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Renewable energy consumption and business density as drivers of sustainable development

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The East Asia and Pacific region have witnessed significant economic growth in recent decades, leading to improved living standards and increased energy consumption. However, this rapid development has also resulted in environmental degradation and heightened concerns about climate change. In response, countries in the region have been increasingly focusing on sustainable development, with renewable energy consumption and business density emerging as key drivers. Given this background, this research empirically examines the impact of entrepreneurship and clean technology on sustainable development in East Asia and the Pacific region. To control for endogeneity, the study applied system the Generalized Method of Moments (SGMM) for the data sourced from the World Development Indicators of the World Bank for the period 2015–2021. The finding indicates that both entrepreneurship and clean technology have an adverse significant impact on sustainable development in the East Asia-Pacific region. When the regions were analysed individually, the results revealed that both entrepreneurship and clean technology have a negative substantial effect on sustainable development in East Asia, but not in the Pacific region. The study concludes that entrepreneurship and renewable energy by themselves would not result in sustainable development, except some certain conditions are met. The positive impacts of entrepreneurship and renewable energy on sustainable development can only be attained when the nature, location, and practices of new businesses are low carbon in nature.

JEL Classifications: Q01, Q42, Q56

KEYWORDS

renewable energy, business density, climate change, green economic growth, sustainable development

1 Introduction

The East Asia and Pacific region have witnessed significant economic growth in recent decades, leading to improved living standards and increased energy consumption. However, this rapid development has also resulted in environmental degradation and heightened concerns about climate change (World Bank, 2022). In response, countries in the region have been increasingly focusing on sustainable development, with renewable energy consumption and business density emerging as key drivers.

Renewable energy consumption plays a crucial role in reducing greenhouse gas emissions and mitigating the adverse effects of climate change. The East Asia and Pacific region have abundant renewable energy resources, including solar, wind, hydro, and geothermal power. Governments have recognised the potential of these resources and have implemented policies to promote their use. As a result, there has been a significant increase in renewable energy consumption, leading to a more diversified energy mix and reduced reliance on fossil fuels (Adeleye et al., 2021).

The transition towards renewable energy has not only environmental benefits but also economic advantages. The development of renewable energy infrastructure has created new business opportunities, attracting investments and stimulating economic growth. This has led to an increase in business density in the region, with a growing number of companies involved in renewable energy production, distribution, and related services. The renewable energy sector has also generated employment opportunities, contributing to poverty reduction and inclusive development (Yin et al., 2022).

Furthermore, the adoption of renewable energy technologies has helped improve energy access in remote and underserved areas. Off-grid solutions such as solar home systems have provided electricity to communities that were previously reliant on expensive and polluting sources like diesel generators. This has had a transformative impact on the lives of individuals, enabling them to engage in income-generating activities, access education and healthcare services, and improve overall quality of life. However, challenges remain in scaling up renewable energy consumption and business density in the East Asia and Pacific region. These include policy and regulatory barriers, limited access to finance, technological constraints, and the need for capacity building. Governments need to continue implementing supportive policies, providing incentives for renewable energy investments, and strengthening regulatory frameworks. Collaboration between public and private sectors, as well as international cooperation, is crucial for overcoming these challenges and accelerating the transition towards a sustainable energy future (World Bank, 2022).

Recognizing the need for sustainable development, countries in East Asia and the Pacific have made significant efforts to promote entrepreneurship and innovation in the clean energy sector. This approach aims to foster economic prosperity while mitigating environmental impacts and ensuring social equity. One of the key drivers behind the focus on clean energy is the region's heavy reliance on fossil fuels for energy generation (Isa et al., 2021). Rapid urbanization, industrialization, and population growth have increased energy demand, leading to concerns about energy security, air pollution, and climate change (Adeleye et al., 2021). These challenges have prompted governments to seek substitute power sources and lessen their reliance on fossil fuels.

Renewable energy has emerged as a viable solution (Adeleye et al., 2021b; Yin et al., 2022). East Asia and the Pacific are rich in green energy resources, involving solar, wind, hydroelectric, and geothermal (Khanna, 2020). Governments have implemented supportive policies and restrictions to tempt private sector investment in renewable energy schemes. Feed-in tariffs, tax incentives, and favourable grid access have encouraged entrepreneurs and investors to develop clean energy infrastructure and technologies.

Innovation and entrepreneurship are vital components of the region's clean energy and sustainable development landscape (Vallaster et al., 2019; Khanna, 2020; Yin et al., 2022). Start-ups and established companies are developing innovative solutions in areas such as solar power, energy storage, smart grids, energy efficiency, and sustainable transportation. These entrepreneurs are leveraging advancements in technology (Osabohien et al., 2023; 2022a), such as artificial intelligence, the Internet of Things, and blockchain, to drive the energy transition and create sustainable business models. Governments, international organizations, and financial institutions are providing support to foster entrepreneurship and promote sustainable development.

Incubators, accelerators, and venture capital funds have been established to nurture start-ups and provide them with the necessary resources and mentorship (Osabohien et al., 2022b). Public-private partnerships are being formed to leverage the expertise and resources of both sectors, facilitating the implementation of large-scale sustainable projects. The idea of a circular economy has achieved traction in the region, aiming to minimize waste generation and maximize resource efficiency (Isa et al., 2021). Entrepreneurs are developing innovative solutions for waste management, recycling, upcycling, and sustainable product design (Omosimua et al., 2020). These initiatives not only address environmental challenges but also create economic opportunities and job growth.

