*; and product eco-innovation: y_{2i}^*. The multivariate tobit assumes that the density of articulation function behaves with a normal multivariate distribution with a mean of zero, constant variances and a constant correlation between the error terms. Using the MVTOBIT command on STATA the parameters β are estimated using the maximum likelihood method.

The variables in the conceptual model are presented in Table 2 below.

Table 2. Dependent, independent and control variables.

Variables			Description
Dependent	Eco-innovation—Process	ORME	Reduce the material and energy used per unit produced
	Eco-innovation—Product	OREI	Reduce the environmental impact
Independent	Inbound—Non-pecuniary	SCOM	Source of information: Competitors or other firms in the same sector of activity
		SINS	Source of information: Consultants, laboratories or private R&D institutions
		SGMT	Source of information: State Laboratories or other public bodies with R&D activities
		SJOU	Source of information: Scientific journals and technical/professional/commercial publications
		SPRO	Source of information: Professional or business associations
		CO11	Cooperation with firms in the same group
		CO21	Cooperation with suppliers of equipment, material, components or software
		CO31	Clients or consumers
		CO41	Competitors or other firms in the same sector of activity
		CO51	Consultants, laboratories or private R&D institutions
		CO61	Universities and other higher education institutions
		CO71	State Laboratories or other public bodies with R&D activities
	Inbound—Pecuniary	RRDEX	External acquisition of R&D activities
		RMAC	Acquisition of machinery, equipment and software
		ROEK	Acquisition of other external knowledge
	Outbound—Non-Pecuniary	MNFIN	Non-financial incentives for employees to develop new ideas, such as: free time and recognition
	Outbound—Pecuniary	RRDIN	R&D activities carried out inside the firm
		INPDGD	New or significantly improved goods
		INPDSV	New or significantly improved services
		INPSPD	New or significantly improved manufacturing or production methods
		INPSLG	New or significantly improved logistics, delivery or distribution methods of the production factors or final products
		INPSSU	New or significantly improved support activities for company processes
		ORGBUP	The firm introduced new business practices in the organisation of procedures
		ORGWKP	The firm introduced new methods of organising responsibilities and decision-making
		ORGEXR	The firm introduced new methods of organising external relations with other firms or institutions
		MKTDGP	The firm introduced significant changes in the aspects or packing of goods or services
		MKTPDP	The firm introduced new techniques or means of communication to promote goods or services
		MKTPDL	The firm introduced new distribution methods or new sales channels
		MKTPRI	The firm introduced new pricing policies for products
	Public Policies	FUNLOC	Public financial support from: Local or Regional Administration
		FUNGMT	Public financial support from: Central Administration (agencies or ministries, through government programmes)
		FUNEU	Public financial support from: European Union
		FUNRTD	The firm participated in the 6th and 7th framework programme of the EU for R&D
	Controls	SIZE_3	Total number of people working for the firm in 2010
		GP	In 2010, the firm was part of a group of firms

Source: Own elaboration.

4. Results

The multivariate tobit model was estimated for the sub-samples of bioeconomy and non-bioeconomy for the moderately innovative countries. For each sub-sample, the dependent variables identified and described above (ORME and OREI) were used. It is noted that for better understanding of the data, descriptive statistics were calculated for both sub-samples of the different countries studied, but they are not presented here to limit the length of the document. The VIF (Variance Inflation Factor) was also calculated, and according to Hair et al. [129], as values of $VIF < 10$ were obtained, potential problems of multicollinearity are not identified.

The estimation process began with the test of a univariate tobit model, which was found to be statistically significant for all sub-samples and countries represented here. For example, 313 bioeconomy firms in Slovakia show a logarithmic likelihood of −131.113 (ORME) and −127.207 (OREI); with a p value of 0.000 and 0.000, respectively, corroborating that the models are statistically significant. For the 2050 non-bioeconomy firms in Slovakia, with a logarithmic likelihood of −1068.832 (ORME) and −1158.779 (OREI) and the p value of 0.000 and 0.000, the models are also statistically significant. The same model, i.e., univariate tobit, is seen to be statistically significant when considering the other countries, and the same goes for the multivariate tobit model which is statistically significant for the sub-samples and all the countries studied (cf. Table 3)

Table 3. Validity and statistical significance of the models.

		Univariate				**Multivariate**			
		Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
		ORME	**OREI**	**ORME**	**OREI**	**ORME**	**OREI**	**ORME**	**OREI**
Slovakia	a.	−131. 113	−127.207	−1068,83	−1158.779	−260.891	−260.891	−1559.421	−1559.421
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Spain	a.	−5427.962	−5381.417	−21,808.94	−21,581.971	−9451.366	−9451.366	−31,205.92	−31,205.92
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hungary	a.	−638.782	−715.703	−2088.466	−2284.845	−957.933	−957.933	−2835.724	−2835.724
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Italy	a.	−1869.155	−1866.256	−10,214.656	−11,264.631	−3114.255	−3114.355	−14,185.097	−14,185.097
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Portugal	a.	−982.547	−957.4881	−4411.592	−5422.166	−1578.583	−1578.583	−7337.374	−7337.374
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Czech Republic	a.	−890.611	−959.084	−2760.673	−2835.036	−1514.236	−1514.236	−4158.295	−4158.295
	b.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Legend: a. Log Likelihood | **b.** P-Value. **Source:** Own elaboration.

