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ENVIRONMENT AND FEMALE ENTREPRENEURSHIP IN SOUTHEAST ASIA: INVESTIGATION OF THE ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS

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Abstract: *This paper examines the relationship between female entrepreneurship and environmental implications in ASEAN economies. While economic growth and affluence benefit society, they come at the cost of environmental degradation, particularly rising carbon dioxide levels and ecosystem concerns. Women entrepreneurs in Southeast Asia can potentially support their families and contribute to societal development by starting their own businesses. Their ventures provide fresh perspectives on societal challenges and enable active participation and contribution to creative endeavors, leading to economic and social empowerment with ripple effects on families and communities. To assess the environmental consequences of women's entrepreneurial activities, the study applies the bias-corrected method of moments and tests the Environmental Kuznets Curve hypothesis across ten ASEAN nations from 1980 to 2021. Results show cross-sectional dependence in all variables and confirm a long-term relationship within the EKC model. The fixed-effects estimator with bias correction is deemed the most suitable model. Findings indicate that GDPpc leads to decreased emissions, while the square of GDPpc contributes to increased emissions; however, the cubic term of GDPpc leads to decreased CO2 emissions, supporting the "inverted N" curve distribution of emissions across ASEAN nations proposed by the EKC theory. Additionally, the study reveals that higher percentages of female entrepreneurs are associated with increased carbon dioxide emissions, potentially due to increased efforts to support and develop female entrepreneurs. Conversely, a reduction in the gender gap in marriage, divorce, remarriage, and domestic violence leads to a shift away from entrepreneurial activities among women, positively impacting the environment.*

Keywords: bias-corrected method of moments, CO2 emissions, entrepreneurship, environmental Kuznets curve, female entrepreneurs.

JEL Classification: C23, J16, L26, O44, Q56.

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Introduction

Success in business is associated with several environmental challenges, despite the fact that entrepreneurship is widely acknowledged as a key strategy for achieving economic growth. This has led many to believe that addressing environmental concerns while also fostering economic growth is contradictory. Employment opportunities and product enhancements are only two of the many ways in which entrepreneurship contributes to broader social progress. Entrepreneurs are the ones who bring forth progress, new ideas, and a more dynamic economy (Schumpeter, 1931).

The economic context, the institutional framework, and the cultural norms vary greatly from country to country; however, (Weber , Fasse , & M. Haugh , 2022) note that entrepreneurship is seen as a meaningful strategy for tackling poverty and inequality in emerging countries. However, there is a lot of discussion in economics about how men and women vary in their propensity to launch new enterprises, even if the reasons for these variations aren't usually explained. To classify a business owner based on their sexuality is unfair. Entrepreneurship, according to neoclassical theory, is "the process by which the forces of production (capital and labor) are integrated, including risk, to develop goods and services that correspond to consumer expectations," regardless of the gender of the entrepreneur (Lowrey, 2003).

Women are strongly encouraged to enter the business world in a wide range of countries. This promotes economic growth and new developments in technology and consumer goods in developed countries. Entrepreneurial women may significantly impact economies in developing countries by generating jobs, income, and social cohesion. In order to boost economic development and tax income, governments actively support women who start their own businesses (Chatterjee, Das, & Srivastava, 2019). Despite the fact that a large number of women are already making significant contributions to the economy of Southeast Asia, there is still a gender gap when it comes to entrepreneurial opportunities (Roche, Anderson, Balmaceda, & Nakornthap-Yomnak, 2020). Increasing the number of successful female entrepreneurs in Southeast Asia might help women there provide for their families and climb the professional ladder. When women take the reins of their own enterprises, they get a fresh perspective on societal challenges and the freedom to participate actively and imaginatively in shaping their communities. Families and communities benefit when more women work and are involved in society as a whole (SPF, 2022).

The creation of economic growth and the accompanying affluence benefits society greatly, but it comes at the price of the natural world. Carbon dioxide has been steadily increasing in the atmosphere, causing widespread concern about the state of the planet's ecosystem. Sustainable development solutions have been promoted via a plethora of research on total emissions-causing elements such as fast urbanization, energy use, and wealth growth. The connection between these processes and environmental degradation is still up for debate between academics and policymakers. Rising energy needs in an expanding global economy have caused a huge jump in carbon dioxide output. (Destek & Sinha, 2020) argue that further study is needed to determine how monetary progress, globalization, and urbanization affect environmental quality.

While entrepreneurial endeavors undoubtedly contribute to economic growth, they have also been historically linked to extensive damage to natural ecosystems. Since women are so important to economic and social growth in Southeast Asian economies, we were interested in investigating how female entrepreneurship affects the environment.