Capacity building and knowledge exchange play a crucial role in promoting entrepreneurship, clean energy, and sustainable development. Governments, organizations, and educational institutions are investing in programs that enhance entrepreneurship skills (Osabohien et al., 2023), provide technical assistance, and facilitate technology transfer. Collaboration and knowledge sharing within the region and with international partners help to accelerate the adoption of best practices and innovative solutions. Regional cooperation is also key to addressing shared challenges and achieving sustainable development goals. Organizations such as the Asian Development Bank, ASEAN, and the Pacific Islands Forum facilitate dialogue, coordination, and joint initiatives among countries in the region (Khanna, 2020). Through these collaborations, governments can align their policies, leverage resources, and create regional markets for sustainable products and services.

While sustainable development initiatives are being implemented in the region, the link between clean energy, entrepreneurship, and sustainable development outcomes has received little attention in the empirical literature. This subject needs to be explored because it would provide insights into the effectiveness of clean energy projects and entrepreneurial activities in generating sustainable development outcomes such as environmental preservation, economic growth, social equality, and enhanced quality of life. Therefore, this research contributes to the literature by submitting empirical facts in examining this concept. This is crucial because, entrepreneurship, clean energy, and sustainable development are vital components of East Asia and the Pacific's development agenda.

This study aims to empirically examine how renewable energy consumption and business density impact sustainable development in the East Asia and Pacific region. To achieve this objective, the study applied the generalised method of moments. Focusing on EAP region is essential as the region is commitment to economic growth, environmental protection, and social wellbeing has led to significant

progress in promoting entrepreneurship, transitioning to clean energy sources, and fostering sustainable development practices. By leveraging innovation, collaboration, and supportive policies, the region is striving to attain an equilibrium between economic prosperity and environmental sustainability. This research is structured into five sections. Following this introduction is the literature review. Section three is the methodology, findings are presented and discussed in section four, while the study concludes with section five.

2 Literature review

This literature review provides a comprehensive overview of the existing exploration of entrepreneurship, clean energy, and sustainable development in East Asia and the Pacific. It highlights the importance of entrepreneurial activities in advancing clean energy adoption and achieving sustainable development goals in the region. This is grouped into two subsections -entrepreneurship and sustainable development and clean energy and sustainable development.

2.1 Entrepreneurship—Business density and sustainable development

The literature has looked into the relationship between entrepreneurship and sustainable development. Mahajan and Bandyopadhyay's (2021) systematic evaluation of the literature on the relationship between entrepreneurship and sustainable development included a few case studies that specifically addressed the relationship. The research determined that it was essential to examine entrepreneurship via a geared lens to assess if the presence of women as innovators is promoting the aim of sustainable development as well as to investigate entrepreneurship as a discipline in general.

Arslam et al. (2023) used a qualitative research methodology and conducted in-depth semi-structured interviews with 12 respondents who represented key players in the development of sustainable entrepreneurship in Oman. The findings revealed that while there has been some encouraging development; there are still several significant issues that prevent the growth of sustainable entrepreneurship. The study also discovered that, despite its limited utilization and adoption, FinTech played a crucial role in addressing this issue for all parties involved. This finding is consistent with that of Osabohien et al. (2023), who observed that the rate of ICT adoption among entrepreneurs is low, particularly in emerging economies like Nigeria.

In Oman, it emerged that a lack of culturally-based hesitations and context-specific training programs were impeding the development of sustainable entrepreneurship opportunities. This finding is consistent with that of Osabohien et al. (2022b), who found that mentorship and education made a significant contribution to sustainable entrepreneurship. In a different investigation, Vig (2022) used a qualitative research methodology with a single-case study design for Indian sustainable entrepreneurs trying to reduce plastic pollution in India and give rural women from economically disadvantaged families employment

opportunities. Semi-structured interviews were the main method used to gather data, which was then processed thematically. The study demonstrated how a businessperson could support sustainable development through the identification of business opportunities and environmentally friendly invention.

Vallaster et al. (2019) conducted a systematic, evidence-based literature review. According to a conceptual review of the literature, five study fields that set liable entrepreneurs apart from simply for-profit businesspeople are highlighted and addressed: balancing the pursuit of revenue and the development of social value; liable entrepreneurs' business models; their significance in developing society as a whole preparing for liable innovation; and the significance of market benefits in promoting sustainable business practices.

Neuman (2022) experimentally evaluated the connection between the national shares of green entrepreneurial activity (GEA) and the advancement of the economy, society, and environment. Higher GEA shares have a beneficial relationship with economic and social development, but not with environmental development, according to the findings. Further investigations demonstrated the conclusions' sensitivity to modifications in time lags, economic development levels, and both independent and dependent factor evaluations. Intensified policy measures are necessary to assist the identification, development, and implementation of green business possibilities given the GEA's inherent economic and social value.

