10 Role of green technology financing in renewable energy development in ASEAN

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10.1 Introduction

The goal of sustainable development is to improve global conditions so that future civilizations have a less difficult time coping with such issues as resource depletion and pollution. A potent notion of progress, it takes into account the interconnected nature of issues pertaining to energy, the environment, and society. development allows us to be certain that our children and grandchildren will have access to essential resources including energy, water, and food and, as mentioned above, to focus on reducing the environmental impact of our actions to the benefit of people everywhere (Nepal, Phoumin, & Khatri, 2021b). While economies across the globe have tried to balance economic expansion by protecting natural resources, the shift toward sustainability is still in its infancy in emerging economic zones. Hence, although developing economies and areas have contributed comparatively little to greenhouse gas (GHG) emissions, it is anticipated that they will be disproportionately harmed by climate change owing to their more limited capacity for adaptation. The COVID-19 epidemic adds to uncertainty in applying sustainable measures to tackle climate change, owing to ensuing economic crises and border restrictions in many countries. Green technology's function and significance to climate change adaptation and its ability to provide a fresh take on sustainable development have always been critical, however.

Shifting to a lower-carbon economy presents significant problems and possibilities for such developing regions as Southeast Asia, which must keep up with increased energy consumption due to industrialization and urbanization, and the rising incomes that are a consequence thereof. In recent times, major regional economies, including Indonesia, Malaysia, the Philippines, Thailand, and Vietnam have been increasing their GHG emissions by an average of 5% annually (Azhgaliyeva, Kapoor, & Liu, 2020). Despite slowing economic development, the region is still forecast to become a net importer of fossil fuels due to industrialization and urbanization, and consequent population increases (Jermsittiparsert & Chankoson, 2019). The Association of Southeast Asian Economies (ASEAN) region's population growth, which is forecast to reach 715 million by 2025, is a significant factor in energy consumption

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increases, amounting to at least 4% annually. Energy demand overall has increased by more than 80% since 2000, and has been met by a doubling in fossil fuel extraction, which in turn engenders such energy security problems as increased dependence on imports and environmental concerns due to rising carbon dioxide (CO_2) emissions (Henderson, 2015). The region's contribution to global GHG emissions rose from 3% in 2010 to 4% in 2018, and it is forecast that annual fatalities in Southeast Asia attributable to domestic air pollution will rise from approximately 450,000 in 2018 to exceed 650,000 by 2040 (Zeraibi, Balsalobre-Lorente, & Murshed, 20121). Average temperatures in ASEAN have been increasing at a rate of 0.1°C–0.3°C each decade for the past 50 years, forecast to accelerate to 2°C–4°C by the end of the 21st century (Nepal, Phoumin, & Khatri, 2021b). ASEAN's 6% annual growth rate makes it one of the world's fastest-growing markets, with regional power demand forecast to quadruple by 2040. In 2016, ASEAN member states (AMS) committed to obtaining 23% of their main energy supply from renewable sources by 2025 (Chandio, Shah, Sethi, & Mushtaq, 2022). Power output is forecast to triple by 2025, driven by the total energy consumption forecast to increase by almost half that amount (Dufrénot & Keddad, 2014). The increased urgency with which ASEAN must accordingly develop and deploy greener energy sources to adapt to climate change is underscored by the region's aforementioned expanding energy consumption and accompanying GHG emissions. Fossil fuels account for about 80% of ASEAN's power generating mix in 2017, and are projected to account for 82% by 2050 if the region does not shift to cleaner energy systems (Chandio et al., 2022). Given this stated fossil fuel dependence, there is also an ongoing conversation within ASEAN on establishing policy initiatives to mitigate and adapt to climate change and balance economic growth with environmental sustainability. It is imperative that Southeast Asia create and implement green technology to meet growing energy consumption and increasing GHG emissions. Certain nations must at least double their proportion of RE annually to respond to climate change. AMSs should have 70% of their energy come from renewable sources by 2040 (Zeraibi et al., 2021). Progress toward adoption of renewables and other green technologies is slower than forecast potential in several Southeast Asian nations, however. Despite the tremendous growth of hydropower and contemporary use of bioenergy for heating and transportation, RE still only meets some 15% of demand (Sharif, Kocak, Khan, Uzunder, & Tiwari, 2023). Solar photovoltaics (PV) and wind are the most abundant renewables in ASEAN, yet they account for only a small percentage of total energy output (Sharif et al., 2023). On the one hand, hydroelectricity has doubled since 2000, while on the other, the region has not yet begun to tap its potential for modern sustainable biofuel production. As mentioned above, despite these potential sustainable energy sources, Southeast Asian economies have yet to deploy RE at scale, owing to numerous obstacles (Nepal, Indra al Irsyad, & Nepal, 2019). Policymakers are working harder than ever to achieve their common goal of a secure, sustainable, and affordable energy sector across the varied and dynamic region that is Southeast Asia (Iqbal, Khan, Gill, & Abbas, 2020). Increased resource use and demand complementarity is possible because of the region's diverse energy mix, which also presents an opportunity to accelerate regional grid interconnections, another energy policy objective that has received considerable support to-date (Liu, Yao, Latif, Aslan, & Iqbal, 2022). In light of green energy development and deployment for climate change adaptation in ASEAN, the purpose of our research is to assess and review energy-economy-environment interrelation in the region in sustainability terms. Thus, we acknowledge unavoidable economy-environment tradeoffs between regional development and unfavorable climate change consequences as a subject for policymakers to concentrate on. Researchers in this field believe, as mentioned above, that a greater emphasis on renewables and other forms of clean energy is essential if ASEAN is to achieve a successful energy transition. Accordingly, we argue that policymakers should develop and execute appropriate policies for all time frames, short-term, medium-term, and long-term alike, based on our objective research, which employs publicly funded data. Scaling renewable energy deployment, concentrating on energy efficiency, limiting use of fossil fuels through price reforms, and adopting hydrogen, carbon capture, utilization, and storage technologies are all examples of proposed policies. The region must, however, overcome the challenges of greater financing requirements to significantly accelerate RE deployment in the region, in addition to managing governance and financial risks.