Assuming that all the models are statistically significant, the results found are now presented, according to the response axes expressed in the research hypotheses, opting to present only the results of estimating the multivariate tobit model, for two reasons. Firstly, the dependent variable being tested for different values, and secondly, not finding substantial differences in the results obtained and in the associated levels of statistical significance and maximum likelihood.

Continuing to present the results for the multivariate tobit (Table A2 in Appendix B) and beginning with Slovakian bioeconomy firms, inbound practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. Outbound practices involving a non-pecuniary flow do not show significant evidence. Pecuniaries are significant and have a positive effect on process (ORME) and product (OREI) innovation. As for public policies, these show mixed significant evidence in process innovation (ORME), with the FUNLOC variable having a positive influence and the FUNGMT variable having a negative influence. In product innovation (OREI), public policies are significant and have a positive effect. Firm size (SIZE) is only significant with a positive influence on product innovation (OREI), with no evidence regarding process innovation (ORME).

The results for Slovakian non-bioeconomy firms show that non-pecuniary inbound practices are significant and have a positive influence on process innovation (ORME), but for product innovation

(OREI) the evidence is mixed. Also non-pecuniary inbound practices are significant, but the evidence is mixed for both process (ORME) and product (OREI) innovation. Non-pecuniary outbound practices do not present significant evidence for either type of innovation, but pecuniaries are significant with a positive influence on process (ORME) and product (OREI)innovation.

Public policies and company size (SIZE) are significant and have a positive influence on process (ORME) and product (OREI) innovation

The results for Spanish bioeconomy firms demonstrate that inbound practices are significant with a positive influence on process (ORME) and product (OREI) innovation. Non-pecuniary outbound innovation practices do not present evidence of their behaviour, whereas pecuniaries have a significant influence on both types of innovation. Public policies have a positive significant relation with process innovation (ORME) with mixed evidence regarding product innovation (OREI). The fact of a company belonging to a group (GP) has a positive influence on process (ORME) and product (OREI) innovation.

The results for Spanish non-bioeconomy firms are almost identical to those found for bioeconomy firms, except for the fact of a firm belonging to a group (GP) not presenting evidence of significance for process innovation (ORME), despite having a significantly positive influence on product innovation (OREI).

The results for Hungarian bioeconomy firms indicate that inbound practices have a positive and significant influence on process innovation (ORME) and product innovation (OREI). Regarding non-pecuniary outbound practices, there is no evidence of their behaviour and pecuniaries are significant and have a positive influence on both innovations. Public policies are significant and have a positive influence on process (ORME) and product (OREI) innovation. The fact of a company belonging to a group (GP) has a positive influence on process innovation (ORME), but this is not found for product innovation (OREI).

The results for Hungarian non-bioeconomy firms indicate that inbound practices have a positive and significant influence on process innovation (ORME) and product innovation (OREI). As for outbound practices, these influence process innovation (ORME) positively and significantly, but there is no evidence of their effect on product innovation (OREI). Pecuniary outbound practices are significant with a positive influence on process (ORME) and product (OREI) innovation. Public policies present mixed evidence on process innovation (ORME) and although significant have a negative influence on product innovation (OREI). Company size (SIZE) is significant and shows a positive influence on process (ORME) and product innovation (OREI).

The results for Italian bioeconomy firms show that non-pecuniary inbound practices have a positive, significant influence on process (ORME) and product (OREI) innovation. Regarding pecuniary inbound practices, these are significant and have a positive influence on process innovation (ORME) with the evidence being mixed for product innovation (OREI). Non-pecuniary outbound practices show no evidence, whereas pecuniaries are significant with a positive influence on both types of innovation. As for public policies, these are significant with a positive influence on process innovation (ORME), with the evidence being mixed for product innovation (OREI). Company size (SIZE) is significant and has a positive influence on both process (ORME) and product (OREI) innovation.

The results for Italian non-bioeconomy firms show that inbound practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. Non-pecuniary outbound practices show no evidence, while pecuniaries are significant with a positive influence on both types of innovation. As for public policies, these are significant, having a positive influence on process (ORME) and product (OREI) innovation. Firm size (SIZE) is significant and has a positive influence on both process (ORME) and product (OREI) innovation, but the fact of a firm belonging to a group (GP) is significant and has a negative influence on product innovation (OREI).

The results for Portuguese bioeconomy firms show that inbound practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. Non-pecuniary outbound practices do not show statistical evidence, while pecuniaries are significant and have a positive influence on both types of innovation. As for public policies, these present mixed evidence regarding process

innovation (ORME) and product innovation (OREI). For firm size (SIZE) and belonging to a group (GP), no significant evidence is found.