The main goal of this study was to add female entrepreneurship as a major economic factor to an econometric Environmental Kuznets (EKC) model so that its effects on the environment in Southeast Asia could be studied. The research examines the dynamics that are driving the resurgence of female entrepreneurship in Southeast Asian nations in order to promote economic growth and its environmental impacts. Even though the factors that affect female entrepreneurship are all qualitative, they are referred to as variables in this study. These variables will be included in our model to examine whether there is a link between their occurrence and CO2 outputs. We quantified female entrepreneurship using the female entrepreneurship indicator score (FEPI), the female assets indicator score (FASI), and the female marriage indicator score (FMRI). We used energy use per person (ECpc), the globalization index (GI), and population density (POPd), all of which have a big effect on emissions, to improve our model.

This paper continues with the following structure: Section two provides a review of the relevant literature, Section three of this paper discusses the research methodology and data utilized, the results and a discussion of the impact of female entrepreneurship factors on CO2 emissions in Section four, and finally the conclusion in Section five.

Literature Review

In a market-based economy, the role of the entrepreneur is to implement novel combinations, or innovations. Schumpeterian entrepreneurs produce market imbalances via creative destruction. The source of economic vitality and sustained expansion can be traced back to this process of creative destruction. Schumpeterian entrepreneurs seek out ways to increase productivity in the hopes of finding new sources of profit. (Kirzner, 1973), the most prominent proponent of the New Austrian Entrepreneurship Theory, emphasizes the importance of the entrepreneur to market equilibrium.

There is no agreed-upon set of parameters for gauging entrepreneurship, making the endeavor a tricky one. There are a variety of ways to quantify entrepreneurship, and a thorough review of these methods can be found in (Iversen, Jorgensen, & Malchow-Moller, 2008); nevertheless, the most commonly used metric is "business demography," which refers to the birth, death, and growth of businesses through time.

The current period presents a challenge and a demand for achieving green and sustainable enterprise development. This procedure relies heavily on entrepreneurial initiative. Entrepreneurship helps firms respond to changing market conditions, and it actively backs enterprises as they engage in activities like technical green innovation and international investment, both of which improve the environmental sustainability (Gu & Zheng, 2021).

The literature review concerning the effect of entrepreneurship on economic growth in general and on its externalities on the environment in particular reveals that the specific theme of the relationship between female entrepreneurship and the environment appears to be novel and unprocessed so far.

According to (Ben Youssef, Boubaker, & Omri, 2017), developing nations, in particular, have a long way to go before they achieve sustainability. Their findings improved our understanding of how institutional quality, innovation, and entrepreneurship all play a part in structural change that will help Africa build a more secure economic future. In Africa, both informal and formal businesses hurt the quality and sustainability of the environment. Innovation and institutional quality boost sustainability and entrepreneurship, which go hand in hand. This report clarifies the criteria for African nations to develop toward sustainable economies. Their findings emphasize innovation and institutions' significance in Africa's sustainability.

(Nakamura & Managi, 2020) examined the association between entrepreneurship and environmental load (focused on CO2). Their key contribution is to include the entrepreneurial component in the interaction between entrepreneurship, the environment, and economic growth via the process of marginal cost. The marginal CO2 emissions costs of economic development and entrepreneurship are U-curve. While Japan has a low marginal CO2 cost, China, which has low CO2 abatement, has more entrepreneurial activity. Encouraging social and environmental entrepreneurship via innovation will help nations approaching the turning point succeed in growing more sustainably, this will be essential for long-term sustainable growth.

To assess the connection between entrepreneurship, economic growth, and pollution, (Gu & Zheng, 2021) employ a regression panel and a moderated mediation model to examine the three environmental outcomes that result from entrepreneurship. The EKC and its implications for business are also examined in this article, as are the variations that can occur depending on factors such as location, industry type, and ownership. The EKC for polluting companies that are publicly traded in China is N-shaped. Entrepreneurship directly degrades the environment and has negative technological, scale, and structural implications. Environmental regulation reverses the mitigated influence on pollution and relieves environmental strain.

(Mekhzoumi , Zerroukhi, & El Wawi, 2022) used the Environmental Kuznets Hypothesis (EKC) to study how entrepreneurship and globalization affected carbon dioxide (CO2) emissions. This study, which makes use of a static panel data approach, assesses EKC standards in 19 industrialized nations covering 2001-2019. The FGLS model and the PCSE model confirm the EKC argument, showing a reversed N curve among pollution and revenue.