Dantas et al. (2022) investigated the causes and effects of circular entrepreneurship in emerging markets. This research adopted a multi-case methodology, which is often utilized in research on circular business. The research identified circular entrepreneurs who launched businesses by identifying possibilities in CE by using practical and deliberate sampling methodologies. According to the research, circular entrepreneurs might be driven by both internal and external factors. The results of circular entrepreneurship demonstrated the effects that these businesses have on society, sustainability, and the economy at large.

The Global Competitiveness Report demonstrates each nation's efficiency while the Global Entrepreneurship Monitor reports highlight the progress of global entrepreneurship in multiple nations. This research centred on the SDG Index 2018s findings about the environmental, social, and economic effects of the SDGs. Statistics from the Global Competitiveness Report 2018 and the Global Entrepreneurship Monitor Report 2018 were reviewed in the study. The technical analysis uses a partial least-squares model of structural equations. Economic SDGs had a beneficial impact on social SDGs (0.796) and environmental SDGs (0.196); additionally, economic SDGs positively affected entrepreneurship (0.590) and competitiveness (0.918). 34.8% of the persistence of entrepreneurship and 84.3% of the persistence of efficiency have been revealed by the approach.

Gupta and Dharwal (2022) asserted that there has been a rise in demand for sustainable goods because of customers' growing environmental awareness and market forces. Entrepreneurs of educational firms may promote green enterprise and sustainable growth by building and bolstering a green culture in their organizations, given the significance of the green market's effect on these fields. Executives and business owners must acquire the competence needed to build green enterprises. Dharhi et al. (2021)

investigated the impact of opportunity- and necessity-driven entrepreneurs on the economic, social, and environmental elements of sustainable development. Utilizing data from 20 emerging economies, it is discovered that opportunity entrepreneurship has a favourable effect on the three pillars of sustainable development, but necessity enterprise hurts the environmental sustainability pillar. The research also discovered through the short- and long-run correlation studies that opportunity-driven entrepreneurs have a greater long-term causation impact on the three characteristics than necessity-driven innovators do. The first hypothesis is stated in its null form is given as.

H0: Business density has no significant impact on sustainable development

The null hypothesis suggests that there is no significant relationship between the density of businesses in EAP region and the level of sustainable development. In other words, the number of numbers of newly registered corporations per 1,000 working-age people (those ages 15–64), not necessarily impact the ability of the region to sustainably develop and grow. This hypothesis will be tested through various research methods and data analysis techniques to determine if it holds true or not.

2.2 Clean-renewable energy and sustainable development

Moses et al. (2022) examined the development of environmental SDG implementation in BRICS (Brazil, Russia, India, China, South Africa) and MINT (Mexico, Indonesia, Nigeria, Turkey) countries utilizing openly accessible information from Voluntary National Reviews and Sustainable Development Reports. The results show that BRICS and MINT have total execution performance levels of 64% and 62%, accordingly. In five of the six environmental SDGs examined, BRICS nations executed better than their MINT counterparts.

Kaawaase et al. (2022) assessed if business features, energy governance procedures, energy consumption, and energy poverty are relevant to sustainable development practices. The research makes utilization of a cross-sectional survey of the chief financial officers, engineers, and production executives of companies affiliated with the Uganda Manufacturers Association. The structural equation modelling with the partial least squares method was primarily used for the data evaluation. The findings of the regression evaluation showed that enhanced sustainable development practices do depend on ownership structure, capital structure, energy governance mechanisms, energy poverty, and energy use.

Ali et al. (2023) utilized a survey questionnaire that comprised 22 aspects from the publication. The questionnaire, which looked at important elements driving sustainable community development, was given out to various social sectors from around Pakistan. There were 349 responses overall (or 77% of the total). Findings from the research support the idea that a community's ability to uphold itself is adversely affected by power outages. According to this research, the most significant criteria for sustainable community development are the decreased production of major manufacturing, decreased

pleasure and convenience, decreased public management effectiveness, a decrease in academic possibilities, and higher consumption of standard forms of energy.

Donnel et al. (2020) addressed the role of energy production in the global capitalist economy and its connections to the Sustainable Development Goals (SDGs), with a special emphasis on SDG 8 and SDG 12. To better comprehend and evaluate unconventional (also known as “extreme”) and “renewable” power generation as examples of the paradoxical nature of sustainable development in the world's financial system. Yasmeeen et al. (2021) utilized the GMCR method and created a system for the sustainable development of the 3E in the framework of Pakistan. The GMCR findings revealed that when the government concentrates on the sustainable growth of the economy through green initiatives and the utilization of green power, the 3E may be developed sustainably to guarantee higher environmental standards.

Isa et al. (2021) examined the evolution of the circular economy in industrialized and emerging economies. The circular economy that Malaysian industrial players use, as well as government measures to inspire and inform Malaysians to embrace the concept of circular economy and sustainable consumerism, are the topics of study. Malaysia has implemented initiatives to incorporate green technology, as have the majority of other nations. Energy, environment, economy, and social issues comprise the four core policy goals. Green technology is essential to boosting the nation's economy and advancing sustainable development. The use of green technology can offer a compromise between economic growth and safeguarding the environment as well as alternatives to the problems caused by global warming.