The results for Portuguese non-bioeconomy firms reveal that non-pecuniary inbound practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. In addition, pecuniary inbound practices are significant and with a positive influence on process innovation (ORME), while for product innovation (OREI) the evidence is mixed. Non-pecuniary outbound practices show no evidence with associated statistical significance, while pecuniaries are significant and have a positive influence on both types of innovation. As for public policies, these show no evidence in relation to process innovation (ORME), while for product innovation (OREI) the evidence is mixed. Firm size (SIZE), is significant and has a positive influence on process (ORME) and product (OREI) innovation.

The results for bioeconomy firms in the Czech Republic show that inbound and outbound innovation practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. As for public policies, these are significant and have a positive influence on both types of innovation. Firm size (SIZE) is significant and has a positive influence on process innovation (ORME), but regarding product innovation (OREI) no significant evidence was found.

The results for Czech non-bioeconomy firms show that inbound practices are significant and have a positive influence on process (ORME) and product (OREI) innovation. Non-pecuniary inbound practices show no evidence of their behaviour, whereas pecuniaries are significant and have a positive influence on both types of innovation. As for public policies, these are significant and have a negative influence on both types of innovation. Firm size (SIZE) is significant and has a positive influence on process (ORME) and product (OREI) innovation.

In general, the results of the multivariate tobit suggest that inbound practices, involving either non-pecuniary or pecuniary flows, have a positive influence on eco-innovative performance. It should be noted that the results obtained for the multivariate tobit suggest non-pecuniaries show mixed evidence, as occurs with non-bioeconomy firms in Slovakia. Regarding outbound practices, these also have a positive influence on eco-innovative performance, but those involving non-pecuniary flows only reveal a significantly positive influence for bioeconomy firms in Slovakia and also for non-bioeconomy firms in Hungary and only in relation to process innovation. As for public policies, these show a positive influence on eco-innovative performance, despite detecting various cases of mixed evidence and even a negative influence. Besides the above, the multivariate tobit also suggests that size (SIZE) has a positive influence on eco-innovative performance. A summary of the results is presented in Appendix B, Table A2. For a more detailed analysis, consult Tables A3–A8, also in Appendix B.

5. Discussion

After presenting the results, they will now be discussed in relation to the research hypotheses. Considering Hypothesis H1, proposing a positive effect of inbound open innovation practices on eco-innovative performance. This hypothesis is confirmed for the bioeconomy and non-bioeconomy sub-samples and for all countries studied. H1 is not rejected, since for the different countries various significant variables stand out. For example, for Slovakia, sources of information from competitors or other firms in the same sector of activity (SCOM) on the sourcing side, and acquisition of other external knowledge (ROEK) on the acquiring side, are always significant, whether focusing on process or product innovation, or bioeconomy or non-bioeconomy firms. For Spain, all the sources considered in this study, i.e., sources of information in competitors or other firms in the same sector of activity (SCOM); consultants, laboratories or private R&D institutions (SINS) State laboratories or other public bodies (SGMT); information from scientific journals and technical/professional publications (SJOU) and professional or business associations (SPRO) on the sourcing side, and external acquisition of R&D activities (RRDEX) and acquisition of machinery, equipment and software (RMAC) on the acquiring side, are always significant, whether focusing on process or product innovation or bioeconomy or non-bioeconomy firms. In Hungary too, sources of information in competitors or other firms in

the same sector of activity (SCOM) on the sourcing side, and external acquisition of R&D activities (RRDEX), as well as the acquisition of machinery, equipment and software (RMAC) on the acquiring side, are always significant, whether focusing on process or product innovation, or bioeconomy or non-bioeconomy firms. In Italy, sources of information in competitors or other firms in the same sector of activity (SCOM); consultants, laboratories or private R&D institutions (SINS) information from scientific journals and technical/professional publications (SJOU) and professional or business associations (SPRO), on the sourcing side, and external acquisition of R&D activities (RRDEX) and the acquisition of machinery, equipment and software (RMAC), on the acquiring side, are always significant in process or product innovation, for both types of firms. In Portugal, sources of information in competitors or other firms in the same sector of activity (SCOM); consultants, laboratories or private R&D institutions (SINS) information from scientific journals and technical/professional publications (SJOU) and professional or business associations (SPRO) are always significant, in process or product innovation and in bioeconomy or non-bioeconomy firms. In Portugal, on the acquiring side, the acquisition of machinery, equipment and software (RMAC) has a significantly positive effect on eco-innovation, considering the results of the multivariate tobit model. For the Czech Republic, sources of information in scientific journals and technical/professional publications (SJOU) on the sourcing side, and the acquisition of machinery, equipment and software (RMAC) on the acquiring side, are always significant in process or product innovation and whatever the type of firm considered.

The results are in line with previous studies by Geffen and Rothenberg [83] and Kammerer [68], who state that knowledge coming from suppliers and clients is relevant for eco-innovation. Bönte and Dienes [85] also mention that institutional sources (universities) have a significant influence on eco-innovation. At the same time, considering the result of De Marchi [76], who underlines that cooperation is more important for the introduction of eco-innovations that other types of innovation, the results obtained here contribute to ratifying the importance of cooperation for eco-innovation. This claim is supported by the following variables: cooperation with firms in the same group (CO11); clients or consumers (CO31); competitors or other firms in the same sector of activity (CO41); consultants, laboratories or private R&D institutions (CO51); universities or other higher education institutions: (CO61); State laboratories or other public bodies with R&D activities (CO71). For inbound practices, on the acquiring side, Rouvinen [95] argues that the acquisition of new equipment, as a form of incorporated knowledge, should encourage mainly process innovations.