In this investigation, the effects of both globalization and entrepreneurship are taken into account. Even though increased levels of CO2 emissions are attributed in part to entrepreneurship in advanced economies, globalization has generally positive effects on the natural world.

Data and Methodology

Ten countries from Southeast Asia (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) are represented in this research, with yearly data from 1980 to 2021. Unfortunately, we were unable to include Timor-Leste in our analysis due to a lack of data for most variables during the study period. The study's dependent and independent variables, together with their definitions and sources of data, are all listed in Table 1.

Table 1. Data variables and their descriptions

	Emissions of carbon dioxide come from the combustion of fossil fuels and manufacturing.	Our World in Data
	The GDP per capita is calculated by dividing the GDP by the midyear population using the 2015 U.S. dollar as a constant.	World Bank
	Measures barriers to women beginning and operating businesses.	Gender Data Portal
	Examines gender inequality in inheritance and property law, as well as customary law and judicial precedent.	
	Measures divorce-related and marriage legal constraints.	
	"Energy" means primary energy, or the energy that is put in before it is converted into other forms.	Our World in Data
	The GI evaluates globalization across three dimensions: economic, social, and political.	KOF
	Midyear population split by the country's land area in square kilometers.	FAO

Source: compiled and systematized by the authors.

Sustainable development is "an approach to achieving a balance between economic growth and natural systems," according to Almeida, (Almeida, Cruz , Barata, & García-Sánchez, 2017). Statistical models have been created to help us comprehend the consequences of economic growth on ecosystems. Multiple studies have shown the potential threat that an economic system poses to an ecosystem's survival (Machado, Schaeffer, & Worrell, 2001). Various researchers are investigating the impact of economic growth on the environment, while policymakers have sought to encourage economic growth that is also environmentally friendly. The EKC hypothesis is a well-known approach in environmental economics for modeling the link between environment and economic growth (Azam & Khan, 2016). According to (Grossman & Krueger , 1991), environmental degradation and economic growth go hand in hand as follows:

$$\mathrm{ED}_{i,t} = \delta_0 + \delta_1 GDP_{i,t} + \delta_2 GDP2_{i,t} + \delta_3 GDP3_{i,t} + \delta_4 Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

where ED is the rate of environmental degradation, GDP is the gross domestic product, and Z is a list of all other factors that might have an impact on environmental quality. The parameter δ_0 shows the average environmental stress when the independent variables don't have any effect. The parameters δ_1 to δ_4 show the direction and importance of the explanatory variables, and the error term is $\varepsilon_{i,t}$. There are seven possible forms of EKC, each of which is determined by the sign of a parameter associated with an individual's income (from δ_1 to δ_3). The following relationships emerge when we plot a country's GDP against the horizontal axis and the environmental degradation index against the vertical axis (Uchiyama, 2016).

Table 2. EKC curve forms

βi	Forms
$\delta_1 = \delta_2 = \delta_3 = 0$	no
$\delta_1 > 0, \delta_2 = \delta_3 = 0$	ascending
$\delta_1 < 0, \delta_2 = \delta_3 = 0$	decreasing
$\delta_1 < 0, \delta_2 > 0, \delta_3 = 0$	U-curve
$\delta_1 > 0, \delta_2 < 0, \delta_3 = 0$	reversed U-curve
$\delta_1 > 0, \delta_2 < 0, \delta_3 > 0$	N-curve
$\delta_1 < 0, \delta_2 > 0, \delta_3 < 0$	reversed N-curve

Source: (Fan & Zheng, 2013).

As illustrated in Table 2, linearly ascending suggests that environmental quality deteriorates as income grows, whereas linearly decreasing means the opposite. The U-curve relationship indicates that the environment's quality increases as income rises in the early stages before declining at higher income levels. However, the converse is true for a reversed U-curve relationship. Furthermore, the N-type relationship explains how, as income levels rise, environmental quality first declines, then gradually improves, before declining again while the inverted N-type relationship is the exact reverse.