The rest of this chapter is organized as follows. Section 10.2 reviews literature on green technology financing and the status of green finance and RE development in ASEAN. Section 10.3 discusses data and methodology. Section 10.4 provides analysis results. Section 10.5 concludes with policy recommendations.

10.2 Green technology financing

Historically, conventional green technologies have been developed and implemented primarily in a framework of national green growth policies and energy transition. This is due to RE technology offering a path to decarbonization and economies the world over setting ambitious objectives to decrease GHG emissions. Numerous underdeveloped nations are accordingly incorporating green growth policies into their plans for future economic expansion. Literature on technology transfer and industry insights throughout the technology lifecycle has been used to bridge the gap between technologies and capabilities. Policymakers' heuristics have been shown to be important when deploying clean technology, and technology-specific green development plans vary depending on the income and resource needs of each specific nation (Iqbal et al., 2021). Notwithstanding, various obstacles to reaching the RE and energy security objectives established by ASEAN have been identified in the energy industry between 2010 and 2015 (Ismail, Ramirez-Iniguez, Asif, Munir, & Muhammad-Sukki, 2015), including financial limits, regulatory disparities, and technical gaps. At the same time, little progress has been made in terms of crucial regional collaboration in infrastructure. An examination of sustainable energy policies in Indonesia, the Philippines, and Singapore between 2000 and 2016 reveals emphases in each country on institutionalizing sustainable energy via alignment with domestic RE systems. Although East and Southeast Asia have great potential for RE, as mentioned above, a 2020 energy transition study elucidated the above-mentioned mismatch between supply and demand (Sadiq, Nonthapot, Mohamad, Ehsannullah, & Iqbal, 2021). In a follow-up study, researchers looked at how several hypothetical consumption scenarios affected the amount of aerosols released by burning fossil fuels in Southeast Asia (Sumner, Ortiz-Juarez, & Hoy, 2020), finding that a 25% decrease in sulfates might be achieved by switching from coal to natural gas in power generation and industry, and that black carbon concentrations would fall by 42% if natural gas similarly replaced biofuels in the residential sector. The International Energy Agency (IEA) found that energy-related air pollution would increase mortality rates in the Southeast Asian area from an anticipated 450,000 in 2018 to 650,000 in 2040, emphasizing the necessity of clean air in the region. Rasoulinezhad and Taghizadeh-Hesary (2022) analyzed 45 Asian economies categorized by their income level between 1993 and 2018, using the generalized method of moments (GMM) estimation methodology. While population expansion was shown to correlate positively with energy transitions across all income levels with economic development, CO emissions were found to have a negative impact.

The greater global biodiversity dangers posed by energy transitions have also become a concern. Research has demonstrated that RE plants may have a significant influence on natural habitats, partly owing to the large amounts of land they require. According to a study by Alemzero et al. (2021), the growth of renewables, including onshore wind, hydropower, and solar PV, interferes with the protected biodiversity areas to a greater or lesser amount depending on the location. It was found that the ambitious aim of 23% renewables in the region's primary energy mix by 2025 would be hindered by governmental inaction, including leaving subsidies of fossil fuels and hurdles to regional market integration in place (Liu et al., 2021). There is a dearth of research on developing and implementing green energy technologies in Southeast Asia within the framework of green growth and energy transition. Our analysis aims to add to this growing body of work by focusing on ASEAN and its efforts to adapt to climate change. Existing research has primarily ignored such leading-edge technologies as hydrogen and carbon capture and storage (CCS) in favor of studying the technical and environmental issues confronting more traditional RE. Our study helps ASEAN governments develop sustainable energy strategy aimed at combating climate change and promoting long-term economic growth in the area by using cutting-edge green technology. Energy consumption in ASEAN is forecast to increase by 50% over the next decade as the region's economies expand at faster rates. The area has a goal of 23% of its main energy needs met by renewables by 2025. Global economic and energy indicators reveal that ASEAN is becoming a net importer of fossil fuels given these selfsame fast rising economies and consequent population growth. Demand for automobiles and other forms of transportation in ASEAN is forecast to keep the region dependent on oil. Strong policy measures to attain economic growth objectives will also increase coal demand. And even while such sources as liquefied natural gas (LNG) are becoming less cost-competitive in ASEAN due to rising oil imports, the IEA estimates that industry is the region's primary natural gas consumer.

Some 10% of the population of Southeast Asia, more than 120 million individuals, still do not have access to electricity, and getting energy to rural areas remains a challenge (Chopra et al., 2022). Approximately 45 million people in the region use biomass as a primary cooking fuel (Chandio et al., 2022). While RE has enormous untapped potential, it now meets only 15% of the world's demand, despite bioenergy for heating and transportation expanding dramatically since 2000, and hydropower generation increasing by a factor of four over the same period.