Hypothesis H2 assumes a positive relation between outbound open innovation practices and eco-innovative performance. A positive effect is confirmed for bioeconomy and non-bioeconomy firms. In greater detail, on the revealing side, for Slovakia, Spain and Portugal, there is no significant evidence in favour of revealing, but for Italy, the results indicate a negative relation and for Hungary and the Czech Republic the results indicate a positive relation. Therefore, the results are in line with Nuvolari [100], who concludes that firms reveal their ideas to their competitors with no identifiable negative consequence. On the selling side, highlighted are variables such as R&D activities carried out in the firm (RRDIN); new or significantly improved goods (INPDGD); new or significantly improved services (INPDSV); among others. So the results agree with the previous findings of Cassiman and Veugelers [130], who state that when firms invest more in internal R&D activities, they become more prepared to absorb external knowledge, and therefore, innovate.

Horbach [67], Kesidou and Demirel [131], Horbach et al. [15] and Triguero et al. [94] are examples of studies agreeing with the third hypothesis of this research, i.e., public policies have a positive relation with eco-innovative performance. In this study, H3 is not rejected for bioeconomy and non-bioeconomy firms.

6. Conclusions

This study analyses the effects of inbound and outbound open innovation practices and public policies on eco-innovative performance, for bioeconomy and non-bioeconomy firms in moderately innovative countries. Inbound practices consider the non-pecuniary flows corresponding

to sourcing and the pecuniary flows corresponding to acquiring, while outbound practices consider the non-pecuniary flows corresponding to revealing and pecuniary flows corresponding to selling.

In terms of general results, inbound practices of the sourcing and acquiring type, outbound practices of the revealing and selling type and public policies show a positive relation with eco-innovative performance. Concerning inbound practices of the sourcing type, for bioeconomy firms, from the results obtained, all the sources considered in this study, i.e., sources of information in competitors or other firms in the same sector of activity (SCOM); consultants, laboratories or private R&D institutions (SINS) State laboratories or other public bodies (SGMT); information from scientific journals and technical/professional publications (SJOU) and professional or business associations (SPRO) are significant for both process and product innovation (see the results, for example, for bioeconomy firms in Spain and Portugal.

Cooperative relations are also incorporated in inbound practices of the sourcing type, revealing that for bioeconomy firms, cooperation with firms in the same group (CO11) is only positive in product innovation in Portugal and cooperation with universities or other higher education institutions (CO61) and negative in process innovation in Slovakia. For inbound practices of the sourcing type, and for non-bioeconomy firms, the results are similar, for example, in the specific case of Spain, all the sources considered in this study are positive and significant, for both process and product innovation.

Still for inbound practices, but of the acquiring type and for bioeconomy firms, it should be noted that external acquisition of R&D activities (RRDEX) is positive and significant in both process and product innovation, as shown by the results for Slovakia and Hungary, although for Italy the results show a significantly negative influence, for both types of innovation. Also, for inbound practices of the acquiring type, but for non-bioeconomy firms, the acquisition of machinery, equipment and software (RMAC), they always show a positive and significant influence on process and product innovation.

Regarding outbound practices, the revealing mode for bioeconomy firms operationalized through non-financial incentives for employees to develop new ideas, such as: free time and recognition (MNFIN); this is seen to be significant and positive for both process and product innovation as observed from the results for the Czech Republic. Considering outbound practices, the revealing mode for non-bioeconomy firms through non-financial incentives for employees to develop new ideas, such as: free time and recognition (MNFIN); is also significant and positive, in terms of process and product innovation, observed through the results obtained for Hungary.

For selling mode outbound practices and for bioeconomy and non-bioeconomy firms, R&D activities carried out in the firm (RRDIN); and new or significantly improved goods (INPDGD) show a positive and significant relation in both process and product innovation.

The empirical evidence now obtained sheds new light and provides both theoretical and empirical contributions to the positive and significant influence of open innovation outbound practices on eco-innovation; in particular, the pecuniary flows, since for non-pecuniary ones, it was only possible to detect a positive relationship for the cases of Bioeconomy companies of the Czech Republic and non-Bioeconomy companies of Hungary, which are two examples of transition economies with an upward innovative profile on the pathway to the maturity of open innovation processes.

These results advance the still limited knowledge about the importance associated with the implementation of open innovation outbound practices on the eco-innovative performance of companies belonging to a strategic sector, worldwide; that is, the Bioeconomy sector, since the previous empirical evidence regarding this sector, with increased strategic importance in the face of global climate change, are still scarce or even neglected in the literature and references on open innovation.

As for public policies, public financial support coming from Local or Regional Administration (FUNLOC) is shown to be significant and positive for both process and product innovation, as confirmed for Spain and Italy. Besides the influences described above, size and the fact of the firm belonging to a group, they also produce a significantly positive influence on process and product innovation.