The following is the link between the explanatory variables and CO2 emissions in our estimated empirical model:

$$CO2pc = F(GDPpc, GDPpc^2, GDPpc^3, FEPI, FASI, FRMI, ECpc, GI, POPd). \quad (2)$$

Compared to linear modeling, the log-linear formulation provides consistent and efficient empirical findings (Shahbaz, Loganathan, Zeshan, & Zaman, 2015). All variables are converted to logarithmic form as follows:

$$LCO2pc_{it} = \alpha_{it} + \delta_1 LGDPpc_{it} + \delta_2 LGDPpc_{it}^2 + \delta_3 LGDPpc_{it}^3 + \delta_4 LFEPI_{it} + \delta_5 LFASI_{it} + \delta_6 LFRMI_{it} + \delta_7 LECpc_{it} + \delta_8 LGI_{it} + \delta_9 LPOPd_{it} + \varepsilon_{it} \quad (3)$$

Extensive studies and evaluations of EKC's usefulness via the lens of econometrics had already been done since the eighties. Throughout the preceding decades, many estimation techniques have been introduced in the econometrics literature. There have been several studies employing a wide range of research approaches. Most studies that looked at whether economic growth and pollution have an inverted U-curve or a U-curve relationship across countries used panel data. In the 1990s, researchers such as (Lau, NG, Cheah, & Choong, 2019) checked the reliability of the EKC hypothesis using pooled OLS. In the next EKC studies, panel data analysis using GLS fixed- and random-effects estimates was used, the same as in the research of (Richmond & Kaufmann, 2006).

In the first stage, data stationarity is checked using panel unit root tests. The first-generation panel stationarity tests are the most often employed in the EKC literature. First-generation panel stationarity tests might be misleading if high levels of cross-sectional reliance are disregarded (due to volume distortions). Because of this shortcoming, (Pesaran, 2007) presented a new panel unit root test (Pesaran's CIPS test) that takes cross-sectional dependence into account. Before 2010, much of the EKC literature used first-generation panel unit root tests that assumed cross-section independence. Shared shocks may have different effects on different nations, leading to a link known as "cross-sectional dependence." It also shows the results on a national or even international scale.

Several tests may be performed to identify CSD, including the (Pesaran, 2004) test, which is frequently used in the EKC literature; an improved version of this test is known as the (Pesaran, 2015) test for weak CSD.

Cointegration tests are used to determine whether two or more nonstationary time series have a long-run stable relationship. According to the cointegration principle, the series follow each other in a long-run equilibrium relationship over time. When the assumption that the panel unit is cross-sectionally independent is broken, panel non-cointegration tests become very sensitive to sample size fluctuations (Gengenbach, Palm, & Urbain, 2005). Due to the large number of independent variables in the econometric model, the current research will use the (Kao, 1999) test, which is one of the panel cointegration tests. Tests like (Pedroni, 2004), (Westerlund, 2005), and (Westerlund, 2007) can't look at the cointegrated relationship between more than seven independent variables. Five different tests are proposed by (Kao, 1999). The Dickey-Fuller regression provides the basis for the Dickey-Fuller t, the modified Dickey-Fuller t, the unadjusted Dickey-Fuller t, and the unadjusted modified Dickey-Fuller t. When the "demean" option is selected, the cross-sectional averages are subtracted from the series before the cointegration test is performed. When selected, (Kao, 1999) estimates the series mean across panels and subtracts this value from the series for each time period. As a method for reducing the influence of cross-sectional dependency, this approach is suggested by (Levin, Lin, & Chu, 2002).

Many different kinds of empirical investigations now make use of dynamic panel data models. Instrumental variables and the generalized moment method (GMM) have been frequently used in the estimation of linear dynamic panel data models since the work of (Anderson & Hsiao, 1981). It is possible to use either a one-step or two-step GMM estimator to estimate the model. The two-step estimator uses an optimal weighting matrix that is determined using the residual values of the one-step estimator. As the time dimension decreases, it becomes more difficult to estimate linear panel data models with negligible unit-specific variability. The process of calculating regression coefficients that are time-fixed is more involved and requires more assumptions regarding regression orthogonality and unobserved unit-specific effects. Due to the extra torque conditions implied by the assumption of orthogonality, a GMM estimator may be constructed to estimate all parameters at once (Kripfganz & Schwarz, 2015).

(Arellano & Bond, 1991), (Arellano & Bover, 1995), and (Blundell & Bond, 1998) dynamic panel estimators are becoming increasingly popular. Both are general estimates designed for cases with: 1) a panel of "T small and N large," which means few time periods and many syllables; 2) a linear functional relationship; 3) one variable on the left side that is dynamic, based on what has been achieved in the past; 4) independent variables that are not entirely external, in the sense that they are related to the past and possibly present realization of the error; 5) fixed individual influences; and 6) heterogeneity and autocorrelation within syllables but not across them. The Arellano-Bond estimation begins with the transformation of all regressions, usually by differences, and uses the generalized moments method (Hansen , 1982), also called "difference GMM." The transformation of anterior orthogonal deflections, proposed by (Arellano & Bover, 1995), is sometimes performed in place of differentials. The Arellano-Bover/Blundell-Bond estimator reinforces the Arellano-Bond by making an additional assumption that the first differences in instrumental variables are not associated with fixed effects. This allows more tools to be inserted and can greatly improve efficiency. It builds a system of two equations—the original equation as well as the transformed equation—and is known as the "system GMM." The main advantage of the two-step approach is that first-stage estimates of incorrect specification do not vary with respect to model assumptions about the association between time-variable regression and unobserved unit-specific effects (Roodman, 2006).

