sustainability

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Is Entrepreneurship the Key to Achieving Environmental Sustainability? A Data-Driven Analysis from the Asia-Pacific Region

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Abstract: This study examines the relationship between entrepreneurship density and environmental quality in 28 Asia-Pacific countries using the PMG estimator as a panel data estimation method in the context of the ARDL model. The study finds that entrepreneurship density has no statistically significant short-term effects on CO_2 emissions in all three economic sectors, but it appears to have statistically significant effects on CO_2 emissions in agriculture and industry in the long run. The study suggests that the nature of entrepreneurship activities and their impact on the environment changes from low-income to high-income countries, with entrepreneurship activities with innovations and creativity primarily found in the industrial sector, improving economic efficiency and reducing industrial emissions. However, entrepreneurship activities with natural resource rents, such as large land use or forest rents, can cause environmental degradation. The study provides further insights by interacting entrepreneurship density with the income variable, revealing that entrepreneurship density has different effects on sectoral emissions in low, lower-middle, upper-middle, and high-income countries. Finally, the study provides interesting findings on the relationship between entrepreneurship density and environmental quality, such as biodiversity and water quality.

Keywords: entrepreneurship; environmental sustainability; panel data analysis

JEL Classification: C33; L31; Q51; Q56

Citation: Le, T.-H.; Nguyen, C.P.; Bui, M.-T. Is Entrepreneurship the Key to Achieving Environmental Sustainability? A Data-Driven Analysis from the Asia-Pacific Region. *Sustainability* **2023**, *15*, 14523. https://doi.org/10.3390/su151914523

Academic Editor: João J. Ferreira

Received: 12 June 2023
Revised: 30 August 2023
Accepted: 28 September 2023
Published: 6 October 2023

1. Introduction

There is growing evidence of environmental deterioration in various parts of the world, primarily attributed to human activities. Responding to this global concern, the United Nations introduced the Sustainable Development Goals (SDGs) in 2015, emphasizing economic security and environmental sustainability across diverse domains. Specifically, Goals 6, 7, 12, 13, 14, and 15 of the SDGs highlight the significance of environmental sustainability. Despite the potential economic gains associated with entrepreneurship, not all entrepreneurial endeavors align with the principles of environmental sustainability. Consequently, questions surrounding the impact of entrepreneurship on environmental quality and strategies to ensure ecologically responsible entrepreneurial practices have become pivotal in conversations about economic growth and sustainable development. Recent studies indicate that entrepreneurship activities could yield positive environmental outcomes [1,2], yet concerns persist regarding potential negative effects [3–5].

Greenhouse gas emissions, as result of economic activities, are closely linked to climate change, causing more frequent and intense extreme weather and climate events globally, such as heatwaves and large storms [6]. Reducing greenhouse gas emissions is critical to mitigating the impacts of climate change [7]. Interestingly, the United States and China, which were among the top greenhouse gas emitters in 2015, are considered the countries with the most favorable conditions for innovation and entrepreneurship [8]. This suggests that the world's two largest carbon dioxide emitters are also leaders in business, technology, innovation, and entrepreneurship indicators. Therefore, investigating the link between emissions and entrepreneurship is crucial from a sustainability perspective. Entrepreneurial action is increasingly recognized to preserve ecosystems, counteract climate change, and address environmental challenges [9,10].

The economic literature has extensively documented the role of entrepreneurship as a driver in transforming political, economic, and social systems. Numerous studies have delved into how entrepreneurship can contribute to solving challenges related to sustainable development [11–13]. Given this context, entrepreneurship is widely recognized as a crucial source in delivering sustainable processes, products, and services, driving progress toward a green economy. A multitude of new projects are emerging as solutions to diverse environmental and social concerns, underscoring entrepreneurship's potential impact [11,14,15].

Despite the growing attention to this topic, most of the literature on the business–sustainability nexus has focused on how sustainable development affects competitive advantage, how businesses can reduce their environmental impact, and how innovation promotes sustainability transitions [11]. For example, Cohen and Winn [9] identified four types of market imperfections that contribute to environmental pollution and create significant entrepreneurial opportunities for developing a sustainable entrepreneurship model. This process could slow down environmental degradation and gradually improve the Earth's ecosystems. In another study on the role of entrepreneurship in sustainable development, Hall, Daneke and Lenox [12] affirmed entrepreneurship as a solution for environmental problems but suggested that further research is needed to investigate the extent to which entrepreneurs can establish sustainable economies. Similarly, York and Venkataraman [16] argued that, under certain conditions, entrepreneurship can contribute to environmental sustainability instead of driving environmental degradation. Their analysis was based on a model that incorporated the ability of entrepreneurs to complement regulation, corporate social responsibility, and activism in addressing environmental challenges.

Meanwhile, only a few studies have analyzed the issue of environmental sustainability from an entrepreneurship perspective, such as Dean and McMullen [10], Hall, Daneke and Lenox [12], Pacheco, et al. [17], Dhahri and Omri [11], Omri and Afi [13], Nguyen, Kim and Su [5], and most of these studies were conducted for developed countries. (The two exceptional cases here are Dhahri and Omri [11], which examined 20 developing countries, and Omri and Afi [13], which explored 32 developing countries). In this study, we focus on the Asia-Pacific region, which is known for its variety, consisting of a blend of established economies, developing markets, and emerging nations.

This study aims to contribute to the literature investigating the impact of entrepreneurship on environmental sustainability in the Asia-Pacific region. Examining the relationship between entrepreneurship and environmental sustainability in this region is crucial for several reasons. Firstly, the Asia-Pacific region contains some of the world's fastest-growing economies, with entrepreneurship being a significant contributor to economic growth. Secondly, this region faces severe environmental challenges, such as air and water pollution, deforestation, and climate change. Thirdly, entrepreneurship can provide innovative solutions to these environmental issues and promote sustainable development. By comprehending the role of entrepreneurship in achieving environmental sustainability in the Asia-Pacific region, policymakers, business leaders, and researchers can devise effective strategies and policies to foster sustainable economic growth and preserve the region's natural resources for future generations.

Specifically, the research objectives are as follows:

- To examine whether the impacts of entrepreneurship and other potential determinants differs across various environmental performance indicators in the Asia-Pacific region;
- To investigate whether the impact of entrepreneurship and other potential determinants differs across different sectors of the economies in the Asia-Pacific region.

The study tests two hypotheses:

Hypothesis 1: *The impact of entrepreneurship on environmental indicators varies across different types of environmental performance indicators in the Asia-Pacific region.*

Hypothesis 2: *The impact of entrepreneurship on the environment varies across various sectors of the economy in the Asia-Pacific region.*

Our study offers significant contributions through its rigorous testing framework and methodological approach. Previous empirical studies examining the influence of entrepreneurship on sustainability matters, particularly environmental performance, often amalgamate a few core variables within their models for empirical assessment. However, our baseline model rests upon a solid theoretical underpinning that integrates the environmental repercussions of socio-economic activities, utilizing the STIRPAT model. Moreover, our empirical analysis tackles several pivotal aspects of panel data modeling, including cross-sectional dependence, endogeneity, stationarity, and variable cointegration, in order to attain outcomes that are both precise and resilient.

The study focuses on investigating the effects of entrepreneurship on environmental performance, including emissions, drinking water, and tree cover, as well as sectoral emissions, in 28 Asia-Pacific countries from 2006 to 2019. Using the Pooled Mean Group (PMG) estimator as a panel data estimation method in the context of the Autoregressive Distributed Lag (ARDL) model to analyze the data, we specifically examine sectoral emissions and find that while entrepreneurship has no significant short-term effects on CO_2 emissions, it does have significant long-term effects on emissions in agriculture and industry. The study suggests that the impact of entrepreneurship on the environment changes from low-income to high-income countries. We also find that entrepreneurship activities with innovation in the industrial sector can improve energy efficiency and reduce industrial emissions, but activities with natural resource rents, such as large land use or forest rents, can cause environmental degradation. Finally, we explore the effects of entrepreneurship density on other aspects of environmental quality, such as biodiversity and water quality.

The rest of this paper is organized as follows. Section 2 offers a comprehensive literature review of the concepts of entrepreneurship and environmental sustainability, delving into their interconnections. Section 3 outlines the model, data, and variables employed in the study, along with the applied empirical techniques. In Section 4, the empirical results are presented and discussed. Lastly, Section 5 concludes the study while exploring its implications.

2. Literature Review

2.1. Understanding Entrepreneurship: Definitions, Characteristics, and Measurement Approaches

The concept of entrepreneurship has been studied in the literature for a long time. According to Brown and Thornton [18], the theory of entrepreneurship was established in 1725 by Richard Cantillon (17th–18th century), who was probably the first scholar to link the theory of entrepreneurship with economic theory. Cantillon's theory of entrepreneurship defines that entrepreneurs bear risk under uncertainty or are risk-takers. Until the 20th century, Schumpeterian economics by Schumpeter [19] noticed entrepreneurship as a force for "creative destruction", which was the first development of entrepreneurship into mainstream economic models. Later, Schultz [20] defined entrepreneurship as "the ability to deal with disequilibria rather than [the] ability to deal with uncertainty". Schultz [21] extends that entrepreneurship is "a pervasive activity in a dynamic economy" [22]. The later theory of Israel Kirzner defines entrepreneurs as those who explore the market imperfections and exploit them, or those who have an alertness to profit opportunities [23]. Hébert and Link [22] developed a "synthetic" definition of an entrepreneur as "someone who specializes in taking responsibility for and making judgemental decisions that affect the location, the form, and the use of goods, resources, or institutions".