Bas and Cosan, (2023) investigated if specific aspects of the Scandinavian Welfare Model are related to the origins of this prosperous depiction of Finland, Denmark, and Sweden, which are ranked first through third in both the Global Energy Innovation Index and the Sustainable Development Report. These nations also rank highly in both of these rankings. The Nordic approach has maintained the welfare state concept in line with its codes, contrary to the changes encountered by other welfare systems, and is now a distinguishing component. This is true given that the utilization of oil and gas enhances the carbon footprint in Scandinavian nations, which are assessed as in other parts of the world.

Dincer et al. (2022) findings demonstrated that sustainable economic development is not primarily caused by greenhouse gases. In this situation, governments must concentrate on other concerns that are more directly related to sustained economic growth. The University of Passo Fundo, a university in the south of Brazil, recently installed energy-saving measures. Reblato et al. (2019) examined these initiatives and their aid to Goal 7. The evaluation depends on information about energy efficiency practices used at the University as well as data on gas that has been obtained. The study covered opportunities, challenges, strengths, and limitations of implementing energy effectiveness at universities and its benefits to Sustainable Development Goal (SDG) 7, as well as the advancements made with energy practices.

Tabash et al. (2023) examined the statistical connection between public-private investment (PPI) in energy and environmental

quality. By sampling 20-year data of growing and growth-leading economies (EAGLE) and using two forecasting methods panel estimated generalized least squares and fully modified ordinary least squares models, the study test presumption that PPI can lower greenhouse gas emissions. The in-depth study confirmed that PPI plays an essential part in sustainable development by showing that it has a negative association with greenhouse gases. Additionally, the research results pointed to a conflicting role in economic development and imported energy. The threat Halo theory is supported by the fact that foreign direct investment is inversely correlated with greenhouse gases in the instance of EAGLE. The second hypothesis is developed as.

H0: Renewable energy consumption (% of total final energy consumption) has no significant impact on sustainable development in East Asia and the Pacific.

The null hypothesis suggests that there is no significant relationship between the consumption of renewable energy as a percentage of total final energy consumption and sustainable development in East Asia and the Pacific. In other words, the level of renewable energy consumption may not necessarily impact the ability of this region to sustainably develop. This hypothesis may will be tested through research methods and data analysis techniques to determine if to accept or fail to accept the null hypothesis.

3 Methodology

To attain the objectives of the research, this research used business density, renewable energy consumption, and sustainable development index as a measurement of entrepreneurship, clean energy, and sustainable development, respectively. The methodology used in this study to explore the impact of clean energy, and entrepreneurship on sustainable development is the Pooled panel regression and the generalized method of moments. Pooled Ordinary Least Squares (OLS) was used instead of the Fixed Effect Model (FEM), Random Effect Model (REM), and Least Squares Dummy Variable (LSDV), because the study was primarily interested in estimating overall relationships between variables rather than capturing individual-level variation or dynamics.

3.1 Data sources and description of variables

This research used panel data to cover the East Asia-Pacific region which includes 22 countries¹ for the period, 2017 to 2021. Twenty-two (22) countries were used in this analysis because of their data availabilities for the variables used in this study. Also, only the period, 2017 to 2021 was covered in this analysis because we used sub-regional analysis where one region (Pacific Region) had few countries. The dependent variable used in this study is the sustainable development Index (proxied by the sustainable

development index) sourced from the SDI database. The main independent variables which include new business density (captured entrepreneurship) and renewable energy consumption (captures clean energy) were sourced from the WDI database. Lastly, the control variables used in this study which include mobile cell subscriptions (captures technology) and voice and accountability index (captures government policies) were sourced from the WDI database and WGI database, respectively. Variables, measurements, and sources are presented in [Table 1](#).

3.2 Model specification and estimation techniques

As mentioned earlier, the study used both the pooled panel least squares regression and the generalised method of moments (GMM) to achieve its objectives. The pooled panel regression is established in Equation 1

$$\ln SDI_{it} = \beta_0 + \beta_1 \ln BDEN_{it} + \beta_2 \ln REC_{it} + \beta_3 \ln C'_{it} + \mu_{it}, i = 1, 2, \dots, I; t = 1, 2, \dots, T \quad (1)$$

Where SDI is sustainable development, is the constant term, is business density the measure of entrepreneurship, is renewable energy consumption (% of total final energy consumption), and is a covariate of the control variables which includes mobile cell subscriptions and voice and accountability index. Also, capture the countries under consideration and captures the period of study. Given that one of the shortcomings of pooled panel regression is that there could be endogeneity, the GMM was utilised in this study as it generates reliable estimations (Arellano and Bond, 1991). As stated in the works of Roodman (2006) and Baltagi (2008), the GMM model is specified in Equation 2

$$\ln SDI_{it} = \beta_0 + \beta_1 \ln SDI_{it-1} + \beta_2 \ln BDEN + \beta_3 \ln REC_{it} + \beta_4 \ln C'_{it} + \mu_{it}, i = 1, 2, \dots, I; t = 1, 2, \dots, T \quad (2)$$

Where is sustainable development, is the constant term, is business density measuring entrepreneurship, is the first leg of sustainable development, of renewable energy consumption proxy for clean energy, and is a covariate of the control variables which includes mobile cell subscriptions (per 100 people) and voice and accountability. Also, captures the country number and captures the period. By using the GMM technique, this study will be able to reduce endogeneity problems associated with pooled panel regression estimation techniques and regulate the individual and temporal impacts of the model. By using Arellano-Bond's AR (2) tests, the validity of the results estimated by the GMM technique is tested (Arellano and Bond, 1991).