In order to study the asymptotic properties of linear dynamic panel data models when the number of time periods is constant or tends to infinity with the number of panels (Breitung, Kripfganz, & Hayakawa, 2022) proposed a bias-corrected method of moments, which is computationally simple bias correction. This method works for high-degree autoregressive models, which include those with fixed effects and random effects assumptions, as well as those with heterogeneous errors. Robust inference in dynamical models with cross-sectional errors has been suggested using panel-corrected standard errors. Under the assumption of stringent external regression, the bias-corrected moments method estimator beats common GMM estimators in terms of efficiency and integer-sized tests, according to Monte Carlo simulations.

Results

The variables that were used in the study are shown in the table below, along with summaries of panel data and descriptive statistics.

Table 3. Study variables' descriptive statistics

		CO2pc	GDPpc	FEPI	FASI	FMRI	ECpc	GI	POPd
Brunei		17.838	35548.31	75	50.476	30.476	94335.01	49.619	62.553
Indonesia		1.388	2202.382	75	60	28.095	5348.256	53.738	114.09
Cambodia		0.2944	644.7269	82.142	95.238	67.619	1165.714	37.357	66.943
Laos		0.5974	1215.086	84.523	91.904	77.619	4784.942	33.619	23.328
Myanmar		0.2522	584.8142	75	80	80	1320.216	30.690	71.007
Malaysia		5.469	6638.315	75	57.619	32.857	24884.21	69.452	68.750
Philippines		0.8597	2186.198	88.095	60	48.571	3616.461	56	266.112
Singapore		10.967	36644.94	75	91.904	85.238	115582.8	75.857	5819.181
Thailand		2.715	3891.709	75	100	53.333	12506.43	57.714	120.630
Vietnam		1.122	1478.943	83.928	100	69.523	4272.24	43.357	250.183
Total	**Mean**	4.150	9103.543	78.869	78.714	57.333	26781.62	50.740	686.278
	Min	0.0445	122.1423	50 100100	40	20	197.6198	19	14.287
	Max	36.594	66176.39	100	100	100	174703.8	84	8379.496
		N = 420, n = 10, T = 42							

Source: calculated by the authors.

The dependent variable (CO2pc) varies greatly across the ten countries, with a mean of 4.150588, a low of.044, and a high of 36.59. Also, the data show that Brunei pollutes the most and Myanmar pollutes the least.

The CSD results for (Pesaran, 2004) and (Pesaran, 2015) are displayed in Table 4.

Table 4. Pesaran (2004) and Pesaran (2015) tests

	CSD	prob-value
LCO2pc	20.59	0.000
LGDPpc	25.73	0.000
LGDPpc2	25.97	0.000
LGDPpc3	26.19	0.000
LFEPI	3.74	0.000
LFASI	6.36	0.000
LFMRI	26.37	0.000
LGI	41.60	0.000
LECpc	34.33	0.000
LPOPd	43.26	0.000

Source: Calculated by the authors.

Given the findings above, it is clear that the null hypothesis should be rejected, confirming the existence of the cross-sectional dependence of all variables. Consequently, the test developed by ((Breitung J. , 2000); (Breitung & Das, 2005)) is preferable to apply since it is resistant to cross-sectional correlation. Table 5 displays the results of the unit root tests using the Breitung method.

Table 5. (Breitung J. , 2000) and (Breitung & Das, 2005) tests

	Level			First difference		
	Constant & trend	Constant	no constant nor trend	Constant & trend	Constant	no constant nor trend
LCO2pc	0.25	2.815	-1.76**	-4.37***	-5.35***	-5.97***
LGDPpc	-0.87	0.753	2.796	-1.785**	2.975***	-4.108***
LGDPpc2	-0.423	1.577	3.132	-1.62*	-3.38***	-4.26***
LGDPpc3	-0.07	2.21	3.05	-1.53*	-4.27***	-3.94***
LFEPI	0.05	0.381	2.113	-4.80***	-6.08***	-6.08***
LFASI	-0.16	0.247	2.378	-5.83***	-7.11***	-7.11***
LFMRI	-1.86**	0.534	3.302	-6.14***	-3.68***	-9.42***
LGI	1.625	1.656	4.467	-1.87**	-1.98**	-4.92***
LECpc	0.107	2.279	3.345	-2.98***	-2.63***	-5.26***
LPOPd	0.677	0.24	2.226	-1.84**	-1.37*	-2.54***

Notes: ***significant at 1%, **significant at 5%, *significant at 10%

Source: Calculated by the authors.