It is important to note that entrepreneurship is a dynamic economic activity that evolves with the development of society and the economy. Therefore, the definition of entrepreneurship has evolved in recent decades, with the inclusion of new dimensions and characteristics, especially innovation and creativity. According to COM [24], entrepreneurship in the business context is defined as "an individual's motivation and capacity, independently or within an organisation, to identify an opportunity and to pursue it to produce new value or economic success". Ahmad and Seymour [25] have summarized the literature and arrived at a formal definition of "entrepreneurial activity" as "enterprising human action in pursuit of the generation of value, through the creation or expansion of economic activity, by identifying and exploiting new products, processes or markets".

Entrepreneurship activities are regarded as an important force of economic development (Neumann, 2021; Sternberg, 2022) and social sustainability [26–28]. Several studies (e.g., Simón-Moya, et al. [29], Bizri [30]) emphasize that entrepreneurial activities vary across countries. Consequently, the measurements of entrepreneurship may face many difficulties and may suffer from imperfections [31].

According to Ahmad and Seymour [25], entrepreneurial activity includes various activities, such as the creation of new products or services, entry into new markets, and innovation associated with different business activities. However, entrepreneurship activity does not include people who consider or plan to perform an entrepreneurial activity [25]. Thus, there are still debates in measuring entrepreneurship activities in the empirical literature.

The creation of new businesses is mostly agreed upon as the salient feature of entrepreneurship and thus one of the best proxies of entrepreneurship activities [32]. Therefore, several studies have used the number of newly registered businesses as the main proxy for entrepreneurship, and it is often considered among the best indicators of entrepreneurship (see Nguyen, et al. [33]; Nguyen, et al. [34]).

2.2. Indicators and Concepts of Environmental Sustainability in the Literature of Environmental Economics

Against the backdrop of climate change and global warming, environmental sustainability has evolved as one of the most important concepts in the literature of environmental economics. Beginning with sustainable development, the World Commission on Environment and Development (WCED), with a convention held by the United Nations in 1983, has defined sustainability as "development that meets the needs of the present generation without compromising the ability of future generations to meet their needs". According to the National Environmental Policy Act of 1969 of the United States, aiming at environmental sustainability is "to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations".

Within this frame of reference, there have been several attempts to construct different indicators to represent environmental sustainability (see Siche, et al. [35] for a review). One of the first indicators is the ecological footprint index, which was introduced by Rees [36] and elaborated by Wackernagel and Rees [37], Wackernagel and Rees [38]. The ecological footprint index reflects the natural resources' human demand through a matrix of consumption/use of land [38]. The ecological footprint index is a purely physical index rather than an economic indicator. Technically, the ecological footprint is measured in global hectares area (gha) (see www.footprintnetwork.org, accessed on 15 October 2021). Later, the energy performance indices (they name these indices "Emergy", with the meaning of

"EMbodied enERGY"), which assume the economic system to be an open thermodynamic system, were also introduced in the 1990s by Odum [39] and Brown and Ulgiati [40].

The environmental sustainability index is, in fact, a multi-dimensional concept that measures the ability to maintain valued environmental assets for future generations for the next several decades [41,42]. The environmental sustainability index is constructed from 21 indicators and 76 variables in five dimensions of environmental systems (see more details on variables and indicators of environmental sustainability index in page 5, Summary for Policymakers from Reports of Colombia University at http://sedac.ciesin.columbia.edu/es/esi/ESI2005_policysummary.pdf, accessed on 15 October 2021). There was also an environmental performance index introduced by a group of researchers from Yale University in 2002 to supplement the environmental targets described in the United Nations Millennium Development Goals (See https://epi.yale.edu/about-epi, accessed on 15 October 2021). This index has been used in several studies on environmental sustainability issues, such as Le, et al. [43], Le, et al. [44].

2.3. The Nexus between Entrepreneurship and Environmental Quality

In the economic literature, entrepreneurship activities are crucially related to innovation for economic development based on the work of Schumpeter [19]. Entrepreneurship has strong links to many economic–social factors, such as economic development [19], innovation [26,45], and human well-being [46]. In particular, green entrepreneurship is beneficial in promoting technological advancements and plays a significant role in aiding environmental regulations to achieve improved results through the reduction of overall pollution from enterprises [2,47]. According to Lipparini and Sobrero [48], the personal networks and relationships of entrepreneurs are used firstly to define possible sources of knowledge for entrepreneurship. Individual social capital is a critical factor for entrepreneurial discovery, such as occupational qualifications, family resources, gender [49], and workforce educational diversity [50]. Entrepreneurs are also concerned about external conditions in their start-up decisions, such as economic dynamics [33,34]. The economic and market conditions have a significant influence on entrepreneurship activities [51]. The literature concludes that entrepreneurship activities depend on the dynamics between social, cultural, economic, and environmental factors [52].

In return, attention has been given to the linkages between entrepreneurship and environmental issues [2,5]. The effects of entrepreneurship on environmental performance could be both positive and negative. On the one hand, entrepreneurship activities are acknowledged to be associated with innovations and creativity that improve the efficiency of economic growth [53]. Entrepreneurship may contribute positively to environmental sustainability by improving the efficiency of economic activities, which can reduce environmental exploitation. In the same vein, entrepreneurship is proposed as a cure rather than a source of environmental degradation [16]. The potential of entrepreneurship is embraced to supplement regulation, corporate social responsibility, and activism in addressing environmental problems. Similarly, entrepreneurial action is thought to help preserve the natural ecosystem; combat climate change; address environmental degradation and deforestation; improve agricultural practices, clean air, and freshwater supplies; and protect biodiversity [54]. Meanwhile, Omri [55] found that the impacts of entrepreneurship on environmental pollution vary across different income country groups.

On the other hand, concerns exist regarding the potential negative impacts of entrepreneurship on the environment, particularly through the exploitation of natural resource rents. Murphy, et al. [56] and Acemoglu [57] emphasize that an increase in rent-seekers could lead to reduced returns for both productive and rent-seeking entrepreneurship. However, the impact on productive entrepreneurship's returns would likely be more significant. This suggests that rent-seeking entrepreneurship might displace productive entrepreneurship, potentially leading to increased natural resource rents. More recently, Canh Nguyen, Nguyen, Thanh and Kim [4] present evidence that heightened entrepreneurship activities correlated with higher natural resource rents across a sample of 60 economies from 2006 to 2016. Similarly, Neumann [58] proposes that a higher proportion of green entrepreneurship may promote economic and social development, though this might not hold true for environmental sustainability.

Furthermore, recent studies have explored the influence of excessive entrepreneurship on natural resource rent [4,5]. Excessive entrepreneurship increases the marginal costs of capital and labor, intensifying competition and reducing profit margins, which leads to a reduction in economic efficiency [59]. The negative effects of excessive entrepreneurship are not limited to newcomers but also affect incumbent firms [60]. To compete with newly established firms that are relatively more flexible and efficient, incumbent firms may aim at opportunistic rather than productive practices to secure market positions, directing their investments toward low-cost technology and short-term goals [61]. Therefore, excessive entrepreneurship activities can cause natural resource rents [4,5].

While numerous studies have explored the notable connections between environmental quality and economic activities in both macroeconomic and microeconomic contexts, encompassing aspects like economic growth, energy consumption, trade, and tourism [43,62–64], there has been a noticeable absence of extensive investigations into the environmental effects of entrepreneurship across various dimensions of environmental performance and economic sectors. Consequently, this research seeks to ascertain whether entrepreneurship has adverse or positive effects on the environment, exploring diverse aspects of environmental performance within different economic sectors. As environmental concerns continue to mount, the findings of this study are expected to hold substantial significance for practitioners, academic researchers, and policymakers in the region, aligning with the global trend of fostering entrepreneurship.