This study has some implications. In terms of theory, it improves understanding of inbound and outbound practices. For example, besides considering sourcing, inbound practices also consider acquiring, and besides considering revealing, outbound practices also incorporate selling.

Regarding implications for innovation managers, they should consider the need to balance internal and external knowledge that improves environmental performance, because as argued by Rothaermel and Alexandre [132], the level of ambidexterity can allow firms to configure and raise their internal and external knowledge resources, in terms of the influence of technology supply strategies on environmental performance. Concerning public policies, public financing bodies should consider the results presented here, for example, in decision-making processes that imply the allocation of funds for activities aiming for open eco-innovation.

One of the main limitations of this study arises from the lack of information observed in successive surveys from CIS 2012 until the most recent CIS 2018, particularly for the variables referring to eco-innovative performance. Another limitation is the lack of studies of reference addressing the effects of, above all, outbound practices on eco-innovative performance. Another concerns the analysis being limited to bioeconomy and non-bioeconomy firms, as industrial and service companies could also be interesting, considering their prominence in economies.

Finally, in terms of future research, it would be interesting to study in greater depth the effects associated with inbound and outbound open innovation practices and public policies on the eco-innovative performance of firms with different profiles of technological intensity, based on a comparison between modest, moderate, follower and leader countries in innovation.

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Conflicts of Interest: The authors declare there are no conflict of interest.

Appendix A

Table A1. Sector classification: National Classification of Economic Activities-NACE Rev.2.

Classification	Description	NACE Code Rev.2
Bioeconomy firms	Agriculture	A01
	Forestry	A02
	Fishing and aquaculture	A03
	Production of food, drinks and tobacco	C10; C11; C12
	Production of biologically-based cloth, clothing and leather	C13 *; C14 *; C15
	Production of wooden products and wooden furniture	C16; C31 *
	Production of paper	C17
	Production of biologically-based chemical products; pharmaceutical products and plastic and rubber	C20 *; C21 *; C22 *
	Bio-ethanol production	C2014 *
	Bio-diesel production	C2059 *
	Bio-electricity production	D3511 *
Non-bioeconomy firms	Mines and quarries	B05-B09
	Printing and reproduction of recorded media	C18
	Production of coke and derivatives of refined oil	C19
	Production of non-metallic mineral products; basic metals; manufactured metal products, except machinery and equipment; computer, electronic and optical products; electrical equipment; machines and equipment n.e.c; vehicles, trailers and semi-trailers; other manufacturing; repair and installation of machines and equipment	C23; C24; C25; C26; C27; C28; C29; C30; C32; C33
	Supply of electricity, gas, steam and air conditioning	D35
	Supply of water; drains, waste management and remediation	E36-E39
	Construction	F41-45
	Wholesale and retail commerce; Repair of motor vehicles and motorbikes	G45-G47
	Transport and storage	H49-H53
	Accommodation activities and food services	I55-I56
	Information and communication	J58-J63
	Financial activities and insurance	K64-K66
	Real estate activities	L68-
	Professional, scientific and technical activities	M69-M75
	Administrative and support service activities	N77-N82
	Public administration and defence and obligatory social security	O84
	Education	P85
	Human health and social work activities	Q86-Q88
	Arts, entertainment and recreation	R90-R93
	Other activities and services	S94-S96
	Activities of households as employers; undifferentiated producing activities of private households for own use	T97-T97
	Activities of foreign organisations and entities	U99

*. Hybrid sector.

Appendix B

Table A2. Results of the multivariate tobit model: Summary.

Samples	Independent	Dependent	Slovakia		Spain		Hungary		Italy		Portugal		Czech Republic	
			1	2	1	2	1	2	1	2	1	2	1	2
			ORME	OREI	ORME	OREI	ORME	OREI	ORME	OREI	ORME	OREI	ORME	OREI
Bioeconomy	Inbound	Non-pecuniary	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	Inbound	Pecuniary	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕⊖	⊕	⊕	⊕	⊕
	Outbound	Non-pecuniary	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊕	⊕
	Outbound	Pecuniary	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	Public policies		⊕⊖	⊕	⊕	⊕⊖	⊕	⊕	⊕	⊕⊖	⊕⊖	⊕⊖	⊖	⊕
	Control		⊗	⊕	⊕	⊕	⊕	⊗	⊕	⊕	⊗	⊗	⊕	⊗
Non-Bioeconomy	Inbound	Non-pecuniary	⊕	⊕⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	Inbound	Pecuniary	⊕⊖	⊕⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕⊖	⊕	⊕
	Outbound	Non-pecuniary	⊗	⊗	⊗	⊗	⊕	⊗	⊗	⊗	⊗	⊗	⊗	⊗
	Outbound	Pecuniary	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	Public policies		⊕	⊕	⊕	⊕⊖	⊕⊖	⊖	⊕	⊕	⊗	⊕⊖	⊖	⊖
	Control		⊕	⊕	⊗	⊕	⊕	⊕	⊕	⊕⊖	⊕	⊕	⊕	⊕

Legend: 1. Process innovation **| 2.** Product innovation. **Source:** Own elaboration.