According to the results in the table above, the alternative hypothesis—that all variables stabilize after the first difference—should be accepted rather than the null hypothesis. Other panel cointegration tests ((Pedroni, 2004), (Westerlund, 2005), and (Westerlund, 2007)) cannot handle more than seven independent variables; thus, we pick the (Kao, 1999) test since it can estimate cointegration even with a high number of independent variables contained in the model.

Table 6 (Kao, 1999) cointegration tests

	Statistic	p-value
Modified Dickey–Fuller t	-6.4518	0.0000
Dickey–Fuller t	-4.7725	0.0000
Augmented Dickey–Fuller t	-3.7825	0.0001
Unadjusted modified Dickey–Fuller t	-8.7284	0.0000
Unadjusted Dickey–Fuller t	-5.2957	0.0000

Note: Cross-sectional means removed.

Source: Calculated by the authors.

All of the test statistics and their associated probability values are shown in the final output. All the test results agree with the alternative hypothesis that the dependent variable (LCO2pc) is cointegrated with the nine independent variables and disagree with the null hypothesis that there is no cointegration. Given the long-term nature of the relationship shown by the co-integration findings, we continue to estimate a pair of models (Fixed-Effects BC-GMM and Random-Effects BC-GMM). We next use the generalized Hausman test to distinguish between them.

Table 7. Bias-corrected method-of-moments estimations

	Fixed-Effects BC-GMM	Random-Effects BC-GMM
L.LCO2	0.6951575*** (0.0537109)	1.018573*** (0.0060627)
LGDPpc	-4.11215*** (0.9250961)	-0.1230251 (0.6225393)
LGDPpc2	0.5765142*** (0.1231733)	0.013557 (0.0752637)
LGDPpc3	-0.0257134*** (0.0051012)	-0.0006072 (0.0029667)
LFEPI	0.1443634*** (0.0501235)	0.1288909** (0.0543582)

Table 7 (cont.). Bias-corrected method-of-moments estimations

	Fixed-Effects BC-GMM	Random-Effects BC-GMM
LFASI	0.3941844 ** (0.1888319)	0.1054938** (0.0415142)
LFMRI	-0.1289928** (0.0659547)	-0.0132141 (0.0178923)
LGI	-0.0870782 (0.0685177)	0.0102382 (0.0380305)
LECpc	0.2278687*** (0.0389329)	0.0025435 (0.013341)
LPOPd	0.0815383 (0.0607914)	-0.014516*** (0.0047318)
cons	5.502758** (2.200763)	-0.4989128 (1.485658)
Generalized Hausman test	chi2(2) = 1942.5808 Prob > chi2 = 0.0000	

Notes: The standard errors for the robust estimates of the coefficients are shown in parenthesis, *** significant at 1%, ** significant at 5%, *significant at 10%

Source: calculated by the authors.

Table 7 shows that the BC-GMM for the fixed-effects estimator is the appropriate model based on the generalized Hausman test. With the exception of LGI and LPOPd, the fixed-effects BC-GMM model shows that all of the remaining independent variables are statistically significant.

In spite of the fact that GDP per capita reduces emissions (as seen by the negative coefficient of LGDPpc), the square of GDP per capita increases them (the positive coefficient of LGDP2), while CO2 emissions fall as the cube of per capita GDP increases (represented by the negative coefficient of LGDP3). Findings like these support the viability of the EKC argument, which says that CO2 emissions in Southeast Asian countries follow an "inverted N"-shaped pattern. Numerous studies, including (Kang, Zhao, & Yang, 2016); (Özokcu & Özdemir, 2017); (Peng, Wu, & Zhao, 2014); and (Minlah & Zhang, 2021) all support this result. Notwithstanding, this runs contrary to the results shown in (Balin & Akan, 2015); (Zhang & Zhao, 2014); (Gyamfi, Adedoyin, Bein, & Bekun, 2021); and (Rashdan, Faisal, Tursoy , & Pervaiz , 2021), where estimates from different econometric methodologies offer the N-shaped EKC.