3. Data, Models, and Methods

3.1. The Baseline Model

We apply an econometric approach to analyze the impacts of entrepreneurship on the environment. To begin with our baseline model, we rely on the IPAT model by Ehrlich and Holdren [65], which attributes environmental impacts (I) to human aspects and activities, consisting of the population (P), affluence (A), and technology (T). The IPAT model is a mathematical notation, expressed as

$$I = P \times A \times T \quad (1)$$

Nevertheless, since the IPAT model is primarily a mathematical equation, where a rigid proportionality between the variables is assumed, it cannot be used for estimation [62]. As such, the empirical analysis of this study utilizes the stochastic version of IPAT developed by Dietz and Rosa [66], namely the STIRPAT model, as follows:

$$I_{it} = \alpha_{it} P_{it}^{\beta_1} A_{it}^{\beta_2} T_{it}^{\beta_3} \varepsilon_{it} \quad (2)$$

in which I, P, A, and T represent the same variables as in the IPAT framework for country i at time t. α represents the country-specific impact. β_1, β_2, and β_3 are the elasticities of the environmental effects with respect to P, A, and T, respectively. To facilitate the empirical estimation and hypothesis testing, model (2) is taken as a natural logarithm, as follows:

$$lnI_{it} = \alpha_{it} + \beta_1 lnP_{it} + \beta_2 lnA_{it} + \beta_3 lnT_{it} + ln\varepsilon_{it} \quad (3)$$

Since this study conducts the empirical analysis of the data in per capita terms, the model in Equation (4) is converted into per capita variables by dividing both sides of the equation by the total population. Most importantly, we incorporate the entrepreneurship factor, our main variable of interest in this study, in the model. The baseline model then takes the following expression:

$$Y_{it} = \alpha_0 + \beta_1 GDP_{it} + \beta_2 ECP_{it} + \beta_3 ENT_{it} + \beta_4 X_{it} + \gamma_i + \varepsilon_{it} \quad (4)$$

in which i, t = 1, 2, 3. . . denote country i at year t. Y denotes emissions, expressed in per capita terms. *GDP* represents the affluence level, proxied by *GDP* per capita. *ECP* stands for primary energy consumption per capita, which proxies for the technological level. *ENT* denotes the level of entrepreneurship. X is the set of other control variables to be included later in the analysis. α and β are estimated coefficients. γ_i is country effects and ε_{it} is residual terms.

3.2. Variables and Data

This research utilizes strongly balanced panel data from 28 countries in the Asia-Pacific region over 14 years (2006–2019). Data were compiled from various sources, including the World Bank, United Nations Development Programme (UNDP), United States Energy Information Administration (EIA), Yale Center for Environmental Law & Policy, and Climate Watch. Data details and descriptive statistics can be found in Table 1.

Table 1. Data and descriptive statistics.

Variable	Description	Source	N	Mean	Std. Dev.	Min	Max
AgriEp	Agriculture emissions (kg per capita)—taken logarithm later	Climate Watch	392	1501.331	2357.976	3.507	10,311.619
IndEp	Industry emissions (kg per capita)—taken logarithm later	Climate Watch	392	1044.543	1143.492	19.259	5243.883
SerEp	Service emissions (kg per capita)—taken logarithm later	Climate Watch	392	4334.734	6971.97	53.793	38,905.941
co2	CO_2 emissions (kg of carbon dioxide equivalents per capita)—taken logarithm later	EIA	392	4.079	4.342	0.068	18.521
uwd *	Unsafe drinking water—"number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to unsafe drinking water"	Wolf et al. (2022)	392	45.183	22.05	7.607	91.799
tcl *	Tree cover loss—"the percentage of forest lost from the extent of forest cover in the reference year 2000"	Wolf et al. (2022)	378	26.709	17.837	0	100
pmd *	PM2.5 exposure—"number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to fine air particulate matter smaller than 2.5 μm"	Wolf et al. (2022)	378	28.567	26.059	0	100
gdp	GDP per capita (constant 2015 USD)—taken logarithm later	WDI	392	10,086.705	15,501.108	384.078	61,373.648
ent	New business density (new registrations per 1000 people ages 15–64)—taken logarithm later	WDI	392	2.606	4.268	0.011	25.038
ECp	Energy consumption (kg per capita)—taken logarithm later	EIA	392	2258.772	3007.826	26.175	16,745.704
hdi	Human development index	HDR	392	0.713	0.126	0.409	0.943
rqe	Regulatory quality	WGI	392	−0.035	0.913	−1.73	2.255

Note: * denotes variables whose definitions and data are derived from the Environmental Performance Index developed by Wolf et al. (2022) from the Yale Center for Environmental Law & Policy. WDI is the World Development Indicators and WGI is the World Governance Indicators of the World Bank. HDR is the Human Development Report of the United Nations Development Program (UNDP). EIA is the United States Energy Information Administration. Data were collected for 28 countries over the period 2006–2019 (except for *pmd* and *tcl* with 27 countries).

Table 2 presents the results of the Pearson's correlation matrix for all variables. Among all the dependent variables of sectoral emission and environmental quality indicators, there are five variables with positive associations with all explanatory variables, namely industrial emissions *(lIndEP)*, service emissions *(lSerEP)*, CO_2 emissions *(lco2)*, unsafe drinking water *(uwd)*, and PM 2.5 exposure *(pmd)*. Meanwhile, the tree cover loss indicator *(tcl)* expresses a negative correlation with all independent variables. A similar trend occurs in the case of the agricultural emission indicator (*lAgriEp)*, except for the entrepreneurship proxy, with a positive correlation. However, unlike the prior variables, the association of *tcl* and *lAgriEp* with the explanatory variables is weak.

Table 2. Pearson's pairwise correlations.

Variables	lAgriEp	lIndEp	lSerEp	lco2	uwd	tcl	pmd	lgdp	lent	lecp	hdi	rqe
lAgriEp	1.000											
lIndEp	−0.120 *	1.000										
lSerEp	−0.135 *	0.901 *	1.000									
lco2	0.014	0.936 *	0.957 *	1.000								
uwd	−0.217 *	0.735 *	0.815 *	0.782 *	1.000							
tcl	−0.058	−0.334 *	−0.343 *	−0.308 *	−0.148 *	1.000						
pmd	0.091	0.389 *	0.491 *	0.432 *	0.665 *	−0.413 *	1.000					
lgdp	−0.138 *	0.822 *	0.900 *	0.860 *	0.884 *	−0.372 *	0.725 *	1.000				
lent	0.120 *	0.556 *	0.637 *	0.614 *	0.666 *	−0.172 *	0.381 *	0.598 *	1.000			
lecp	−0.133 *	0.884 *	0.898 *	0.915 *	0.803 *	−0.191 *	0.458 *	0.864 *	0.562 *	1.000		
hdi	−0.115 *	0.784 *	0.857 *	0.846 *	0.910 *	−0.242 *	0.644 *	0.936 *	0.689 *	0.852 *	1.000	
rqe	−0.150 *	0.674 *	0.748 *	0.676 *	0.781 *	−0.358 *	0.750 *	0.882 *	0.623 *	0.698 *	0.866 *	1.000

Note: * denotes correlation coefficients significant at the 5% level or better. Source: Authors' calculation.

3.3. Empirical Approach

Our empirical analyses began with several data diagnostic tests, including a cross-sectional dependence test, unit root tests for stationarity, and panel cointegration tests. To examine cross-sectional dependence among our variables, we first used Pesaran's [67] CD test. The results in Table 3 show evidence of cross-sectional dependence for all variables. Next, we applied Pesaran's [68] cross-sectionally augmented Im–Pesaran–Shin (CIPS) unit root test to check the stationarity of the variables, as it accounts for cross-sectional dependence. We also used additional unit root tests, namely the Im–Pesaran–Shin [69], Fisher-type [70], Levin–Lin–Chu [71], and Harris and Tzavalis' [72] tests, for cross-checking. The results indicated that all variables were stationary at different levels, with no risk of I(2) variables.

Table 3. Cross-sectional dependence and stationarity tests' results.

Statistic	CD Test	CIPS Test	IPS Test	Fisher Test	LLC Test	HT Test
	CD Test	CIPS *	Z-t-Tilde-Bar	Inverse Chi-Squared	Adjusted t *	Rho (Z)
			Variables in Level			
lAgriEp	0.78	−1.397	1.4428	94.9787 ***	−5.3968 ***	−3.0922 ***
lIndEp	12.658 ***	−1.674	0.3387	77.6997 **	−4.3927 ***	1.6345
lSerEp	26.256 ***	−1.937	2.5581	36.9949	−1.4965 *	3.6363
lco2	19.901 ***	−1.745	2.4038	50.7832	−2.6416 ***	3.4420
uwd	50.636 ***	−1.502	0.4680	113.6261 ***	−4.7187 ***	3.1090
tcl	3.226 ***	−1.364	6.0893	62.9828	−1.5978 *	5.9767
pmd	5.253 ***	−1.620	0.7119	162.3837 ***	−9.7623 ***	2.3372
lgdp	66.722 ***	−2.045	3.6611	30.5272	−0.5107	3.7634
lent	30.682 ***	−1.836	3.5490	102.5898 ***	−2.1085 **	−1.6059 *
lecp	13.872 ***	−2.018	0.4916	67.3755	−2.3960 ***	2.5197
hdi	70.09 ***	−1.931	1.2159	45.8550	−4.1983 ***	3.9290
rqe	15.088 ***	−2.298 **	−0.9946	50.8251	−1.5497 *	−0.9252