4 Results and discussion

4.1 Descriptive statistics of the variables

[Table 2](#) indicates the descriptive statistics for the sustainable development index (SDI), new business density (BDEN), renewable energy consumption (REC), mobile cell subscriptions (MOB), and voice and accountability (VOC) for the entire region in the East Asia-Pacific and the sub-region. One of the variables, the sustainable

¹ East Asia Countries: Brunei Darussala, Cambodia, China, Indonesia, Japan, Korea, Rep., Lao PDR, Malaysia, Mongolia, Myanmar, Philippines, Russian Federation, Singapore, Thailand, Timor-Leste, Vietnam. Pacific Countries: Australia, Kiribati, New Zealand, Samoa, Tonga, Vanuatu.

TABLE 1 Variables, measurements, and sources.

Variables	Measurement	Source	Expectations
Sustainable Development	Index	SDI	Not Applicable
New Business Density	number of newly registered corporations per 1,000 working-age people (those ages 15–64)	WDI	Negative (-)
Renewable Energy Consumption	% of total final energy consumption	WDI	Positive (+)
Mobile cellular Subscriptions	Per 100 people	WDI	Positive/Negative (+/-)
Voice and Accountability	The scale of 1–5, the higher the better	WGI	Positive/Negative (+/-)

NB: SDI, WDI, and WGI, means sustainable development index, World Development Indicators, and World Governance Indicators, respectively.
Source: Authors' Compilation.

development index (SDI) has an average value of 0.5299 in the entire East Asia-Pacific region. This indicates that the average ecological efficiency of human development in the region is 0.5299. When analysing the East Asia region and Pacific region individually, it is significant to note that the average SDI is higher in the East Asia region than in the Pacific region. The lowest country's SDI in the Pacific region was higher than the lowest country's SDI in the East Asia region. Also, it is significant to note that the lowest and highest SDI was recorded in the East Asia Region.

New Business density (explained as the number of newly registered corporations per 1,000 working-age persons (those ages 15–64), capturing entrepreneurship in this study has an average value of 3.5818 in the entire East Asia-Pacific region. This means that the average number of new businesses in the region is 3.5818 (that is about 4 in every 1,000 people ages 15–64 registered for business corporations). The Pacific region recorded the highest mean value of new businesses compared to that in the East Asia region. Also, the country with the highest number of new businesses in the region was the Pacific region. Despite the Pacific region having the country with the highest number of new businesses, the region also has the country with the least number of new businesses.

Renewable energy consumption (percentage of total final energy consumption) was used in the study to represent clean energy. The mean renewable energy consumption in the region was 20.7%. Also, when analysing the regions individually, the Pacific region recorded the highest mean value of renewable energy consumption. The countries with the minimum and maximum value of renewable energy consumption were in the East Asia region. One reason for the large mean value of renewable energy consumption could be the number of countries in the region. The number of mobile cellular subscriptions was used to measure technology in this study.

The mean number of mobile cellular subscriptions in the region was 117.45. When analysing the region individually, the East Asia region recorded the highest mean value of mobile cellular subscriptions compared to that the Pacific region. Also, the countries with the lowest and highest number of mobile cellular subscriptions were recorded in the East Asia region. The last variable in this study which is the voice and accountability index was used to measure government policies. The mean voice and accountability index in the entire East Asia-Pacific region is 2.4268. The Pacific region recorded the highest mean voice and accountability index compared to that recorded in the East Asia region. Also, it is significant to note that the country with the lowest voice and accountability index was in the East Asia region while the country with the highest voice and accountability index was in the Pacific region.

4.2 Pooled OLS and system GMM results

Pooled panel regression and system Generalised method of moments (GMM) were used as the preferred estimation technique in this study. The results from the two estimation techniques were recorded in Table 3. In this study, the entire variables were logged and because of that, the interpretation would be made in percentages. The coefficients of the variables would be deemed significant at 1%, 5%, and 10% significance levels. Also, the interpretation would be made by comparing the East Asia region to the Pacific region using the two techniques.

Using both the pooled panel regression and the system GMM technique, the study found new business density to have a negative effect on sustainable development in the entire East Asia-Pacific region. This finding disagrees with the findings of Neuman (2022) in his study of green entrepreneurship and environmental development, and Vig (2022) who analysed the effect of sustainable entrepreneurship on plastic pollution in India but agrees with the expectations of this study and the finding of Dharhi et al. (2021) who analysed the effect of necessity driven entrepreneurship on sustainable development. Using the pooled panel regression technique, it was shown that if the number of new businesses increases in the East Asia-Pacific region increased by 1%, the sustainable development index would decline by 0.15%. This indicates that the new businesses in the region are not sustainable to bring about sustainable development. Also, it indicates that the new businesses in the region prioritise profits over environmental or social considerations, leading to activities that harm the environment.