The fixed-effects BC-GMM model shows that an increase of one point in the Female Entrepreneurship Indicator Score (LFEPI) is associated with a 0.14-point increase in LCO2 in Southeast Asian nations. Although this rise is modest, it is believed that female entrepreneurship increases environmental deterioration, which in turn hinders sustainable development in Southeast Asia. According to the EKC hypothesis, the research on the effects of female entrepreneurship is almost nonexistent. Nonetheless, we attempt to conduct inference analyses on this topic. (Omri, 2018) found that entrepreneurship in developing countries did more damage to the environment. By figuring out the marginal cost, (Nakamura & Managi, 2020) found that once a certain tipping point is reached, entrepreneurship goes up, which makes the marginal cost of CO2 emissions go up. (Kövendi, Nagy, Salah Uddin, & Hoon Kang, 2021) say that entrepreneurship in both developing and developed countries increases CO2 emissions in industrialized economies. On the other, (Mekhzoumi & Gharbi , 2021) found that Total Early-Stage Entrepreneurial and Income per Working Person have a negative relationship in industrialized countries, which is good for the environment.

The Female Assets Indicator Score (LFASI) correlates positively with LCO2 in Southeast Asian economies, with a one-point rise in LFASI being related to a 0.39-point increase in LCO2, as shown by the fixed-effects BC-GMM model. According to the FASI, the ability to inherit property gives women a leg up in the business world by providing a financial cushion from which to launch their ventures. Women's entrepreneurial desire may be

understood in contexts where they have the same legal rights to inheritance as males. Because of this, doubts regarding the family's ability to provide beginning capital have arisen. To better care for their children and maintain their homes, women need access to financial resources. Despite attempts in Southeast Asia to protect women's access to productive and financial resources, major problems exist (OECD, 2021). East and Southeast Asian MSMEs are 60% female-owned, and 45% have a credit gap. Financial difficulties limit female entrepreneurs' training and networking. As a result, less formal, time- and resource-intensive businesses have emerged.Slow growth makes it difficult for female entrepreneurs to acquire financing and network (USAID, 2015). Even in places where the law grants equal rights, discriminatory cultural behaviors may prevent women from claiming them. Despite equal marriage and inheritance rights, Southeast Asian women hold 10% of farmland. One-third of South Asian men and women say women shouldn't work outside the house for money (Asian Development Bank & The Asia Foundation, 2018). A rise in the LFASI suggests more resources are being devoted to bolstering and promoting female entrepreneurs in Southeast Asia, which will have a deleterious impact on the environment due to increased emissions.

Following the BC-GMM with fixed effects results, a one-point increase in the Female Marriage Indicator Score (LFMRI) is associated with a 0.13-point drop in LCO2 in Southeast Asian countries. FMRI demonstrates that in southeast Asian nations with tighter limitations on marriage, divorce, remarriage, and domestic violence, more women establish enterprises. The conventional role married women are expected to perform in their families, together with their household obligations, creates a barrier to entrepreneurial activity, which requires availability and mobility. Also, forced or early marriages impede women's access to school and work possibilities in emerging Asian nations. This discourages them from starting their own businesses (Franzke, Wu, Froese, & Chan, 2022). Despite Southeast Asia's variety, cultural traditions, religious views, and family values all influence women to seek careers in business and politics. Institutionalized patriarchal cultures emphasize obedience, conformity, authority, surveillance, social hierarchy, and inequality. Women's entrepreneurship and development are prominent themes in local policy discussions, yet their entrepreneurial operations garner varied reviews (Ojediran & Anderson, 2020). The LFASI has a negative impact on women's entrepreneurial activities in Southeast Asian nations, but it also empirically proves to have a beneficial impact on the environment by reducing emissions.

Based on the estimation results of the fixed-effects BC-GMM, we found that higher energy use was associated with more CO2 emissions. CO2 emissions rise by around 0.23 percent for every one percent increase in energy use in southeast Asia. (Saboori & Sulaiman, 2013); (Akbar, Rehman, Ullah, Zeeshan, & Afridi, 2020); and (Chontanawat, 2020), all of which focused on ASEAN countries, as well as (Anwar, et al., 2022), which focused on 15 Asian countries, all found similar findings. These identical findings verify that industrial businesses mostly use non-renewable energy sources throughout the production process, greatly increasing CO2 emissions. The quantity of energy needed to produce industrial output and evolve toward export-oriented technology in ASEAN nations is already under strain. Coal, oil, and gas provide around 90% of the main commercial energy demand in ASEAN (Saboori & Sulaiman, 2013). Potentially increased emissions might increase the urgency of taking measures to reduce pollution. And as indicated by (Narayan & Narayan, 2010), In the long run, the carbon emission elasticity of the energy usage variable is greater than its short-run counterpart. This means that throughout time, the ASEAN countries' carbon emissions have grown in proportion to their energy use.