Table 3. *Cont.*

Statistic	CD Test	CIPS Test	IPS Test	Fisher Test	LLC Test	HT Test
	CD Test	CIPS *	Z-t-Tilde-Bar	Inverse Chi-Squared	Adjusted t *	Rho (Z)
			Variable in 1st difference			
D.lAgriEp	0.064	−3.398 ***	−8.3822 ***	214.3366 ***	−9.7000 ***	−24.1068 ***
D.lIndEp	2.084 **	−2.947 ***	−7.5021 ***	183.0294 ***	−8.0117 ***	−21.9757 ***
D.lSerEp	2.465 **	−3.272 ***	−7.3129 ***	168.0258 ***	−8.8073 ***	−16.0269 ***
D.lco2	2.744 ***	−2.790 ***	−6.7238 ***	158.0443 ***	−8.4986 ***	−15.2901 ***
D.uwd	4.235 ***	−2.307 **	−2.9353 ***	89.3890 ***	−5.0344 ***	−5.5466 ***
D.tcl	8.726 ***	−2.506 ***	−4.4916 ***	76.4393 **	−2.4678 ***	−13.4173 ***
D.pmd	5.744 ***	−1.578	0.0304	113.6987 ***	−6.5023 ***	−2.9537 ***
D.lgdp	15.993 ***	−2.639 ***	−6.4150 ***	211.9486 ***	−7.3056 ***	−16.2599 ***
D.lent	3.121 ***	−3.412 ***	−7.6038 ***	217.3135 ***	−8.6864 ***	−23.2974 ***
D.lecp	4.789 ***	−3.095 ***	−7.4177 ***	259.7323 ***	−9.8929 ***	−15.8450 ***
D.hdi	9.814 ***	−2.967 ***	−7.0334 ***	163.8554 ***	−4.9558 ***	−19.7672 ***
D.rqe	1.204	−3.648 ***	−8.1319 ***	168.1175 ***	−7.6491 ***	−20.3226 ***

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels. Δ is the first difference. In the CD test, under the null hypothesis of cross-section independence, CD~N (0,1); *p* values close to zero indicate that data are correlated across panel groups. In the CIPS test (Pesaran panel unit root test), H0 (homogeneous non-stationary): bi = 0 for all i. In the IPS test (Im–Pesaran–Shin unit root test), Ho: all panels contain unit roots, Ha: some panels are stationary. In the Fisher test (the Fisher-type unit root test), Ho: all panels contain unit roots, Ha: at least one panel is stationary. In the LLC test (the Levin–Lin–Chu unit root test), Ho: panels contain unit roots, Ha: panels are stationary. In the HT test (the Harris–Tzavalis unit root test): Ho: panels contain unit roots, Ha: panels are stationary. Source: Authors' computation.

In the next step, we used Westerlund's [73] cointegration test to check for cointegration relationships among the variables. This test was appropriate for our panel as it addressed cross-sectional dependence. We also used Kao's [74] and Pedroni's [75] cointegration tests for robustness checks. The results in Table 4 indicate that long-run cointegrations existed in all estimated equations.

Table 4. Cointegration tests.

Model	Kao Test	Pedroni Test	Westerlund Test
	Dickey–Fuller t	Phillips–Perron t	Variance Ratio
lAgriEp = f(lgdp, lent, lecp, hdi, rqe)	−1.5319 *	−7.3860 ***	2.5912 ***
lIndEp = f(lgdp, lent, lecp, hdi, rqe)	0.0613	−5.6913 ***	2.8334 ***
lSerEp = f(lgdp, lent, lecp, hdi, rqe)	2.2534 **	−6.9462 ***	1.8657 **
lco2 = f(lgdp, lent, lecp, hdi, rqe)	1.8345 **	−8.1270 ***	1.7371 **
uwd = f(lgdp, lent, lecp, hdi, rqe)	−1.4383 *	−3.6287 ***	4.1538 ***
tcl = f(lgdp, lent, lecp, hdi, rqe)	5.0656 ***	−2.9738 ***	3.7584 ***
pmd = f(lgdp, lent, lecp, hdi, rqe)	−3.2244 ***	0.6468	4.8807 ***

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. In the Kao test for cointegration, Ho: no cointegration, Ha: all panels are cointegrated. In the Pedroni test for cointegration, Ho: no cointegration, Ha: all panels are cointegrated. In the Westerlund cointegration test, Ho: no cointegration, Ha: some panels are cointegrated. Source: Authors' computation.

The existence of cointegration and the stationarity of variables at different levels made the ARDL model the most appret alopriate estimator. The ARDL model also allowed us to identify short- and long-term effects by including lags of both dependent and independent variables in the estimation, regardless of whether the regressors were endogenous or exogenous (Pesaran and Shin, 1995; Pesaran and Smith, 1995). The unrestricted error correction model (UECM) regressions are estimated as follows:

$$\begin{aligned}\Delta Y_{it} = \mu_{1i} + \varphi_{1i}.\ &\left(Y_{i,t-1} - \gamma_{11}.lGDP_{i,t} - \gamma_{12}.lENT_{i,t} - \gamma_{13}.lECP_{i,t} - \gamma_{14}.HDI_{i,t}\right.\\ &\left.- \gamma_{15}.RQE_{i,t}\right) + \sum_{j=1}^{a} \delta_{11ij}.\Delta Y_{i,t-j} + \sum_{j=0}^{b} \delta_{12ij}.\Delta lGDP_{i,t-j}\\ &+ \sum_{j=0}^{c} \delta_{13ij}.\Delta lENT_{i,t-j} + \sum_{j=0}^{d} \delta_{14ij}.\Delta lECP_{i,t-j} + \sum_{j=0}^{e} \delta_{15ij}.\Delta HDI_{i,t-j}\\ &+ \sum_{j=0}^{f} \delta_{16ij}.\Delta RQE_{i,t-j} + \xi_{1it}\end{aligned} \quad (5)$$

in which Y represents dependent variables of economic sectoral emissions and environmental quality indicators. *lGDP*, *lENT*, *lECP*, *HDI*, *RQE* subsequently refer to the logarithm of real domestic output, the logarithm of new business intensity, the logarithm of energy consumption, the human development index, and regulatory quality. i, t refers to country i at year t; a, b, c, d, e, and f are lag lengths; μ_{1i} is the drifts; and ξ_{1it} is white noise errors. γ_{1i} (i = 1–5) are the coefficients indicating the long-run causal relationship; δ_{1i} (i = 1–6) are the coefficients indicating the short-run causal dynamics of the model. φ_1 is the error correction coefficients, or the speed of adjustment parameters, showing the degree of short-run disequilibrium corrected toward achieving the long-run equilibrium. φ_1 must differ from zero or there would be no long-run relationship. The Akaike Information Criterion (AIC) is utilized to determine optimal lag lengths.

The ARDL model can use several estimators, such as Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Fixed Effects (DFE). To determine the best approach, slope homogeneity tests were conducted following Bersvendsen and Ditzen [76] to address cross-sectional dependence issues. The results in Table 5 confirm that the slope coefficients across panels are homogenous. Therefore, DFE and ME are not practical since they assume heterogeneous slope coefficients across groups. The PMG estimator is the most appropriate approach since it both assumes homogeneous long-run coefficients and allows short-run dynamics for each country [77].

Table 5. Slope homogeneity test.

Model	Delta	Adjusted-Delta
lAgriEp = f(lgdp, lent, lecp, hdi, rqe)	0.341	0.964
lIndEp = f(lgdp, lent, lecp, hdi, rqe)	0.114	0.324
lSerEp = f(lgdp, lent, lecp, hdi, rqe)	−0.647	−1.829 *
lco2 = f(lgdp, lent, lecp, hdi, rqe)	0.132	0.374
uwd = f(lgdp, lent, lecp, hdi, rqe)	1.323	3.741 ***
tcl = f(lgdp, lent, lecp, hdi, rqe)	−0.992	−2.807 ***
pmd = f(lgdp, lent, lecp, hdi, rqe)	1.806 *	5.107 ***

Note: Tests for slope homogeneity are conducted following Bersvendsen and Ditzen (2021). In this test, H_0: slope coefficients are homogenous. *, and *** denote statistical significance at the 10%, and 1% levels, respectively. Source: Authors' calculation.

4. Results and Discussion

Our estimation results are displayed in Tables 6 and 7. Table 6 illustrates the impact of entrepreneurship density on sectoral emissions, while Table 7 presents the effect of entrepreneurship density on different indicators of environmental quality. It is worth noting that the error correction terms (ec) in the estimates are largely statistically significant, and their absolute values are less than one. This indicates that the application of our estimates is appropriate, and short-term changes in dependent variables are moving toward the long-term trend.

Table 6. Regression results with sectoral emissions as dependent variables.