Comparing the East Asia region and the Pacific region using the pooled panel regression, the study saw that new business density has a negative effect on the sustainable development index in the East Asia region but not in the Pacific region. This could be because of the type of new businesses, and geographical locations in the region. One of the key challenges of the East Asia region is air pollution and deforestation. One could infer that the majority of new businesses in the region still use non-renewable energy for operations and that forests are being brought down to build new businesses causing excess greenhouse gases to be released into the atmosphere. Also, the table reveals that the coefficient of business density was statistically significant at 5% significance levels in the East Asia-Pacific region, and East Asia individual region but not in the Pacific region. One plausible explanation for that discrepancy is the differences in the regions' entrepreneurs' access to infrastructure, financial capital, technology, and training that can help them to develop and implement sustainable business practices.

TABLE 2 Descriptive statistics of the variables.

Variable	Entire region			East Asian region			Pacific region		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
SDI	0.5299	0.0990	0.7730	0.5422	0.0990	0.7730	0.4836	0.1560	0.7610
BDEN	3.5818	0.0285	18.5237	2.7418	0.0718	10.1929	5.8219	0.0285	18.5237
REC	20.7221	0.0100	59.9200	19.0985	0.0100	59.9200	25.0518	1.7700	41.1500
MOB	117.4503	32.1036	181.7670	131.7330	51.5459	181.7670	79.3632	32.1036	134.8432
VOC	2.4268	0.6835	4.1219	2.0185	0.6835	3.5769	3.5157	3.0986	4.1219

Source: Authors' Compilation.

TABLE 3 Pooled panel regression and generalised method of moments.

Dependent variable: Sustainable development						
Panel least squares result				Generalised method of moments result		
Variables	All	East Asia	Pacific	All	East Asian	Pacific
lnL1(—	—	—	0.6184* (0.000)	0.5129* (0.000)	0.7785* (0.001)
lnBDEN	-0.1487* (0.000)	-0.1466* (0.002)	0.02583 (0.750)	-0.0855* (0.000)	-0.0780* (0.000)	-0.0146 (0.528)
lnREC	0.1212423* (0.000)	0.1146103* (0.000)	0.8820154* (0.000)	-0.0175** (0.013)	-0.0205* (0.003)	-0.1118 (0.268)
lnMOB	0.0185 (0.887)	0.6204** (0.012)	-0.1947** (0.023)	-0.0619* (0.004)	0.0088 (0.866)	-0.0648* (0.006)
lnVOCA	-0.2221** (0.014)	-0.3813* (0.002)	-1.9725** (0.011)	0.0213** (0.033)	-0.0498* (0.005)	-0.0033 (0.988)
Constant	-0.8865 (0.170)	-3.7190* (0.002)	-0.3646 (0.707)	0.2734* (0.008)	-0.0397 (0.877)	1.5063* (0.000)
R.sq	0.5018	0.5190	0.9956	—	—	—
F-Stat	22.66* (0.000)	18.88* (0.000)	850.38* (0.000)	—	—	—
AR (1)	—	—	—	-3.23* (0.001)	-2.71* (0.007)	-1.52 (0.128)
AR (2)	—	—	—	1.28 (0.202)	1.35 (0.176)	0.51 (0.607)

Note: *, **, *** means significant at 1%, 5% and 10%, respectively.

Source: Authors' Compilation.

Using the GMM estimation technique, the study revealed that if business density increased by 1% in the East Asia-Pacific region, the sustainable development index would decline by 0.09% which is also in line with my expectations. Unlike the pooled panel regression technique, business density has a negative impact on sustainable development in both the East Asia region and the Pacific region. This indicates that the new businesses formed in the regions prioritise profits over environmental or social considerations, leading to unsustainable business practices. When comparing the two regions (East Asia region and the Pacific region), it could that the magnitude of impact measured by the coefficient of BDEN was large.

Table 3 revealed that a 1% increase in business density in the East Asian region would result in a fall in the sustainable development index in that region by 0.08 which is higher than the 0.01% drop in the sustainable development index that would be seen in the Pacific region if business density increased by the same 1%. That is because there is a large proportion of unsustainable business practices in the East-Asia region, particularly China as compared to that of the Pacific region. Also, results in Table 3 reveal

that the coefficient of business density was statistically significant at 5% significance levels in the East Asia-Pacific region, and East Asia individual region but not in the Pacific region. That finding was in line with the estimates of the pooled panel regression technique.

Table 3 revealed that renewable energy consumption has a positive result on the sustainable development index in the entire East Asian-Pacific region and the individual regions (East Asian region and Pacific region) when the pooled panel regression was used but the otherwise was shown in all regions when the GMM was used. The finding revealed in the pooled panel regression agrees with my expectations in this study, the finding of Yasmeeen et al. (2021) who analysed the impact of environmental policies and renewable energy on sustainable development, and Isa et al. (2021) who analysed the effect of green power on environmental preservation.

Using the pooled panel regression first, the study revealed that a 1% boost in renewable energy consumption would result in a 0.12% improvement in the sustainable development index. This is because renewable energy emits almost no carbon when utilised to create power. When comparing the two individual regions by using the

same technique, there was a large difference in the magnitude of impact. The 0.88% improvement in the sustainable development index in the Pacific region that would be seen if there were a 1% rise in renewable energy consumption was larger than the 0.11% that would be seen if the same happened in the East Asian region. The differences in the energy mix, cost of renewable energies, and public knowledge of renewable energy in the two regions could account for this large discrepancy. In both the East Asia-Pacific region and the individual regions, the coefficient of renewable energy consumption was statistically significant at 5% significance levels.