Table A3. Estimation results of multivariate tobit model Slovakia.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN								
RRDIN								
INPDGD	1.420	0.000 ***	0.703	0.000 ***	1.162	0.000 ***	0.935	0.000 ***
INPDSV			0.380	0.001 ***			0.328	0.013 ***
INPSPD	0.580	0.000 ***	0.265	0.019 **	0.706	0.000 ***	0.339	0.012 ***
INPSLG							0.295	0.050 **
INPSSU			0.601	0.000 ***			0.501	0.000 ***
ORGBUP			0.314	0.011 ***			0.481	0.001 ***
ORGWKP								
ORGEXR					−0.429	0.029 **		
MKTDGP			−0.382	0.005 ***			−0.317	0.051 **
MKTPDP								
MKTPDL								
MKTPRI	−0.472	0.020 **	0.230	0.082 *			0.310	0.051 **
SCOM	0.150	0.057 *	0.321	0.000 ***	0.186	0.020 **	0.304	0.000 ***
SINS			0.156	0.019 **				
SGMT								
SJOU	0.334	0.000 ***	0.458	0.000 ***	0.500	0.000 ***	0.458	0.000 ***
SPRO								
CO11								
CO21			0.421	0.015				
CO31			−0.718	0.001 ***			−0.519	0.039 **
CO41			0.356	0.082 *				
CO51			−0.389	0.042 **			−0.405	0.075 *
CO61					−2.380	0.017 **		
CO71								
RRDEX								
RMAC	0.654	0.001 ***	1.178	0.000 ***	0.856	0.000 ***	1.406	0.000 ***
ROEK			−0.255	0.051 **			−0.313	0.045 **
FUNLOC	1.720	0.040 **			2.158	0.011 ***		
FUNGMT	−0.628	0.047 **						
FUNEU			0.575	0.004 ***			0.608	0.010 ***
FUNRTD								
SIZE			0.122	0.045 **	0.261	0.006 ***	0.168	0.024 **
Log Likelihood	−260.891		−1559.421		−260.891		−1559.421	
P-value	0.000		0.000		0.000		0.000	
AIC	671.7824		3268.842		671.7824		3268.842	
BIC	952.7476		3690.762		952.7476		3690.762	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

Table A4. Estimation results of multivariate tobit model Spain.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN								
RRDIN	0.430	0.000 ***	0.700	0.000 ***	0.631	0.000 ***	0.809	0.000 ***
INPDGD	0.302	0.000 ***	0.532	0.000 ***	0.448	0.000 ***	0.519	0.000 ***
INPDSV								
INPSPD	0.966	0.000 ***	0.914	0.000 ***	0.701	0.000 ***	0.709	0.000 ***
INPSLG			0.187	0.000 ***			0.178	0.000 ***
INPSSU	0.351	0.000 ***	0.618	0.000 ***	0.287	0.000 ***	0.508	0.000 ***
ORGBUP	0.196	0.000 ***	0.118	0.001 ***	0.203	0.000 ***	0.179	0.000 ***
ORGWKP			0.182	0.000 ***			0.201	0.000 ***
ORGEXR	−0.174	0.005 ***	−0.150	0.000 ***	−0.115	0.080 *	−0.155	0.000 ***
MKTDGP								
MKTPDP								
MKTPDL	−0.167	0.011 ***	−0.179	0.000 ***	−0.142	0.042 **	−0.154	0.003 ***
MKTPRI	0.105	0.094 *						
SCOM	0.288	0.000 ***	0.370	0.000 ***	0.304	0.000 ***	0.358	0.000 ***
SINS	0.188	0.000 ***	0.241	0.000 ***	0.189	0.000 ***	0.275	0.000 ***
SGMT	0.135	0.000 ***	0.203	0.000 ***	0.169	0.000 ***	0.217	0.000 ***
SJOU	0.155	0.000 ***	0.178	0.000 ***	0.218	0.000 ***	0.259	0.000 ***
SPRO	0.108	0.000 ***	0.163	0.000 ***	0.134	0.000 ***	0.205	0.000 ***
CO11								
CO21			0.143	0.003 ***			0.168	0.001 ***
CO31			−0.256	0.000 ***			−0.106	0.071 *
CO41			−0.265	0.000 ***	−0.282	0.011 ***	−0.313	0.000 ***
CO51			−0.177	0.002 ***			−0.139	0.020 **
CO61								
CO71	−0.222	0.002 ***	−0.314	0.000 ***	−0.224	0.003 ***	−0.328	0.000 ***
RRDEX			0.145	0.000 ***			0.188	0.000 ***
RMAC	0.403	0.000 ***	0.627	0.000 ***	0.442	0.000 ***	0.591	0.000 ***
ROEK								
FUNLOC	0.163	0.001 ***	0.168	0.000 ***	0.133	0.012 ***	0.221	0.000 ***
FUNGMT			−0.064	0.104 *				
FUNEU					−0.408	0.097 *		
FUNRTD			−0.258	0.039 **			−0.371	0.005 ***
SIZE								
GP	0.217	0.000 ***			0.149	0.001 ***	0.060	0.060 *
Log Likelihood	−9451.366		−31,205.92		−9451.366		−31205.92	
P-value	0.000		0.000		0.000		0.000	
AIC	19,048.73		62,557.85		19,048.73		62,557.85	
BIC	19,541.12		63,160.07		19,541.12		63,160.07	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