Although prices for solar PV and wind have fallen in recent years, they still account for a tiny portion of consumption. While their implementation may be bolstered by a market-based framework for energy efficiency, there is currently no such framework in place. Southeast Asia's total energy consumption is also predicted to climb by 60% by 2040, based on a stated policy scenario provided by the IEA in 2019, anticipating that the economy would double by that time and the bulk of the population, some 120 million people will be concentrated in metropolitan areas. Although Southeast Asia's demand will account for 12% of global energy growth by 2040, the pace of that demand is forecast to decrease compared to past decades due to a structural economic shift toward less energy-intensive manufacturing and service sectors and greater efficiency. On the other hand, oil consumption will have increased from 6.5 million barrels per day (mb/d) as of this writing to more than 9mb/d, again by 2040.

Natural renewable resource endowments are another geographical advantage enjoyed by Southeast Asian countries. Countries like Vietnam, Cambodia, Laos, and Myanmar, as well as Indonesia and the Philippines, have tremendous untapped hydropower potential. Similarly, the majority of these nations receive at least 12 hours of sunlight daily on average, making them prime candidates for solar PV electricity generation. At the end of 2017, the total installed capacity of RE generators throughout the world was 2179 GW, with the largest share going to hydroelectricity, at 1271 GW. At the same time, Asia contributed 64% of the world's new RE capacity, and some 85% of all such new renewable capacity built in ASEAN is new solar PV and wind plants. Thailand has the second-highest proportion of bioenergy capacity among the AMSs, at 430MW, while Indonesia has added 306 MW to its geothermal capacity, making it the world leader in this category (Sharif et al., 2023). Additionally, solar PV accounts for 47% of grid-connected renewable electricity output in Malaysia in 2017, and Malaysia is also the world's third-largest PV manufacturer (Fang, Liu, & Surya Putra, 2022).

Laos has also recognized its potential and now meets some 80% of its primary energy needs with renewables, biomass being chief among these, derived primarily from forestry and agricultural waste and utilized for home cooking and low-volume rural manufacturing. Hydroelectricity accounts for 12% of the remainder. Direct combustion, gasification, anaerobic digestion, and hybrid systems are all viable options for more commercial biomass in Laos (Sun et al., 2021). 300 days of sunshine a year also helped Laos equip 13,000 houses in rural areas with solar panels.

The Indonesian government has taken the initiative to construct a massive floating power plant, paving the way for 60 other reservoirs around the nation. The nation also has tremendous wind potential. A 100 ha wind farm capable of supplying power to some 70,000 families has been established in South Sulawesi.

The Philippines, however, possesses Southeast Asia's greatest wind energy potential, greater even than that alluded to above for Indonesia, yet many residents lack modern power. Almost 51% of the population still uses wood or charcoal for cooking (Nepal et al., 2021c). Green startups have had a significant impact by using this and the country's other abundant RE resources. Once such firm, Sustainable Alternative Lighting, developed a light source that lasts up to eight hours on a fuel derived saltwater solution. Its disposable component may be used for up to six months before needing to be replaced, which is cheap and easy.

Energy consumption in ASEAN is projected to increase by 60% by 2040, far less than the cumulative increase over the past few decades. In 2020, RE accounted for 24 percent of all electricity produced, a figure that is forecast to reach 30%, again, by 2040. The current ASEAN policy framework is, however, inadequate to raise RE performance to levels achieved by such other developing nations as China and India. On the other hand, the emergence of wind and solar PV as well as biofuels and bioenergy from waste products promises exciting developments to come, even as hydropower continues to be the backbone of ASEAN's energy portfolio, accounting for some 80% of the region's renewables share, and advancements in hydrogen carbon technology may further alter ASEAN's energy environment (Nepal, Phoumin, & Khatri, 2021a).

10.3 Data and methodology

Our research included data from global development indicators between 2010 and 2022 Population, inflation, and FDI are given as percentages, grants for technical assistance, public spending, tax revenues, and GDP denominated in USD (this last based on purchasing power in 2017), and sewage, regulation, and renewable consumption as a proxy for green financing in kilotons (kt).

10.3.1 Difference in differences (DID)

We extrapolate some findings from Upton and Snyder (2017), Sun et al. (2021), and Nawaz et al. (2021), as these all use the familiar Difference in differences (DID) model in their analyses (2017). We accordingly apply DID ourselves when cross-sectional or panel data from AMSs are available for a given period, because it offers precise estimates of Africa's green financing coefficient. Assume that y is the ideal result for country I at time t (i, t). In this chapter, we contrast how countries behaved before (t = 0) and after (t = 1) therapy. Which countries' groups will receive treatment during these periods is specified by D (I t) = 1. If and only if country I was a member of the treatment group before time t, then D (I t) = 0. D (I t) = 0 signifies control nations that are not undergoing therapy, in contrast to AMSs that are. All N-11 countries receive special consideration. Hence, a nation's sole remedy is D (I t) = 0 for i = 0 to t = 2018 (Abadie). The model is estimated using the techniques outlined in Card (1985) and Abadie (1994) processes (2018), with a linear parametric model often utilized as the primary DID estimator. Assume further that the result variable is produced by the variance process in the following equation:

$$Y(i, t) = (i, t) = \delta(t) + \alpha \, . \, D(i, t) + \eta(i) + v(i, t) \tag{10.1}$$