	Regular Model			**Model with Interaction Term**		
	Agricultural Emission (1)	*Industrial Emission (2)*	*Service Emission (3)*	*Agricultural Emission (4)*	*Industrial Emission (5)*	*Service Emission (6)*
			Long-term			
lgdp	−0.3830 ***	−0.3823 *	1.1737 ***	−0.3866 ***	−0.8474 ***	0.9564 ***
	(0.0818)	(0.1983)	(0.0686)	(0.0661)	(0.1765)	(0.1172)
lent	0.2366 ***	−0.1252 ***	0.0029	−0.1337 ***	0.3133 ***	−0.4834 ***
	(0.0279)	(0.0247)	(0.0059)	(0.0497)	(0.0552)	(0.0659)
lecp	0.1657 ***	0.5292 ***	0.5944 ***	0.2382 ***	0.3413 ***	0.4402 ***
	(0.0408)	(0.0795)	(0.0379)	(0.0405)	(0.0312)	(0.0673)
hdi	−0.8463 *	3.9847 **	−5.2361 ***	−1.2070 **	14.2435 ***	−2.1003 ***
	(0.5100)	(1.5797)	(0.3442)	(0.5313)	(1.1859)	(0.7053)
rqe	−0.3550 ***	0.4679 ***	0.1794 ***	−0.3339 ***	−0.1790 ***	0.2953 ***
	(0.0254)	(0.0747)	(0.0278)	(0.0237)	(0.0656)	(0.0365)
int				0.1223 ***	−0.2497 ***	0.1419 ***
				(0.0215)	(0.0249)	(0.0221)
			Net effect of *lent* if income level is			
Low income				−0.1337	0.3133	−0.4834
Lower-middle income				−0.0114	0.0636	−0.3415
Upper-middle income				0.1109	−0.1861	−0.1996
High income				0.2332	−0.4358	−0.0577
			Short-term			
ec	−0.2589 ***	−0.2480 ***	−0.4135 ***	−0.2792 ***	−0.2202 ***	−0.3217 ***
	(0.0620)	(0.0721)	(0.0963)	(0.0595)	(0.0795)	(0.0744)
D.lgdp	−0.0180	2.2281 *	−1.1805	−0.1388	2.0970 *	−1.1430
	(0.2852)	(1.3053)	(1.1197)	(0.3170)	(1.1981)	(1.2675)
D.lent	0.0002	0.1341	0.0062	−0.0015	0.0004	0.0085
	(0.0790)	(0.1014)	(0.0413)	(0.0015)	(0.0004)	(0.0085)
D.lecp	0.1734	0.0099	0.3922 *	0.1816	0.1422	0.4735 **
	(0.1884)	(0.2533)	(0.2046)	(0.1893)	(0.2631)	(0.1906)
D.hdi	1.0880	6.6339	5.2065 *	1.9488	5.0111	3.1513
	(3.8645)	(6.9892)	(3.0547)	(3.7955)	(6.9670)	(2.5937)
D.rqe	0.0760	−0.1168	−0.1897	0.0906	−0.0477	−0.2255
	(0.0776)	(0.1465)	(0.1677)	(0.0787)	(0.1556)	(0.1698)
D.int				0.0049	0.0512	0.0105
				(0.0276)	(0.0344)	(0.0175)
Constant	2.3431 ***	0.5725 ***	−1.0495 ***	2.4660 ***	0.0244	−0.6110 ***
	(0.5955)	(0.1924)	(0.2550)	(0.5625)	(0.1118)	(0.1635)
N	364	364	364	364	364	364

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Source: Authors' calculation.

Table 7. Regression results with environmental quality indicators as dependent variables.

	Baseline Model				Model with Interaction Term			
	CO_2 Emission (1)	***Unsafe Drinking Water (2)***	***Tree Cover Loss (3)***	***PM2.5 exposure (4)***	***CO_2 Emission (5)***	***Unsafe Drinking Water (6)***	***Tree Cover Loss (7)***	***PM2.5 exposure (8)***
				Long-term				
lgdp	0.3311 ***	0.8219	−11.6649 **	31.8411 ***	0.2489 ***	3.7078 ***	−37.8489 ***	18.3855 ***
	(0.0799)	(1.8213)	(5.9430)	(3.4313)	(0.0780)	(0.9392)	(5.7346)	(2.7589)
lent	0.0194 **	0.3564 *	−3.1938 ***	−3.6063 ***	0.1717 **	−21.8670 ***	15.8203 ***	−107.1750 ***
	(0.0082)	(0.1876)	(0.6683)	(0.4048)	(0.0790)	(4.9608)	(2.4931)	(22.5735)
lecp	1.0122 ***	−11.4131 ***	−9.3073 ***	−27.2777 ***	0.9917 ***	−0.8483 ***	4.2656 *	−21.6150 ***
	(0.0338)	(1.3886)	(1.9902)	(1.9899)	(0.0367)	(0.2184)	(2.1828)	(1.7418)
hdi	−1.5700 ***	−23.9232 *	178.6863 ***	−50.3925 **	−0.8248 *	69.5729 ***	295.6688 ***	2.5996
	(0.5003)	(14.1879)	(46.6197)	(25.2935)	(0.4653)	(5.2713)	(40.2758)	(20.4940)
rqe	0.1651 ***	2.2794 ***	−6.6635 ***	−1.7028	0.1769 ***	−0.6535 **	−0.0371	1.2660
	(0.0315)	(0.4702)	(1.5577)	(1.0646)	(0.0324)	(0.2787)	(1.1680)	(0.9530)
inter					−0.0546 **	7.6223 ***	−7.5928 ***	34.3877 ***
					(0.0271)	(1.6553)	(1.0164)	(7.5338)
				Net effect of *lent* if income level is				
Low income					−21.867	15.8203	−107.175	−21.867
Lower-middle income					−14.2447	8.2275	−72.7873	−14.2447
Upper-middle income					−6.6224	0.6347	−38.3996	−6.6224
High income					0.9999	−6.9581	−4.0119	0.9999
				Short-term				
ec	−0.4148 ***	−0.0609 **	−0.0839	−0.1449 ***	−0.4131 ***	−0.2050 ***	−0.1065	−0.1277 ***
	(0.0803)	(0.0285)	(0.0553)	(0.0494)	(0.0788)	(0.0753)	(0.0730)	(0.0446)
D.lgdp	0.3530	−1.1560	8.5633	10.3611	0.3741	−3.9299	20.5007 *	10.6565
	(0.5300)	(1.0668)	(8.6167)	(7.2018)	(0.5181)	(2.6259)	(11.0034)	(7.2985)
D.lent	0.0280	0.0059	2.2888 ***	−0.4414	−0.0016	0.0265	0.3323	0.1598
	(0.0492)	(0.1893)	(0.8146)	(0.5421)	(0.0016)	(0.0265)	(0.3323)	(0.1598)
D.lecp	0.1530	0.6378	−3.6268	4.7681 **	0.1515	0.5336	−5.9455 *	4.6587 ***
	(0.1070)	(0.4549)	(3.0408)	(1.9251)	(0.1089)	(0.5024)	(3.2205)	(1.7841)
D.hdi	6.7538 **	21.1296 **	−17.9627	−23.9044	5.8943 **	23.3215	−63.8067	−37.4824
	(3.0083)	(9.5822)	(106.7016)	(45.2666)	(2.8328)	(18.2371)	(128.6212)	(43.1318)
D.rqe	−0.0262	−0.5625 **	1.5915	1.9726 **	−0.0328	−0.2400	1.1760	1.4065
	(0.0775)	(0.2500)	(1.5147)	(1.0060)	(0.0778)	(0.3651)	(1.5661)	(1.0340)
D.inter					0.0009	−0.1340	0.6102 **	0.1201
					(0.0187)	(0.1188)	(0.2794)	(0.2742)
Constant	−3.2478 ***	10.4512 **	4.1445	−1.1997	−3.1087 ***	−7.0136 **	11.3977	4.4694 **
	(0.6113)	(5.2094)	(3.6427)	(1.5114)	(0.5765)	(3.1786)	(8.1321)	(1.9369)
N	364	364	351	351	364	364	351	351

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Source: Authors' calculation.

Table 6 shows that entrepreneurship density (*D.lent*) has no statistically significant short-run effects on CO_2 emissions in all three economic sectors: agriculture, industry, and service (models 1, 2, and 3, respectively). However, entrepreneurship density (*lent*) appears to have statistically significant effects on CO_2 emissions in agriculture and industry in the long run. Increases in entrepreneurship density appear to induce agricultural emissions (model 1) and reduce industrial emissions (model 2) in the long run. The results imply that entrepreneurship activities can have both positive and negative effects on the environment. On one hand, entrepreneurship activities can be good for the environment by reducing industrial emissions, but, on the other hand, they can be bad by inducing agricultural emissions. More importantly, these effects are long-term. The results effectively validate our Hypothesis 2, demonstrating that entrepreneurship has varying impacts on the environment across the three economic sectors: industry, agriculture, and services.

These findings provide novel insights into the intricate connection between entrepreneurship and the environment, particularly concerning sectoral emissions. Previous studies have debated the pros and cons of entrepreneurship for the environment [28]. This study adds that the positive and negative impacts of entrepreneurship activities on the environment can be clearly defined through the view of sectoral emissions. It is important to note that economists mostly agree that entrepreneurship activities are associated with innovation and creativity, which can improve economic efficiency [53], thus benefiting the environment. Meanwhile, entrepreneurship activities have also been found to be linked with higher natural resource rents [59]. The findings of this study imply that these arguments are not contradictory when considered from the viewpoint of sectoral entrepreneurship and its interaction with the environment. Entrepreneurial endeavors that encompass innovation and creativity are predominantly located within the industrial sector. In this context, they have the potential to enhance economic efficiency, particularly in terms of energy consumption efficiency. For instance, Chatterji, et al. [78] emphasized that entrepreneurship clusters in the United States are strongly associated with new technologies and the industrial sector, which could reduce industrial emissions.