Table A5. Estimation results of multivariate tobit model Hungary.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN			0.075	0.048 **				
RRDIN	0.577	0.000 ***			0.565	0.002 ***	0.963	0.000 ***
INPDGD	0.844	0.000 ***	0.814	0.000 ***	0.880	0.000 ***		
INPDSV							0.461	0.000 ***
INPSPD			0.341	0.000 ***	0.391	0.039 **		
INPSLG							0.420	0.000 ***
INPSSU	0.354	0.037 **	0.442	0.000 ***	0.410	0.059 *		
ORGBUP								
ORGWKP								
ORGEXR								
MKTDGP								
MKTPDP								
MKTPDL	−0.467	0.007 ***					−0.283	0.076 *
MKTPRI	0.371	0.018 ***						
SCOM	0.507	0.000 ***	0.267	0.000 ***	0.575	0.000 ***	0.281	0.000 ***
SINS			0.274	0.000 ***	0.179	0.042 **	0.310	0.000 ***
SGMT							0.184	0.012 ***
SJOU			0.319	0.000 ***	0.275	0.009 ***	0.329	0.000 ***
SPRO	0.149	0.071 *	0.132	0.017 **			0.237	0.001 ***
CO11								
CO21								
CO31								
CO41								
CO51								
CO61								
CO71	−0.466	0.075 *						
RRDEX	0.650	0.000 ***	0.347	0.000 ***	0.569	0.004 ***	0.470	0.000 ***
RMAC	0.687	0.000 ***	1.113	0.000 ***	0.775	0.000 ***	1.258	0.000 ***
ROEK			0.202	0.044 **				
FUNLOC			0.747	0.044 **				
FUNGMT	0.319	0.056 *						
FUNEU	0.316	0.086 *						
FUNRTD	1.477	0.013 ***	−0.764	0.012 ***	1.266	0.0955 *	−1.015	0.009 ***
SIZE			0.148	0.008 ***			0.208	0.004 ***
GP	0.243	0.058 *			0.243	0.058 *		
Log Likelihood	−957.933		−2835.724		−957.933		−2835.724	
P-value	0.000		0.000		0.000		0.000	
AIC	2065.867		5821.447		2065.867		5821.447	
BIC	2449.353		6281.532		2449.353		6281.532	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

Table A6. Estimation results of multivariate tobit model Italy.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN								
RRDIN	0.530	0.000 ***	0.538	0.000 ***	0.463	0.000 ***	0.494	0.000 ***
INPDGD	0.437	0.000 ***	0.487	0.000 ***	0.573	0.000 ***	0.432	0.000 ***
INPDSV			0.116	0.005 ***			0.267	0.000 ***
INPSPD	0.365	0.000 ***	0.437	0.000 ***	0.480	0.000 ***	0.404	0.000 ***
INPSLG			0.126	0.010 ***			0.108	0.000 ***
INPSSU	0.193	0.010 ***	0.340	0.000 ***			0.264	0.029 ***
ORGBUP								
ORGWKP			0.143	0.001 ***			0.189	0.000 ***
ORGEXR					0.143	0.083 *		
MKTDGP			0.156	0.002 ***			0.146	0.004 ***
MKTPDP								
MKTPDL			−0.228	0.000 ***			−0.152	0.007 ***
MKTPRI								
SCOM	0.203	0.000 ***	0.269	0.000 ***	0.146	0.000 ***	0.209	0.000 ***
SINS	0.160	0.000 ***	0.253	0.000 ***	0.204	0.000 ***	0.253	0.000 ***
SGMT								
SJOU	0.132	0.002 ***	0.222	0.000 ***	0.159	0.000 ***	0.212	0.000 ***
SPRO	0.184	0.000 ***	0.146	0.000 ***	0.168	0.000 ***	0.177	0.000 ***
CO11								
CO21								
CO31								
CO41			−0.362	0.000 ***			−0.291	0.003 ***
CO51					−0.308	0.062 *		
CO61								
CO71								
RRDEX	−0.158	0.064 *			−0.182	0.032 **		
RMAC	1.195	0.000 ***	1.619	0.000 ***	1.231	0.000 ***	1.655	0.000 ***
ROEK	−0.151	0.101 *					−0.130	0.015
FUNLOC	0.279	0.000 ***	0.180	0.001 ***	0.358	0.000 ***	0.269	0.000 ***
FUNGMT			0.187	0.008 ***			0.159	0.025 **
FUNEU								
FUNRTD								
SIZE	0.140	0.0787 *	0.174	0.000 ***			0.159	0.000 ***
GP					0.1162	0.041 **	−0.075	0.090 *
Log Likelihood	−3114.255		−14,185.097		−3114.255		−14,185.097	
P-value	0.000		0.000		0.000		0.000	
AIC	6378.51		28520.19		6378.51		28,520.19	
BIC	6808.405		29,096.44		6808.405		29,096.44	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