The time-specific component (t), the country-specific component (I), the treatment effect (I), and the time-specific shocks (v(i, t)) with zero mean within each period (t = 0, 1) are defined in Eq. (10.1). y(i, t) and D may both be measured directly as (i, t):

$$P(D(i, t) = 1|-(i, t) = P(D(i, 1) = 1 \tag{10.2}$$

where t = 0, 1. Performing addition and multiplication on $E[\eta(i)|D(i, 1)$ in Eq. (10.1) gives:

$$Y(i, t) = \delta(t) + \alpha \, . \, D(i,t) + [\eta(i)|D(i, 1)] + \varepsilon(i, t) \tag{10.3}$$

From Eq. (10.3) $(i, t) = \eta(i) - E[\eta(i)]|D(i, 1)] + v(i, t)$. Note that $\delta(t) = \delta(0) + \delta(1) - \delta(o)t$.

$E[\eta(i)]|D(i, 1)] = E[\eta(i)]|D(i, 1) = 0] + E[\eta(i)] \, |D(i, 1) = 1] - E[\eta(i)] \, |D(i, 1) = 0]D(i, 1)$. Let $\mu = E[\eta(i)]|D(i, 1) = 0] + \delta(0)$, $\tau = E[\eta(i)]|D(i, 1) = 1] - E[\eta(i)]|D(i, 1) = 0]$, and $\delta = \delta(1) - \delta(o)$. Eq. (10.4) is derived as follows:

$$Y(i, t) = \mu + \tau \, . \, D(i, 1) + \delta \, . \, t + \delta \, . \, D(i, t) + \varepsilon(i, t). \tag{10.4}$$

We drew on DID to develop a green finance-based tool to analyze how financial policies affect attempts to decrease air pollution, by comparing pollution levels in regions that have green finance projects with those that do not. We chose DID because it is simple to comprehend and adapt to, and in some circumstances may demonstrate cause and effect from observational data. Note that as DID emphasizes change rather than absolutes, groups being compared may start from different places.

Two of the air pollutants are the Air Quality Index (AQI) and the components that make up particulate matter (PM) in a province's monthly averages of SO_2, CO, O_3, and PM2.5 and PM10. The latter two refer respectively to emissions of particulate matter with dimensions less than or equal to 2.5 μm and greater than 2.5 μm and less than or equal to 10μm. We used these contaminants as dependent variables to assess the aforementioned relation between green financing policies and aggregate and individual air pollution alike.

The chosen location is a region where the month and year of choice are after January 2010. This may be determined using a marker variable named $Green_{i,t}$, with i assigned a value of 1. Industrial pollution from adjacent sites represents a unique set of control variables. We take into account the arithmetic means of commercial SO_2 emissions, sooty combustion characteristics in advanced manufacturing, and the rate at which home waste is fully used. We calculated the estimated GDP incorporation coefficient, the proportion of public spending and tertiary industries, the arithmetic mean of indigenous populations, sustainable growth, and economic benefits of manufacturing. The percentage of local manufacturers is used in combination with public spending, sector, and environmental legislation to categorize manufacturing. The fixed-effect model incorporates the time-independent, all-encompassing economic inequalities of the aboveground region. While the economy might have benefited if the green financing plan had been implemented sooner, these risks do not fall into the category of time-fixed consequences.

The correlation of 1 in Eq. (10.2), which is the case for green finance policies in region, reflects the two-fold difference between pre- and post-green finance policies in urban centers in other regions throughout this time span. Comparing the 1 correlation coefficient is one technique for obtaining additional knowledge about efficient financial management. A coefficient of –1 signifies that economic resources have a negative impact on air pollution.

Each region must first choose a city to test the new system in, even if all regions incorporate green funding. Eq. (10.2) serves as the foundation for this study, which then applies a variety of unique monthly quantitative research techniques and Eq. (10.3) to demonstrate how various funding options affect changes in carbon emissions.

10.4 Findings

Subsidies for fossil fuels are monetary grants or tax breaks provided by government to the energy industry or consumers to lower the overall cost of energy production and distribution. See Table 10.1. Different countries draw on a variety of subsidy methods, including imposing direct financial and trade limitations such as tariffs. These subsidies can be calculated with the lowest-part

Table 10.1 Statistical summary

Variable	*Mean*	*Std*	*Min*	*P30*	*Max*	*N*
A. Country-month panel						
AQ1	51.31	21.03	18.5	50.38	180.3	550
SO_2	1.31	1.66	2	12.18	80.31	550
CO	0.81	0.221	0.266	0.638	2.631	550
O_2	41.21	18.1	11.1	4.21	11.6	550
PM2.5	28.21	16.8	4.055	31.22	131.3	550
PM10	48.6	31.4	16.18	36.33	51	550
Green	0.066	0.66	0	0		550
Sewage	5.21	1.238	2.34	3.3	10.36	550
Soot	4.431	1.88	2.646	3.522	12.1	550
Solid	4.21	1.231	3.333	6.283	11.31	550
Population	5.002	1.041	3.338	5.3	6.21	550
GDP	3.68	1.036	5.038	10.04	11.38	550
IVA	1.03	1.518	11.1	1.6	1.31	550
Public spending	28.28	4.06	13.2	31.0	38.3	550
Regulations	0.51	0.121	0.321	0.351	0.818	550
Taxes	21.31	21.31	0.866	1.3	100.3	550
Subsidies	1.51	1.88	0.21	1.36	4.36	550

stockpile approach, which looks at all policies that help a single industry, the needs-and-response approximate approach, which combines transfer and market assistance, and the through, which compares retail prices to the global market rate. Note that the United States and EU are excluded from IEA statistics due to their tax credit and loan guarantee programs being for production rather than consumption.