As mentioned earlier, the otherwise was revealed when the GMM was adopted. The GMM revealed that a 1% increase in renewable energy consumption would result in a 0.02% decline in the sustainable development index. This finding disagrees with the expectation in this study. One explanation of this finding is the adoption of renewable energies like solar and wind power might potentially lead to habitat loss and biodiversity impacts as significant land use is required. As a result of the differences in the renewable energy profile in the two regions, the negative effect of renewable energy consumption on sustainable development when there was a 1% increase in renewable energy consumption was higher in the Pacific region (0.11) than in the East Asian region (0.02). The coefficient of renewable energy consumption was statistically significant in the East Asia-Pacific region and East Asian region but not in the Pacific region. One possible explanation for why renewable energy consumption has no substantial influence on sustainable development in the Pacific area is that renewable energy has not been adequately integrated into larger systems and policies to promote sustainable development.

When the pooled panel regression technique was used to estimate the coefficient of mobile cellular subscriptions, it was revealed that the number of mobile cellular subscriptions has a positive result on the sustainable development index in the East Asia-Pacific region, and East Asian region but not in the Pacific Region. The finding revealed for the East Asia-Pacific region, East Asia, and the Pacific region agrees with my expectations and also the findings of [Hilty et al. \(2006\)](#) who analysed the relevance of ICT for environmental sustainability. It was also revealed from the table that if the number of mobile cellular subscriptions increased by 1%, the sustainable development index would improve by 0.02%. The number of mobile cellular subscriptions was not statistically significant in improving sustainable development in the East Asia-Pacific region as revealed in the table below because of the cost of technology like electricity in the region. The high cost of such basic technologies would deprive many people of having access to those technologies.

When the countries were analysed individually, the coefficient of the number of mobile cellular subscriptions was statistically significant but the direction of the relationship was different as mentioned earlier. The table below revealed that if the number of mobile cellular subscriptions in the East Asia region increased by 1%, the sustainable development index in the region would improve by 0.62%. Also, if the number of mobile cellular subscriptions in the Pacific region increased by 1%, the sustainable development index in the region would decline by 0.19%. The differences in access to technology, the nature of technology, and technological lock-in could account for this discrepancy in the two regions.

When the GMM was adopted to estimate the coefficient of the same variable (number of mobile cellular subscriptions), it was revealed that the number of mobile cellular subscriptions has a negative impact on the sustainable development index. It was shown in the table that if the number of mobile cellular subscriptions increased by 1%, the sustainable development index would decline by 0.06%. This finding agrees with the expectations in this study. It was also revealed that the coefficient of mobile cellular subscriptions in the East Asia-Pacific region was statistically significant at a 5% significance level. That means that the number of mobile cellular subscriptions is significant in reducing the sustainable development index in the East Asia-Pacific region.

When the two individual regions were compared using the GMM technique, it was revealed that if the number of mobile phone users in the Pacific region increased by 1%, the sustainable development index in that region would reduce by 0.06%. The otherwise was revealed in the East-Asia region where a 1% rise in the amount of mobile phone users would result in a 0.01% improvement in the sustainable development index. Judging from the *p*-values as shown in the table below, the number of mobile phone users was not significant in improving sustainable development in the East Asia region but was significant in reducing the sustainable development index in the Pacific region.

The last variable used in the study which is the voice and accountability index is shown to have a negative effect on the sustainable development index when the pooled panel regression was used as the estimation technique. This finding agrees with the expectations in this study and the findings of [Fatima et al. \(2021\)](#) on the effect of government policies and renewable energy on environmental sustainability. This might be because the government's strategy to encourage voice and accountability is impacted by conflicting interests that prioritise political aims above environmental and social goals. Another possible explanation is that government policy promoting voice and accountability is focused on short-term aims rather than long-term environmental repercussions. The result from the table showed that if the voice and accountability index in the East Asia-Pacific region increased by 1%, the sustainable development index would decrease by 0.22%.

When the results for the East Asia Region and Pacific region were compared against each other using the same estimation technique, there was a huge difference in the coefficient. The results from [Table 3](#) revealed that if the voice and accountability index in the East Asia region increased by 1%, the sustainable development index in that region would fall by 0.38% which is far lower than the 1.97% estimated decline in the sustainable development index in the Pacific region if the same improvement in the voice and accountability index occurred. Judging from the *p*-values as shown in the table below, the voice and accountability index has an adverse significant influence on the sustainable development index in the East Asia-Pacific region and in the individual regions (East Asia region and Pacific region).

From the GMM results, it shows that first lag of sustainable development significantly influence the current level of sustainable development. Furthermore, When the GMM was used as the estimation technique, the result revealed that the voice and accountability index have a beneficial effect on the sustainable

development index in the East Asia-Pacific Region which is contrary to that estimated by the pooled panel regression model. The study further revealed that if the voice and accountability index increased by 1%, the sustainable development index would increase by 0.02%. The finding still agrees with the 'a priori estimation of the study. The coefficient of the voice and accountability index was found to be statistically significant meaning that the voice and accountability index is significant in improving the sustainable development index in the East-Asia region.