In contrast, entrepreneurship activities with natural resource rents, such as large land use or forest rents, can cause environmental degradation, as evidenced by the inducing effect of entrepreneurship density on agricultural emissions. In fact, the development of other sectors with entrepreneurship would attract labor from the agricultural sector [79], which would prompt farmers to use more machines in their agricultural activities, leading to the exploitation of more land or other types of natural resource rents. Although there have been some positive changes in agricultural entrepreneurship toward social responsibility or environmental protection [80], the nature of agricultural activities and entrepreneurship activities in agriculture appears to be linked to the more intensive use of machines to replace human labor. Thus, increases in entrepreneurship density in general are likely to increase agricultural emissions. Finally, it is worth reaffirming that these effects are long-term ones, as entrepreneurship activities take time to establish a new business and exert changes in economic systems.

In addition to these findings, models 4, 5, and 6 in Table 6 provide further insights. In these models, we interact entrepreneurship density (*lent*) with the income variable (0 for low-income countries, 1 for lower-middle-income countries, 2 for upper-middle-income countries, and 3 for high-income countries). All interaction terms (*int*) are statistically significant. To examine the effect of entrepreneurship density on sectoral emissions by income level, we calculate the net effects (the coefficient of *lent* plus the coefficient of the interaction term [*int*] multiplied by the value of the income variable). The net effects by income level are presented in the last rows of the long-run effects. The findings indicate that the influence of entrepreneurship density on sectoral emissions varies between low- and lower-middle-income countries and upper-middle and high-income countries. In the latter group, entrepreneurship density exhibits a positive effect on agricultural emissions and a negative effect on industrial emissions. Conversely, in low- and lower-middle-income countries, entrepreneurship density has a negative impact on agricultural emissions and a positive impact on industrial emissions. These results suggest a significant shift in the nature of entrepreneurial activities as countries transition from low-income to high-income statuses within the Asia-Pacific region. As income levels rise, entrepreneurship activities appear to contribute to environmental harm in terms of agricultural emissions, while concurrently exhibiting a favorable effect in terms of industrial emissions. This trend aligns with the ongoing economic growth patterns observed in the region.

It should be noted that entrepreneurship activities in upper-middle and high-income countries with well-developed economic structures, such as financial development and government policies, are more likely to support high-technology entrepreneurship [81], which can improve economic efficiency, especially in industrial sectors. Meanwhile, entrepreneurship activities in low- and lower-middle-income countries with lower economic development and less developed economic infrastructure may not be feasible with high-technology businesses. Instead, entrepreneurs in these countries may focus on manufacturing activities or even natural resource exploitation, without much consideration for the environment [82], resulting in high emissions.

As discussed, a simplistic view of the effects of entrepreneurship activities on the environment through emissions may lead to biased conclusions. Table 7 provides interesting findings on the effects of entrepreneurship on various environmental quality indicators.

The results indicate that entrepreneurship density in the short run (*D.lent*) does not have statistically significant effects on the environment, except for one case: tree cover loss. Entrepreneurship density appears to have a significant positive effect on tree cover loss in the short run (model 3). In contrast, entrepreneurship density in the long run (*lent*) appears to have a significant negative effect on tree cover loss. It also has a negative effect on PM2.5 exposure in the long run, while having positive effects on CO_2 emissions and unsafe drinking water in the long run. Once more, these findings validate our Hypothesis 1, asserting that the effects of entrepreneurship would diverge across different indicators of environmental performance. It is interesting to note that entrepreneurship density in the long run would induce higher CO_2 emissions. This means that the contrasting effects of entrepreneurship density on emissions in industry and agriculture, in the long run, are unified into a positive effect of entrepreneurship density on total CO_2 emissions. This finding is consistent with the study of Ben Youssef, et al. [83], while it is the opposite of other studies such as York and Venkataraman [16]. This result can be explained by two possible channels: (i) entrepreneurship density has an insignificant positive effect on CO_2 emissions in services (see Table 6—model 3), which could add to the effects on industrial and agricultural emissions, resulting in an increase in total CO_2 emissions in the long run; (ii) the long-run positive effect of entrepreneurship density on agricultural emissions has a stronger marginal effect than the long-run negative effect of entrepreneurship density on industrial emissions. Regardless of the explanation, the result provides new evidence in the literature of the nexus between entrepreneurship density and the environment, supporting the negative impact of current entrepreneurship activities. This is in line with some recent studies, such as Canh Nguyen, Nguyen, Thanh and Kim [4].

More interestingly, the findings show that entrepreneurship activities still have pros and cons for environmental sustainability in the long run by reducing tree cover loss and air pollution (PM2.5), but it has the side effect of increasing unsafe drinking water. Again, the findings provide very interesting evidence to contribute to the debates over the pros and cons of entrepreneurship. That is, entrepreneurship activities with strong linkages to innovation and creativity, especially technologies, would help to improve environmental quality in the long run, such as forest protection or the reduction of air pollution. In fact, these effects can be understood since there are several innovations and entrepreneurship activities with new technologies in terms of social and environmental protections [84]. However, there is a surprising result that entrepreneurship density increases unsafe drinking water. This raises serious concerns and calls for future studies on entrepreneurship activities and water quality.

Similar to the case of sectoral emissions, the interaction terms between entrepreneurship density and income variables (0: low income, 1: lower-middle income, 2: upper-middle income, and 3: high income) are estimated and presented in models 5, 6, 7, and 8 in Table 7. The net effects are also calculated. Some interesting findings are noticed, as follows: (i) entrepreneurship could reduce total CO_2 emissions in low-income countries, but its effect is degraded when income levels increase, and it could even increase CO_2 emissions in high-income countries; (ii) the increasing effect of entrepreneurship on unsafe drinking water appears to be dominant in low-income levels; (iii) the positive effects of entrepreneurship on the environment by reducing tree cover loss or air pollution are also dominant in lower-income countries. These results add further findings that the effects of entrepreneurship density on the environment vary across income levels. This is, in fact, in line with several previous studies that have shown that the effects of economic factors on the environment vary across income levels [55,63]. These differentiations might be due to the different priorities of government policies toward economic development and entrepreneurship, differences in market opportunities and competition, and differences in economic and social infrastructures [33,51]. This calls for further comparative studies on the motivations for entrepreneurship across income levels.

5. Concluding Remarks

The study investigates the impact of entrepreneurship on the environment across various economic sectors for 28 Asia-Pacific countries, utilizing the ARDL model and the PMG estimator as panel data analysis methods. Overall, the study affirms the hypotheses regarding entrepreneurship's influence on environmental sustainability, supported by both environmental indicators and sectoral emissions.

Specifically, the study finds that entrepreneurship density does not exert short-term effects on CO_2 emissions in any of the three economic sectors, but it does yield significant long-term effects on CO_2 emissions in agriculture and industry. The research suggests that entrepreneurship activities can generate both positive and negative environmental consequences, and these effects persist over time. Furthermore, the character of entrepreneurship activities evolves as countries transition from low- to high-income statuses. In low-income settings, entrepreneurship seems to negatively impact the environment in terms of agricultural emissions as income levels rise, while it positively influences industrial emissions with increasing income levels.

According to the study, the relationship between entrepreneurship and the environment is intricate and defies easy categorization as solely positive or negative. This complexity yields several implications. Firstly, dependent on the industry and a country's economic stage, entrepreneurship can elicit both favorable and unfavorable environmental outcomes. As a result, policymakers and stakeholders must carefully deliberate on the environmental ramifications of entrepreneurship and institute policies fostering sustainable entrepreneurship. Secondly, this research, conducted in the Asia-Pacific region, underscores that the environmental impact of entrepreneurship is contingent on a country's developmental level. Consequently, a universal solution does not exist for all nations. In developed economies, encouraging high-tech entrepreneurship can enhance economic efficiency and decrease industrial emissions. In contrast, in low- and lower-middle-income countries, promoting forms of entrepreneurship that prioritize environmental preservation becomes crucial. Policies that stimulate innovation and creativity within the industrial sector while simultaneously addressing the adverse effects of natural resource exploitation in agriculture could yield substantial environmental benefits.

In summary, this study underscores the significance of a nuanced comprehension of the interplay between entrepreneurship and the environment. It highlights the necessity of factoring in sectoral and country-specific intricacies when shaping policies and strategies to foster sustainable entrepreneurship.

In this study, entrepreneurship density is utilized as a measure for entrepreneurial activities, a widely accepted concept in the literature that indicates a registered business engaged in formal economic endeavors. However, it is important to recognize that other manifestations of entrepreneurship, like early-stage entrepreneurial activities, exist and may not be formalized into registered businesses [31]. Given the heterogeneous nature of entrepreneurship, a limitation of this study lies in its incapability to differentiate the impacts of various entrepreneurial types on environmental performance due to the lack of country-level data.