Fossil fuel incentives have been falling rapidly since it became evident in 2017 that they harm the environment in contradiction of COP21's objectives, following a rise due to a brief surge in oil prices in 2018. It is thus more difficult to develop renewables initiatives because of unsustainable solar PV subsidies, which lower fossil fuel supply and demand alike. It is accordingly necessary to phase out fossil fuel subsidies, and redirect these funds instead to renewables.

A 12-year return comparison showed that conventional funds outperform renewables. Thus, investors seeking environmentally conscious investments should be ready to sacrifice profits. According to Khan, Naqvi, Hakeem, Din, and Iqbal (2021), investments during the COVID-19 pandemic have switched to more environmentally friendly choices, and risk-adjusted performance outcomes between renewable and non-renewable funds were the same throughout the pandemic. Such performance indicators as the modified Sharpe ratio, excess returns to DID ratio, and Jensen's alpha all fell after the spread of COVID-19. Country-specific research shows that traditional funds have filled the voids left by Sharpe and VAR ratios. According to Jensen's alpha, more nations provide lucrative investment prospects. Being successful has a significant positive impact on regular investments therein. Both the overall data set and the budgets of various nations exhibit this pattern. Developing nations must strive harder as the disease spreads to stave off prospective investors.

As mentioned above, we discovered that conventional funds often produced larger risk-adjusted returns than their green counterparts, due to managers' knowledge of markets and timings of market fluctuations. This implies that individuals who choose ecologically friendly options would suffer the consequences of their choices, which is meant to discourage them from doing so. Our results could have an impact on UN sustainability programs. Green energy projects must be sustainably funded with annual worldwide capital investments of US$101 billion by 2025. Our analysis accordingly shows that there is no financial incentive for companies to become environmentally friendly, given green mutual funds' continual failures. The success of green energy programs depends on lenders' confidence (Table 10.2).

The funding shortfall for green projects may thus only grow as a consequence. This analysis examines the impact of DID as well as that of post-renewables and renewables-related factors, per Table 10.3. For this research, we use Exponentiated and Tobit models to estimate our findings for the innovation dummy variable, and fixed-effect models to assess the marginal impact of tax reduction policy for low-energy enterprises. It has been shown that tax breaks and other incentives for companies with low energy usage have a significant, favorable impact on investment decisions. We discover that a single unit change in the explanatory variables has a marginal impact on the originality of 0.5% after accounting for all influencing variables. Our analysis reveals that government fiscal policy might help maintain these incentives and implies that tax credits such as the foregoing may help promote low-energy industry. We share recent research results from Sadiq et al. (2021) in support of this hypothesis and to further our knowledge of how the green recovery affects creativity. We also examine the impact of income intermediation on control systems as a mediator among businesses in various resource positions. We may now refer to monetary transmission mechanisms as a distinction to explain why marginal impact is reduced as a result of such complexity. The difference more closely resembles what would be seen in various economic circumstances, per Table 10.4.

10.4.1 Mechanism analysis

Monetary success may be measured with a variety of metrics. The results indicate that tax credits might benefit from a tinted moisturizer ratio improvement. There is a 3% chance of a 3% effect happening 1% of the time. We show that improving a company's financial health by promoting creative activities and increasing liquidity may have a positive impact on that company's propensity to innovate. At the 1% significance level, the typical path has a 2.7% effect on innovation, which is noteworthy. Companies with fewer employees and less resources may benefit from government financial incentives. For every percentage point that someone is considered influential, their contribution to creative output increases by 34%. Our case is strengthened by the fact that