Table A7. Estimation results of multivariate tobit model Portugal.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN								
RRDIN	0.194	0.030 **	0.176	0.001 ***	0.268	0.002 ***	0.115	0.025 **
INPDGD	0.574	0.000 ***	0.457	0.000 ***	0.540	0.000 ***	0.514	0.000 ***
INPDSV							0.142	0.003 ***
INPSPD	0.662	0.000 ***	0.659	0.000 ***	0.641	0.000 ***	0.502	0.000 ***
INPSLG			0.112	0.035 **			0.112	0.035 **
INPSSU	0.321	0.000 ***	0.515	0.000 ***	0.323	0.000 ***	0.555	0.000 ***
ORGBUP					−0.297	0.001 ***		
ORGWKP	0.324	0.000 ***	0.195	0.000 ***	0.314	0.000 ***	0.178	0.001 ***
ORGEXR	−0.205	0.046 **						
MKTDGP	0.176	0.038 **			0.230	0.005 ***	0.120	0.023 **
MKTPDP	−0.164	0.077 *						
MKTPDL	−0.222	0.059 *	−0.136	0.033 **	−0.199	0.083 *		
MKTPRI	0.250	0.008 ***			0.212	0.022 *		
SCOM	0.290	0.000 ***	0.282	0.000 ***	0.260	0.000 ***	0.239	0.000 ***
SINS	0.105	0.034 **	0.129	0.000 ***	0.124	0.010	0.126	0.000 ***
SGMT								
SJOU	0.196	0.000 ***	0.161	0.000 ***	0.221	0.000 ***	0.165	0.000 ***
SPRO	0.093	0.066 **	0.282	0.000 ***	0.099	0.045 **	0.276	0.000 ***
CO11								
CO21					−0.274	0.071 *		
CO31								
CO41								
CO51			−0.298	0.003 ***				
CO61								
CO71								
RRDEX								
RMAC	0.746	0.000 ***	0.699	0.000 ***	0.671	0.000 ***	0.648	0.000 ***
ROEK							−0.123	0.045 **
FUNLOC	0.586	0.007 ***			0.667	0.002 ***	0.313	0.034 **
FUNGMT	−0.198	0.040 **			−0.200	0.033 **	0.105	0.071 *
FUNEU							−0.197	0.038 **
FUNRTD								
SIZE			0.082	0.015			0.072	0.033 **
GP								
Log Likelihood	−1578.583		−7337.374		−1578.583		−7337.374	
P-value	0.000		0.000		0.000		0.000	
AIC	3307.166		3307.166		3307.166		3307.166	
BIC	3690.346		3690.346		3690.346		3690.346	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

Table A8. Estimation results of multivariate tobit model Czech Republic.

	Bioeconomy		**Non-Bioeconomy**		**Bioeconomy**		**Non-Bioeconomy**	
	ORME		**ORME**		**OREI**		**OREI**	
	Coef	**P**	**Coef**	**P**	**Coef**	**P**	**Coef**	**P**
MNFIN	0.055	0.055			0.057	0.094 *		
RRDIN	0.353	0.000 ***	0.381	0.000 ***	0.232	0.028 **	0.303	0.000 ***
INPDGD	0.644	0.000 ***	0.332	0.000 ***	0.879	0.000 ***	0.425	0.000 ***
INPDSV								
INPSPD	0.414	0.000 ***	0.338	0.000 ***	0.367	0.000 ***	0.391	0.000 ***
INPSLG			0.278	0.000 ***			0.236	0.004 ***
INPSSU			0.122	0.064 *				
ORGBUP			0.266	0.000 ***			0.249	0.002 ***
ORGWKP	0.163	0.075 *						
ORGEXR								
MKTDGP					−0.202	0.057 *	−0.130	0.099 *
MKTPDP			−0.112	0.098 *				
MKTPDL								
MKTPRI							0.280	0.000 ***
SCOM	0.348	0.000 ***			0.296	0.000 ***	0.192	0.000 ***
SINS			0.101	0.008 ***				
SGMT							0.280	0.000 ***
SJOU	0.339	0.000 ***	0.323	0.000 ***	0.373	0.000 ***	0.192	0.000 ***
SPRO			0.139	0.001 ***	0.156	0.013 ***		
CO11							0.237	0.016 **
CO21					−0.234	0.083 *	−0.318	0.004 ***
CO31			−0.221	0.020 **				
CO41							−0.282	0.023 **
CO51								
CO61								
CO71								
RRDEX								
RMAC	0.837	0.000 ***	1.053	0.000 ***	0.859	0.000 ***	1.138	0.000 ***
ROEK								
FUNLOC								
FUNGMT	−0.224	0.077 *						
FUNEU					0.266	0.066 *		
FUNRTD			−0.258	0.060 *			−0.421	0.008 ***
SIZE	0.123	0.017 **	0.105	0.004 ***			0.131	0.002 ***
GP								
Log Likelihood	−1514.236		−4158.295		−1514.236		−4158.295	
P-value	0.000		0.000		0.000		0.000	
AIC	3178.472		8466.59		3178.472		8466.59	
BIC	3573.641		8933.12		3573.641		8933.12	

AIC—Akaike Information Criterion; BIC—Schwarz Bayesian Information Criterion. *** 1%; ** 5%; * 10%.

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