Consequently, future investigations could delve into the potential contributions of these diverse entrepreneurial activities to environmental sustainability. This presents a prospect for forthcoming research to concentrate on specific entrepreneurial types or structures, shedding light on their influence on environmental sustainability both at national and regional scales. Additionally, considering the differing motivations for entrepreneurship across countries, particularly across different income levels, future studies incorporating these motivations could offer deeper insights into the subject as relevant data become accessible.

Author Contributions: Conceptualization, T.-H.L. and C.P.N.; methodology, T.-H.L., C.P.N. and M.-T.B.; software, T.-H.L., C.P.N. and M.-T.B.; validation, T.-H.L., C.P.N. and M.-T.B.; formal analysis, T.-H.L., C.P.N. and M.-T.B.; investigation, T.-H.L., C.P.N. and M.-T.B.; resources, T.-H.L. and C.P.N.; data curation, C.P.N. and M.-T.B.; writing—original draft preparation, T.-H.L., C.P.N. and M.-T.B.; writing—review and editing, T.-H.L.; visualization, T.-H.L. and C.P.N.; supervision, T.-H.L.; project administration, T.-H.L. and C.P.N.; funding acquisition, T.-H.L. and C.P.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Foundation for Science and Technology Development grant number: 502.01-2021.14.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Rosário, A.T.; Raimundo, R.J.; Cruz, S.P. Sustainable Entrepreneurship: A Literature Review. *Sustainability* **2022**, *14*, 5556. [CrossRef]
2. Zeng, J.; Ren, J. How does green entrepreneurship affect environmental improvement? Empirical findings from 293 enterprises. *Int. Entrep. Manag. J.* **2022**, *18*, 409–434. [CrossRef]
3. Canh, N.P.; Kim, S.; Thanh, S.D. Entrepreneurship and natural resource rent-seeking: The roles of institutional quality. *Econ. Bull.* **2020**, *40*, 1159–1177.
4. Canh Nguyen, P.; Nguyen, B.; Thanh, S.D.; Kim, S. Entrepreneurship and natural resource rents: Evidence from excessive entrepreneurial activity. *Sustain. Prod. Consum.* **2021**, *25*, 15–26. [CrossRef]
5. Nguyen, C.P.; Kim, S.; Su, T.D. The Nonlinear Relationship Between Entrepreneurship and Natural Resource Rents. *J. Entrep.* **2022**, *31*, 632–662. [CrossRef]
6. IPCC. *Climate Change Widespread, Rapid, and Intensifying*; Intergovernmental Panel on Climate Change: Geneva, Switzerland, 2021.
7. Nguyen, C.P. The "karma" of impact on the Earth: Will humans take responsibility? Evidence of energy consumption and CO_2 emissions. *Environ. Sci. Pollut. Res.* **2022**, *29*, 50686–50703. [CrossRef] [PubMed]
8. ITU. *Innovation & Entrepreneurship Data—TCdata360*; The International Telecommunication Union: Geneva, Switzerland, 2021.
9. Cohen, B.; Winn, M.I. Market imperfections, opportunity and sustainable entrepreneurship. *J. Bus. Ventur.* **2007**, *22*, 29–49. [CrossRef]
10. Dean, T.J.; McMullen, J.S. Toward a theory of sustainable entrepreneurship: Reducing environmental degradation through entrepreneurial action. *J. Bus. Ventur.* **2007**, *22*, 50–76. [CrossRef]
11. Dhahri, S.; Omri, A. Entrepreneurship contribution to the three pillars of sustainable development: What does the evidence really say? *World Dev.* **2018**, *106*, 64–77. [CrossRef]
12. Hall, J.K.; Daneke, G.A.; Lenox, M.J. Sustainable development and entrepreneurship: Past contributions and future directions. *J. Bus. Ventur.* **2010**, *25*, 439–448. [CrossRef]
13. Omri, A.; Afi, H. How can entrepreneurship and educational capital lead to environmental sustainability? *Struct. Change Econ. Dyn.* **2020**, *54*, 1–10. [CrossRef]
14. Dana, L.-P.; Salamzadeh, A.; Hadizadeh, M.; Heydari, G.; Shamsoddin, S. Urban entrepreneurship and sustainable businesses in smart cities: Exploring the role of digital technologies. *Sustain. Technol. Entrep.* **2022**, *1*, 100016. [CrossRef]
15. Holzmann, P.; Gregori, P. The promise of digital technologies for sustainable entrepreneurship: A systematic literature review and research agenda. *Int. J. Inf. Manag.* **2023**, *68*, 102593. [CrossRef]

16. York, J.G.; Venkataraman, S. The entrepreneur–environment nexus: Uncertainty, innovation, and allocation. *J. Bus. Ventur.* **2010**, *25*, 449–463. [CrossRef]
17. Pacheco, D.F.; Dean, T.J.; Payne, D.S. Escaping the green prison: Entrepreneurship and the creation of opportunities for sustainable development. *J. Bus. Ventur.* **2010**, *25*, 464–480. [CrossRef]
18. Brown, C.; Thornton, M. How entrepreneurship theory created economics. *Q. J. Austrian Econ.* **2013**, *16*, 401–420.
19. Schumpeter, J.A. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*; Harvard Unversity Press: Cambridge, MA, USA, 1911.
20. Schultz, T.W. The Value of the Ability to Deal with Disequilibria. *J. Econ. Lit.* **1975**, *13*, 827–846.
21. Schultz, T.W. Investment in Entrepreneurial Ability. *Scand. J. Econ.* **1980**, *82*, 437–448. [CrossRef]
22. Hébert, R.F.; Link, A.N. In search of the meaning of entrepreneurship. *Small Bus. Econ.* **1989**, *1*, 39–49. [CrossRef]
23. Kirzner, I.M. *Competition and Entrepreneurship*; University of Chicago Press: Chicago, IL, USA, 2015.
24. COM. *Green Paper: Entrepreneurship in Europe*; Commission of the European Communities: Brussels, Belgium, 2003.
25. Ahmad, N.; Seymour, R.G. Defining entrepreneurial activity: Definitions supporting frameworks for data collection. *OECD Stat. Work. Pap.* **2008**. [CrossRef]
26. Douglas, E.; Prentice, C. Innovation and profit motivations for social entrepreneurship: A fuzzy-set analysis. *J. Bus. Res.* **2019**, *99*, 69–79. [CrossRef]
27. Pedeliento, G.; Bettinelli, C.; Andreini, D.; Bergamaschi, M. Consumer entrepreneurship and cultural innovation: The case of GinO12. *J. Bus. Res.* **2018**, *92*, 431–442. [CrossRef]
28. Heiskanen, E.; Kivimaa, P.; Lovio, R. Promoting sustainable energy: Does institutional entrepreneurship help? *Energy Res. Soc. Sci.* **2019**, *50*, 179–190. [CrossRef]
29. Simón-Moya, V.; Revuelto-Taboada, L.; Guerrero, R.F. Institutional and economic drivers of entrepreneurship: An international perspective. *J. Bus. Res.* **2014**, *67*, 715–721. [CrossRef]
30. Bizri, O.F. Chapter 5—Innovation and Entrepreneurship in the Arab Countries. In *Science, Technology, Innovation, and Development in the Arab Countries*; Bizri, O.F., Ed.; Academic Press: Cambridge, MA, USA, 2018; pp. 455–502.
31. Wong, P.K.; Ho, Y.P.; Autio, E. Entrepreneurship, Innovation and Economic Growth: Evidence from GEM data. *Small Bus. Econ.* **2005**, *24*, 335–350. [CrossRef]
32. Munemo, J. Foreign direct investment and business start-up in developing countries: The role of financial market development. *Q. Rev. Econ. Financ.* **2017**, *65*, 97–106. [CrossRef]
33. Nguyen, B.; Canh, N.P.; Thanh, S.D. Institutions, Human Capital and Entrepreneurship Density. *J. Knowl. Econ.* **2021**, *12*, 1270–1293. [CrossRef]
34. Nguyen, B.; Schinckus, C.; Canh, N.P.; Thanh, S.D. Economic Policy Uncertainty and Entrepreneurship: A Bad for a Good? *J. Entrep.* **2021**, *30*, 81–133. [CrossRef]
35. Siche, J.R.; Agostinho, F.; Ortega, E.; Romeiro, A. Sustainability of nations by indices: Comparative study between environmental sustainability index, ecological footprint and the emergy performance indices. *Ecol. Econ.* **2008**, *66*, 628–637. [CrossRef]
36. Rees, W.E. Ecological footprints and appropriated carrying capacity: What urban economics leaves out. *Environ. Urban.* **1992**, *4*, 121–130. [CrossRef]
37. Wackernagel, M.; Rees, W.E. Perceptual and structural barriers to investing in natural capital: Economics from an ecological footprint perspective. *Ecol. Econ.* **1997**, *20*, 3–24. [CrossRef]
38. Wackernagel, M.; Rees, W. *Our Ecological Footprint: Reducing Human Impact on the Earth*; New Society Publishers: Gabriola Island, BC, Canada, 1998; Volume 9.
39. Odum, H. *Environmental Accounting (Emergy and Environmental Decision Making) 1996*; Wiley: New York, NY, USA, 1996.
40. Brown, M.T.; Ulgiati, S. Emergy-based indices and ratios to evaluate sustainability: Monitoring economies and technology toward environmentally sound innovation. *Ecol. Eng.* **1997**, *9*, 51–69. [CrossRef]
41. Esty, D.C.; Levy, M.; Srebotnjak, T.; De Sherbinin, A. Environmental sustainability index: Benchmarking national environmental stewardship. *New Haven Yale Cent. Environ. Law Policy* **2005**, *47*, 60.
42. Nguyen, C.P.; Dinh Su, T. Tourism, institutional quality, and environmental sustainability. *Sustain. Prod. Consum.* **2021**, *28*, 786–801. [CrossRef]
43. Le, T.-H.; Chang, Y.; Park, D. Economic development and environmental sustainability: Evidence from Asia. *Empir. Econ.* **2019**, *57*, 1129–1156. [CrossRef]
44. Le, T.-H.; Chang, Y.; Park, D. Governance, environmental vulnerability, and PM2. 5 concentrations: International evidence. *Energy J.* **2021**, *42*, 6. [CrossRef]
45. Suseno, Y.; Abbott, L. Women entrepreneurs' digital social innovation: Linking gender, entrepreneurship, social innovation and information systems. *Inf. Syst. J.* **2021**, *31*, 717–744. [CrossRef]
46. Wiklund, J.; Nikolaev, B.; Shir, N.; Foo, M.-D.; Bradley, S. Entrepreneurship and well-being: Past, present, and future. *J. Bus. Ventur.* **2019**, *34*, 579–588. [CrossRef]
47. Udemba, E.N.; Emir, F.; Philip, L.D. Mitigating poor environmental quality with technology, renewable and entrepreneur policies: A symmetric and asymmetric approaches. *Renew. Energy* **2022**, *189*, 997–1006. [CrossRef]
48. Lipparini, A.; Sobrero, M. The glue and the pieces: Entrepreneurship and innovation in small-firm networks. *J. Bus. Ventur.* **1994**, *9*, 125–140. [CrossRef]