Table 10.2 Country-month panel: effects of green finance

Variables	*AQI*	*SO*	*NO*	*CO*	O_2	*PM.3*	*PM10*
	–1	*–2*	*–3*	*–4*	*–5*	*–6*	*–7*
Green	–2.352***	–2.55**	–1.541***	–0.031	–1.130	–3.328*	–2.1
	(–31.40)	(–0.80)	(–3.66)	(–0.31)	(–0.61)	(–2.03)	(–0.21)
Sewage	–.238	3.361	–0.838	0.161	–5.380	3.21	–2.41
	(–0.38)	–1.38	(–0.8)	–0.58	(–1.30)	–0.8	(–0.21)
Soot	0.141**	1.128*	0.8	0.038**	1.081*	1.638***	2.131**
	–2.3	–2.8	–1.31	–0.51	–0.28	–2.8	–0.66
Solid	21.288	–21.012	4.448	–0.432	42.11	–3.653	8.666
	–1.36	(–1.06)	–0.3	(–0.58)	–1.51	(–0.1)	–0.3
Population	–5.380	–11.640	–8.11	–0.221	40.388*	–0.280	–18.341*
	(–1.30)	(–1.12)	(–1.38)	(–1.18)	–2.21	(–0.03)	(–2.30)
GDP	1.01	1.128	.166	–0.030	21.81*	3.038	21.238
	–1.28	–0.31	–1.04	(–0.8)	–2.5	–0.18	–1.66
IVA	–0.066	0.21	–0.031	0.004	–0.268	–0.038	–0.326
	(–0.18)	–0.66	(–0.8)	–0.3	(–0.4′)	(–0.04)	(–0.44)
Public spending	–0.631	–0.028	–0.04	–0.005	–0.44	–0.5	–0.540
	(–2.50)	(–0.18)	(–0.16)	(–0.61)	(–1.31)	(–1.16)	(–1.0)
Regulations	31.8	13.81	2.155	0.28	–11.81	21.44	38.021
	–0.66	–2.13	–0.21	–1.02	(–0.21)	–1.03	–1.21
Taxes	0.036	0.021	0.138**	0.003	–0.066	0.123	–0.338
	–0.21	–0.8	–2.8	–0.38	(–0.8)	–1.1	(–0.68)
Subsidies	0.121**	0.338	0.328*	0.003	1.58	1.640***	3.331**
	–2.66	–0.44	–1.8	–0.1	–2.13	–4.03	–2.38
Constants	–131.1	41.38	21.05	2.344	–426.230*	–60.330	–1.540
	(–1.66)	–0.41	–0.31	–1.06	(–248)	(–0.866	(–0.0)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	550	550	550	550	550	550	550
Adjusted R	0.321	0.331	0.38	0.288	0.1	0.331	0.338

*,**,*** *show significant results in 10%, 5%, and 1% respectively.*

Table 10.3 Mechanism tests

Variables	*AQI*	SO_2	NO_2	*PM2.5*
	–1	*–2*	*–3*	*–4*
Economy	–0.051**	–0.218**	–0.131*	–0.144***
	(–3.48)	(–2.66)	(–1.48)	(–1.38)
Green	–2.211***	–1.880**	–1.411***	–3.218*
	(–41.40)	(–1.48)	(–3.21)	(–1.66)
Sewage	–2.648	2.031	–1.820	1.6
	(–0.60)	–0.44	(–0.48)	–0.11
Soot	1.121**	1.011	0.141	1.442***
	–4.5	–1.48	–1.31	–2.61
Solid	21.555	–4.421	11.566	1.631
	–1.61	(–0.21)	–0.58	–0.04
Population	–4.522	–3.111	–3.588	1.3
	(–1.21)	(–0.68)	(–1.31)	–0.05
GDP	14.221	–2.422	1.34	0.241
	–1.31	(–0.66)	–0.4	–0.02
IVA	–0.026	0.4	0.051	0.121
	(–0.04)	–1.48	–0.41	–0.18
Public spending	–0.651	–0.111	–0.041	–0.532
	(–2.51)	(–0.40)	(–0.38)	(–1.18)
Regulations	31.011	11.141	1.844	21.111
	–0.66	–1	–0.11	–0.66
Taxes	0.048	0.08	0.160**	0.138
	–0.18	–0.44	–1.66	–1.31
Subsidies	1.148**	0.321	0.348*	1.442***
	–3.01	–1.02	–2.28	-3.11
Constants	–131.011	38.461	21.442	–60.321
	(–1.44)	–0.4	–0.28	(–0.66)
Year fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes
Observations	441	441	441	441
Adjusted R^2	0.421	0.341	0.481	0.222

*Note: *,**,*** show significant results in 10%, 5%, and 1% respectively.*

low-energy organizations are more likely to innovate by limiting internal business consequences.

Making environmentally friendly products requires research and development (R&D) as well as technical diversification by manufacturers. Manufacturers may improve their reputations and lower the cost of their products' lifecycles while also helping the economy and the environment. Thus, we find that the first four hypotheses were correct. Environmental rules have wide-ranging effects on green products and innovation thereof. Large negative economic regression coefficients in through four may be due to a misalignment between R&D investment and current demand for innovative skills, which are insufficient to sustain green innovation breakthroughs. Positive correlations among green coefficients may indicate that including scientists and engineers

Table 10.4 Developed regions in ASEAN

Variables	*AQI*	*SO_2*	*NO_2*	*CO*	*O_2*	*PM2.5*	*PM10*
	–1	*–2*	*–3*	*–4*	*–5*	*–6*	*–7*
Green	–1.000	1.066	–0.426	0.004	1.148	–1.241	–1.441
	(–0.44)	–1.04	(–1.04)	–0.06	–1.02	(–1.31)	(–0.11)
Sewage	12.331	–148.141***	13.541	–1.255	161.366**	–48.661	–41.146
	–0.51	(–4.41)	–0.41	(–0.40)	–2.4	(–1.02)	(–0.06)
Soot	1.221**	–0.241*	0.441***	0.041**	0.288*	1.34	1.021
	–14.11	(–2.48)	–6.38	–3.41	–2.4	–1.41	–0.18
Solid	–141.311	1144.051***	–138.385	11.011	–1411.341**	340.54	140.14
	(–1.13)	–4.8	(–0.51)	–0.41	(-2.41)	–0.8	–0.06
Population	80.066	11.431	–58.180***	–4.332***	311.050***	–61.531	–41.844
	-1.21	-1.38	(–3.41)	(–3.51)	–21.01	(–1.31)	(–0.04)
IVA	–0.411	–0.644***	–0.111	0.011	0.641**	–1.031**	–0.438
	(–1.11)	(–4.41)	(–1.44)	–0.51	–1.21	(–1.58)	(–0.11)
Public spending	–1.344	–1.443***	–1.011***	–0.041**	0.641***	–2.140**	–2.435
	(–1.04)	(–21.80)	(–11.61)	(–1.66)	–11.41	(–2.31)	(–0.31)
Regulations	–18.416	–51.441**	–41.066**	–0.431	80.311*	–140.380***	–118.321
	(–3.48)	(–1.31)	(–1.58)	(–0.28)	–2.41	(–4.40)	(–0.21)
Taxes	0.6*	0.441***	0.431***	0.011***	–0.431***	1.180***	1.031
	–3.36	–11.21	–11.61	–3.4	(–11.80)	–4.28	–0.41
Subsides	0.418	0.013	0.316**	0.021	1.441***	0.161	1.531
	–1.48	–0.11	–2.08	–1.41	–2.48	–0.38	–0.18
Constants	–158.321	–1440.111***	631.111**	31.111	–1123.432**	141.31	148.43
	(–0.31)	(–4.05)	–2.41	–1.41	(–1.61)	–0.21	–0.03
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	300	300	300	300	300	300	300
Adjusted R^2	0.341	0.411	0.231	0.28	0.0341	0.238	0.366