Conclusions

Various growth theories, including neoclassical, endogenous, and Schumpeterian growth theories, have been used to study the impact of entrepreneurship on economic growth. However, the intersection between entrepreneurship and sustainability has been largely overlooked. Comprehensive studies of the scientific literature show that entrepreneurship has a substantial effect on economic growth.

Women are strongly encouraged to enter the business world in a wide variety of nations. This promotes economic growth and new developments in technology and consumer goods in industrialized nations. Entrepreneurial women may significantly impact economies in developing countries by generating jobs, income, and social cohesion. Boosting national development and income is a top priority for governments, so they actively support

women entrepreneurs. Increasing the number of successful female entrepreneurs in Southeast Asia might help women there provide for their families and climb the professional ladder. When women take the reins of their own enterprises, they get a fresh perspective on societal challenges and the freedom to participate actively and imaginatively in shaping their communities. Families and communities benefit from women's increased participation in the labor force and society at large.

The worldwide trend toward industrialization and the rise of entrepreneurial pursuits, especially among women, have the potential to spur rapid economic development in the nations of Southeast Asia. Rapid economic growth and increased energy use are both factors in the increase in carbon dioxide emissions. Climate change, brought on by man's rising carbon footprint, threatens life on Earth and calls into question our existing way of life.

During the course of the previous several decades, a number of studies have been conducted to investigate the relationship between CO2 and economic growth. The EKC model is one example of a model that accomplishes this goal. This model makes an effort to explain the link between increasing economic activity and deteriorating environmental conditions. The most important thing that has come out of this study is the combination of the role that female entrepreneurship plays in the challenge of sustainability with the use of the EKC hypothesis in Southeast Asian countries. To that end, this paper employs a panel data model to conduct an empirical investigation of ten Southeast Asian countries from 1980 to 2021. Per capita CO2 served as the dependent variable in an Environmental Kuznets Curve model with independent variables including GDP per capita (GDPpc), its square (GDPpc2), and its cube (GDPpc3); female entrepreneurship indicator score (FEPI); female assets indicator score (FASI); female marriage indicator score (FMRI); energy consumption per capita (ECpc); globalization index (GI); and population density (POPd). This empirical study adopts the (Breitung, Kripfganz, & Hayakawa, 2022) fixed-effects bias-corrected method of moments (BC-GMM) approach.

The findings lend credence to the EKC hypothesis by providing empirical proof of the phenomenon in Southeast Asian nations. The negative LGDPpc coefficient, the positive LGDP2 coefficient, and the negative LGDP3 coefficient show that CO2 follows the inverted N-shaped pattern predicted by the EKC. The results of this study will be used to make policy suggestions that will give female entrepreneurs in Southeast Asia the tools they need to make protecting the environment one of their top priorities.

Within this context, we believe that female entrepreneurial activities are necessary to address the environmental difficulties in Southeast Asia and that the greatest benefits will be attained by capitalizing on the inventiveness of female entrepreneurs who create novel economic solutions to address these issues. There are two major strategies used to get female-owned businesses of all sizes to adhere to the principles of sustainable development: coercion and incentives. The former is enforced by law and regulation, while the latter are corporate social responsibility pledges made voluntarily by the companies themselves. We also urge the governments of the region to consider adopting broader women's responsibilities. However, this must be done cautiously lest it have a cascading impact on local markets, making domestic businesses less competitive.

Energy consumption and carbon emissions are positively correlated, so southeast Asian countries should promote sustainability and reduce environmental deterioration. More labor and supply chain capabilities are needed to reduce CO2 emissions from fossil fuels. These countries can only attain energy security by switching to natural gas and higher-grade coal. A policy that promotes renewable energy in Southeast Asia may reduce emissions. Investing in renewable energy research and development and implementing market mechanisms that encourage firms to use renewable energy are alternative ways to minimize energy-related pollution. Many forms of renewable energy exist, so research money must be used intelligently.

One big limitation with this research is that there isn't enough detailed data, especially about female entrepreneurship. Only the female entrepreneurship indicator, the female assets indicator, and the female marriage indicator were considered in this study. More female entrepreneurship criteria might be included in future research on this subject, which could be useful to academics (e.g., female pay indicators, female workplace indicator, female mobility indicators, etc.). This article's focus on Southeast Asian nations means that its findings may not generalize to other regions. Future research will use a comparative method to investigate the influence of female

entrepreneurship on carbon dioxide emissions in a more statistically significant sample of developed and developing economies.

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