49. Berglann, H.; Moen, E.R.; Røed, K.; Skogstrøm, J.F. Entrepreneurship: Origins and returns. *Labour Econ.* **2011**, *18*, 180–193. [CrossRef]
50. Marino, M.; Parrotta, P.; Pozzoli, D. Does labor diversity promote entrepreneurship? *Econ. Lett.* **2012**, *116*, 15–19. [CrossRef]
51. Asongu, S.A.; Nwachukwu, J.C. Openness, ICT and entrepreneurship in sub-Saharan Africa. *Inf. Technol. People* **2018**, *31*, 278–303. [CrossRef]
52. Castaño, M.-S.; Méndez, M.-T.; Galindo, M.-Á. The effect of social, cultural, and economic factors on entrepreneurship. *J. Bus. Res.* **2015**, *68*, 1496–1500. [CrossRef]
53. Audretsch, D.; Keilbach, M. Entrepreneurship Capital and Economic Performance. *Reg. Stud.* **2004**, *38*, 949–959. [CrossRef]
54. Shepherd, D.A.; Patzelt, H. The New Field of Sustainable Entrepreneurship: Studying Entrepreneurial Action Linking "What is to be Sustained" with "What is to be Developed". *Entrep. Theory Pract.* **2011**, *35*, 137–163. [CrossRef]
55. Omri, A. Entrepreneurship, sectoral outputs and environmental improvement: International evidence. *Technol. Forecast. Soc. Change* **2018**, *128*, 46–55. [CrossRef]
56. Murphy, K.M.; Shleifer, A.; Vishny, R.W. Why Is Rent-Seeking So Costly to Growth? *Am. Econ. Rev.* **1993**, *83*, 409–414.
57. Acemoglu, D. Reward structures and the allocation of talent. *Eur. Econ. Rev.* **1995**, *39*, 17–33. [CrossRef]
58. Neumann, T. The impact of entrepreneurship on economic, social and environmental welfare and its determinants: A systematic review. *Manag. Rev. Q.* **2021**, *71*, 553–584. [CrossRef]
59. Prieger, J.E.; Bampoky, C.; Blanco, L.R.; Liu, A. Economic Growth and the Optimal Level of Entrepreneurship. *World Dev.* **2016**, *82*, 95–109. [CrossRef]
60. Bretschger, L. Economics of technological change and the natural environment: How effective are innovations as a remedy for resource scarcity? *Ecol. Econ.* **2005**, *54*, 148–163. [CrossRef]
61. Wennekers, S.; Thurik, R. Linking Entrepreneurship and Economic Growth. *Small Bus. Econ.* **1999**, *13*, 27–56. [CrossRef]
62. Le, T.-H.; Nguyen, C.P. Determinants of greenhouse gas emissions revisited: A global perspective. *Singap. Econ. Rev.* **2021**, *0*, 1–27. [CrossRef]
63. Le, T.-H.; Quah, E. Income level and the emissions, energy, and growth nexus: Evidence from Asia and the Pacific. *Int. Econ.* **2018**, *156*, 193–205. [CrossRef]
64. Nguyen, C.P.; Su, T.D. Alleviating energy poverty for forest conservation: It seems to work, but what are we missing? *Land Use Policy* **2021**, *109*, 105625. [CrossRef]
65. Ehrlich, P.R.; Holdren, J.P. Impact of population growth. *Science* **1971**, *171*, 1212–1217. [CrossRef] [PubMed]
66. Dietz, T.; Rosa, E.A. Effects of population and affluence on CO_2 emissions. *Proc. Natl. Acad. Sci. USA* **1997**, *94*, 175–179. [CrossRef]
67. Pesaran, M.H. General diagnostic tests for cross-sectional dependence in panels. *Empir. Econ.* **2021**, *60*, 13–50. [CrossRef]
68. Pesaran, M.H. A simple panel unit root test in the presence of cross-section dependence. *J. Appl. Econom.* **2007**, *22*, 265–312. [CrossRef]
69. Im, K.S.; Pesaran, M.H.; Shin, Y. Testing for unit roots in heterogeneous panels. *J. Econom.* **2003**, *115*, 53–74. [CrossRef]
70. Choi, I. Unit root tests for panel data. *J. Int. Money Financ.* **2001**, *20*, 249–272. [CrossRef]
71. Levin, A.; Lin, C.-F.; James Chu, C.-S. Unit root tests in panel data: Asymptotic and finite-sample properties. *J. Econom.* **2002**, *108*, 1–24. [CrossRef]
72. Harris, R.D.F.; Tzavalis, E. Inference for unit roots in dynamic panels where the time dimension is fixed. *J. Econom.* **1999**, *91*, 201–226. [CrossRef]
73. Westerlund, J. New Simple Tests for Panel Cointegration. *Econom. Rev.* **2005**, *24*, 297–316. [CrossRef]
74. Kao, C. Spurious regression and residual-based tests for cointegration in panel data. *J. Econom.* **1999**, *90*, 1–44. [CrossRef]
75. Pedroni, P. Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors. *Oxf. Bull. Econ. Stat.* **1999**, *61*, 653–670. [CrossRef]
76. Bersvendsen, T.; Ditzen, J. Testing for slope heterogeneity in Stata. *Stata J.* **2021**, *21*, 51–80. [CrossRef]
77. Pesaran, M.H.; Shin, Y.; Smith, R.P. Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *J. Am. Stat. Assoc.* **1999**, *94*, 621–634. [CrossRef]
78. Chatterji, A.; Glaeser, E.; Kerr, W. Clusters of Entrepreneurship and Innovation. *Innov. Policy Econ.* **2014**, *14*, 129–166. [CrossRef]
79. Swinnen, J.F.M.; Dries, L.; Macours, K. Transition and agricultural labor. *Agric. Econ.* **2005**, *32*, 15–34. [CrossRef]
80. Dias, C.S.L.; Rodrigues, R.G.; Ferreira, J.J. Agricultural entrepreneurship: Going back to the basics. *J. Rural Stud.* **2019**, *70*, 125–138. [CrossRef]
81. Zhang, G.; Peng, X.; Li, J. Technological entrepreneurship and policy environment: A case of China. *J. Small Bus. Enterp. Dev.* **2008**, *15*, 733–751. [CrossRef]
82. Madzikanda, B.; Li, C.; Dabuo, F.T. What Determines the Geography of Entrepreneurship? A Comparative Study Between Sub-Saharan Africa and South-East Asia. *J. Entrep. Innov. Emerg. Econ.* **2021**, *7*, 246–262. [CrossRef]

83. Ben Youssef, A.; Boubaker, S.; Omri, A. Entrepreneurship and sustainability: The need for innovative and institutional solutions. *Technol. Forecast. Soc. Change* **2018**, *129*, 232–241. [CrossRef]
84. Gurău, C.; Dana, L.-P. Environmentally-driven community entrepreneurship: Mapping the link between natural environment, local community and entrepreneurship. *Technol. Forecast. Soc. Change* **2018**, *129*, 221–231. [CrossRef]