*Note: *,**,*** show significant results in 10%, 5%, and 1% respectively.*

in technological and scientific endeavors, and investing in same, helps foster the creation of environmentally friendly goods and services.

10.4.2 Economic development indicators

Manufacturing emissions are typically transformed into more controllable components by terminal governance systems, which are process innovations that decrease emissions by handling pollutants. End-of-life technical advancement has been demonstrated to aid industry in meeting state and federal emission regulations, navigating regulatory scrutiny, and minimizing operations' environmental impact. The purpose of terminal governance technology is to mitigate the effects of pollution caused by manufacturing rather than actively renewably energizing it as it occurs. While it does help, this approach only shifts the problem elsewhere. According to Shin and Park (2018), it necessitates far greater expenditures, mostly increased resources and equipment. Terminal management technology innovation's drawbacks include large initial outlays and ongoing maintenance expenses associated with pollution rehab facilities' proactive approach to lowering pollution. Insufficient political will in many Asian nations, engendered by government corruption and housing investments, to abandon fossil fuels and support renewables instead, together with industrialization and inefficient urban development, has slowed the region's transition to a green economy, necessitating government fiscal and regulatory measures. Market distortions supporting fossil fuels persist in the region despite a range of government activities, for example, zero-interest loans, rebates, and tax credits to accelerate installation and use of renewables and conservation.

Subsidies that are harmful to the environment are a hotly debated topic in Asian politics. People often believe they are entitled to cheap energy as subsidies are deeply rooted in or secretly integrated into many national political and economic systems. Hence, protests over gasoline price hikes are expected in Asia, where subsidies are strongly politicized as mentioned above. If aid is withdrawn, governments might be toppled. Changes to tax and non-tax revenues, spending reforms that specify projects and objectives, and expenditure reforms may remove existing political obstacles to affordable and adequate energy prices in the region, but only if governments in the affected region work together to find solutions that adequately address the concerns of the cultural circles that would be most negatively impacted by elimination of gasoline subsidies. Convincing data suggests that the changeover is possible with well-designed programs and dogged political action, including but not necessarily limited to a 51% marginal tax rate on high-income families and a 0% rate on low-income families to compensate.

10.4.3 Robustness analyses

Robustness analyses were performed on all statistically significant data in Table 10.2 to ensure reliability. According to Table 10.5, none of the control data

Table 10.5 Underdeveloped areas

Variables	*AQI*	*SO_2*	*NO_2*	*CO*	*O_3*	*PM2.5*	*PM10*
	–1	*–2*	*–3*	*–4*	*–5*	*–6*	*–7*
Green	–16.111***	–2.655*	–1.051***	–0.180***	–3.631***	–13.181***	–15.116***
	(–66.66)	(–2.41)	(–11.61)	(–11.40)	(–18.13)	(–11.02)	(–2.60)
Sewage	–3.350	3.221**	–1.366***	0.213***	2.521***	0.566	–16.622**
	(–1.80)	–1.66	(–11.18)	–8.41	–3.18	–0.41	(–3.80)
Soot	1.360**	2.138***	–0.350***	0.116***	–0.451*	0.131	1.323*
	–18.66	–3.61	(–11.50)	–11.38	(–3.40)	–0.56	–2.41
Solid	50.058	–33.328***	3.331***	–1.260***	–12.250***	13.003*	161.021***
	–2.4	(–2.80)	–11.66	(–8.66)	(–3.58)	–2.21	–3.21
Population	–11.600	–41.630***	–2.440***	–1.540***	130.144***	–21.111**	–41.300
	(–0.48)	(–3.66)	(–2.51)	(–13.04)	–31.21	(–3.02)	(–1.21)
IVA	–1.381*	0.341**	–0.016	0.018***	–1.532***	–0.611**	–2.333***
	(–4.28)	–3.11	(–0.48)	–4.18	(–12.03)	(–2.31)	(–3.60)
Public spending	–1.166	0.311***	0.06	0.003	–1.038***	–0.488***	–1.633**
	(–1.21)	–3.55	–1.4	–1.51	(–3.60)	(–2.04)	(–2.40)
Regulations	11.851	11.116	3.318***	–1.361***	48.111***	–5.636	23.46
	–1.28	–1.6	–3.12	(–4.50)	–13.31	(–1.50)	–0.8
Taxes	–0.380*	–0.321***	1.038***	–0.058***	1.538***	–1.166***	–1.031*
	(–3.51)	(–3.58)	–11.66	(–21.55)	–8.41	(–5.18)	(–2.60)
Subsidies	13.640**	–1.441	–1.030***	0.041	–2.138***	4.166***	21.831**
	–18.18	(–2.11)	(–8.60)	–1.31	(–3.58)	–3.21	–1.3
Constants	158.21	300.421***	31.111***	16.431***	–1041.480***	388.288***	516.241**
	–1.28	–6.28	–3.41	–11.18	(–18.03)	–5.02	–3.4
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	300	300	300	300	300	2300	300
Adjusted R^2	0.348	0.348	0.331	0.301	0.15	0.348	0.388