When analysing the East-Asia region and Pacific region individually, the study also revealed that the voice and accountability index has an adverse effect on the sustainable development index in both regions which was in line with the estimates derived from the pooled panel regression model. This finding agrees with the expectations in this study. The result showed a negative significant influence of the voice and accountability index on the sustainable development index in the East Asian Region and that if the voice and accountability index in that region increased by 1%, the sustainable development index in the same region would decline by 0.05%. In the case of the Pacific region, the table revealed that the voice and accountability index have no significant impact in affecting the sustainable development index. This might be owing to a lack of resources, such as funding and monitoring systems, to encourage voice and responsibility in the Pacific area to achieve sustainable development.

4.3 Implications of findings

4.3.1 Theoretical implications

The topic of renewable energy consumption and business density as drivers of sustainable development in East Asia and the Pacific has several theoretical implications. Firstly, it highlights the importance of renewable energy consumption in promoting sustainable development in the region. The use of renewable energy sources such as solar, wind, hydro, and geothermal power can help reduce carbon emissions, mitigate climate change, and enhance energy security.

Secondly, the topic emphasizes the role of business density in promoting sustainable development. Business density refers to the number of businesses operating in a particular area. A high business density can lead to economic growth, job creation, and innovation, but it can also lead to environmental degradation if not managed sustainably. Therefore, the topic underscores the need for a balance between economic growth and environmental sustainability.

4.3.2 Policy implications

The study has several policy implications. Firstly, policymakers should prioritize the development and implementation of policies that promote renewable energy consumption. This can include incentives for renewable energy investments, tax credits for renewable energy production, and regulations that require a certain percentage of energy to come from renewable sources. Secondly, policymakers should promote sustainable business practices that minimize the negative environmental impact of businesses while promoting economic growth. This can include regulations on waste management, pollution control, and sustainable resource use.

5 Contributions

The study makes contributions to the field of sustainable development. Firstly, it highlights the importance of renewable energy consumption in promoting sustainable development. This is particularly relevant in East Asia and the Pacific, where rapid economic growth has led to increased energy demand and carbon emissions. Secondly, the topic emphasizes the role of business density in promoting sustainable development. This is important because businesses are major drivers of economic growth but can also have negative environmental impacts. Therefore, promoting sustainable business practices is crucial for achieving sustainable development. Finally, the topic contributes to the ongoing debate on the relationship between economic growth and environmental sustainability. It underscores the need for a balance between economic growth and environmental sustainability and highlights the potential of renewable energy consumption and sustainable business practices in achieving this balance.

6 Conclusion and recommendations

This study utilised both the panel least squares regression and the GMM estimation techniques to analyse the impact of entrepreneurship (captured by new business density), and clean technology (captured by renewable energy consumption) on sustainable development (captured by the sustainable development index) for 22 countries in the East Asia-Pacific region from 2017 to 2021. The GMM estimates were the accepted estimates in the study as GMM solves the endogeneity issues of the pooled panel regression model. The result from the GMM estimation technique shows that both entrepreneurship and clean technology have a negative notable effect on sustainable development in the East Asia-Pacific region. When the regions were analysed individually, the results revealed that both entrepreneurship and clean technology have a negative substantial effect on sustainable development in the East Asia region but not in the Pacific region.

The study concludes that entrepreneurship and renewable energy by themselves would not result in a sustainable environment expect some certain conditions are met. The positive impacts of entrepreneurship and renewable energy on sustainable development can only be attained when the nature, location, and practices of new businesses are sustainable. Similarly, when the level of use of non-renewable energy compared to renewable energy is massively reduced, and the availability of renewable energy to the deprived areas is improved, the improvement in sustainable development would be actualised.

This study hereby recommends that sustainable business practices should be encouraged in the East Asia-Pacific region. The governments in the region should enforce strong environmental regulations, and laws protecting natural resources to encourage entrepreneurs to prioritise long-term environmental sustainability over profits. Social and green entrepreneurship should also be improved in the region as it helps to address environmental and social practices through sustainable business practices. It is also recommended that the government should have strong incentives supporting the development of renewable energies so that renewable energy can be significant in improving sustainable development. This research also highlighted that there is limited access to renewable energy in some regions. This could be addressed by improving the supply of renewable energy, revisiting the energy

profile, and also regulating the costs of those energies so that they can be available and affordable to the populace. In conclusion, renewable energy consumption and business density are key drivers of sustainable development in the East Asia and Pacific region. The increased adoption of renewable energy technologies not only helps mitigate climate change but also promotes economic growth, job creation, and improved energy access. Governments, businesses, and international organizations must work together to overcome barriers and seize the opportunities presented by renewable energy to ensure a sustainable and prosperous future for the region.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#), further inquiries can be directed to the corresponding authors.

Author contributions

RZ: Methodology, Writing—original draft, Funding acquisition, Project administration, Resources, Supervision. RO: Methodology, Conceptualization, Data curation, Writing—original draft, Writing—review and editing. EM: Conceptualization, Data curation, Formal Analysis, Writing—original draft, Writing—review and editing. AJ: Funding acquisition, Methodology, Supervision, Writing—review and editing.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenrg.2023.1268903/full#supplementary-material>

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