Note: *,**,*** show significant results in 10%, 5%, and 1% respectively is significant. Hence, the primary conclusions shown in Tables 10.3 and 10.4 are credible.

Regional states prioritize building required infrastructure. They are promoting government agility in the face of new issues, defining tax base concepts, tightening regulatory conformity, and ensuring macroeconomic influence from green financing domestically as well as beyond institutional boundaries. Governance must be transparent under clearly defined criteria, responsive frameworks, and national sovereignty, to properly monitor and efficiently administer fiscal instruments, and swiftly distribute tax credits for green commercial development. Politicians may use tax money for political leverage to further their own goals at the cost of intended recipients. Such mismanagement poses the greatest risk to public confidence in environmentally responsible budgeting. The government's recycling efforts and tax revenues suffer (Table 10.6).

Table 10.6 Robustness tests

Variables	*AQI*	*SO_2*	*NO_2*	*PM2.5*
	–1	*–2*	*–3*	*–4*
Green	2.048	1.218	–0.080	1.111
	–1.5	–0.56	(–0.11)	–0.41
Sewage	–1.332	3.58	–1.188	2.351
	(–0.21)	–0.51	(–0.31)	–0.31
Soot	3.066	1.065	0.211	1.566***
	–3.31	–0.84	–1.31	–1.28
Solid	18.111	–18.231	3.233	–11.148
	–0.41	(–0.31)	–0.3	(–0.18)
Population	–4.866	–11.322	–8.211	0.111
	(–0.38)	(–0.28)	(–1.31)	–0.02
GDP	11.131	0.148	1.458	0.811
	–0.8	–0.02	–0.61	–0.05
IVA	–0.066	0.121	–0.38	–0.031
	(–0.13)	–0.3	(-0.21)	(–0.06)
Public spending	–0.600	–0.016	–0.008	–0.341
	(–1.31)	(–0.04)	(–0.06)	(–1.16)
Regulations	30.631	11.136	1.651	18.111
	–1.11	–0.38	–0.21	–1.31
Taxes	–0.151	–0.066	0.036	–0.050
	(–0.31)	(–0.31)	–1.11	(–0.31)
Subsidies	1.138	0.33	0.388	1.842**
	–2.2	–0.48	–1.61	–2.5
Constants	–111.418	48.411	31.866	–38.432
	(–1.60)	–0.21	–0.31	(–1.04)
Year fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes
Observations	551	551	551	551
Adjusted R^2	0.321	0.331	0.361	0.331

10.5 Conclusion and policy recommendations

A number of AMSs are looking at green finance for renewables to refocus financial resources on reducing GHG emissions. This study may determine whether such efforts are economically sound by comparing and contrasting the effects of such green money on the use of renewables for emission reduction policy implementation. It finds that green funding plans do not significantly affect overall efforts to cut GHG emissions. They are most successful at lowering SO_2, NO_2, and PM2.5. Local businesses are encouraged to contribute money to environmental causes via green financing for renewables, while underdeveloped areas benefit more from green finance policies than developed nations. There are serious pollution issues in ASEAN and throughout the globe as a result of air cleaning technologies reaching their breaking point. The results of this study are important for green financing in renewable energy for emission reduction as they imply that using economic tactics to reduce air pollution may succeed.

We find that government must take the initiative in enforcing environmental laws and encouraging business efficiency. Reduced air pollution may also result from shifting economic growth to greener regions. Everyone has a role to play when it comes to green finance, from governments to credit brokers to businesses to consumers. The first issue to address is information asymmetry. Between microfinance organizations and green enterprises and initiatives, there is a lack of transparency on how environmentally good an organization really is. Investment managers and financial intermediaries need to be made aware of green enterprises. The many financial services and financing sources that are accessible to businesses need to be better understood.

Economic frameworks for green finance must be established, to foster an environment more conducive to said green finance thriving. A key aspect is standardizing green project requirements and determining what types of investments conform to green bond standards, as well as tightening regulations governing environmental reporting. It is essential to establish methods of sharing information on corporate pollutant production, ecological transgressions, and reliable green credit as part of our overall social credit and credit assessment systems. Reform initiatives must employ social capital and entice more socially responsible investors if they are to be effective. We must determine how to promote green finance, encourage environmentally conscious economic growth, and direct long-term investments in human capital toward green sources of financing.

This study is limited in that it regards green finance policy as an exogenous variable without examining the variables that could affect it. And it is affected in many ways, regardless of situation. We advise including monetary and credit policy variables as controls in future studies.

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