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Original Article

Financial Development and Renewable Energy Consumption - Empirical Evidence in Southeast and East Asian Countries

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Abstract: Climate change is one of the biggest challenges in our times. Climate change is happening such as rising in temperatures and sea level, drought, the destruction of the ozon layer. Climate change is consistent with a higher level of carbon dioxide that negatively affects human health and the economy. To mitigate the climate change, countries must reduce the emissions linked to the human activities in order to protect the earth safe as well as maintain economic growth in the context of sustainable development. In this case, renewable energy consumption is one of the most effective tools in the form of fighting against climate change. The purpose of the study is to evaluate the impact of financial development on renewable energy consumption in six Southeast Asian countries (i.e. Vietnam, Indonesia, Malaysia, Thailand, and the Philippines) and three East Asian countries (i.e. China, Korea, and Japan). Using the generalized least squares method, the research results confirm that financial development has a negative impact on renewable energy consumption. The research results also find negative effects of inflation and urbanization rates on renewable energy use. Finally, economic growth and lending rates have no impact on renewable energy in the East and Southeast Asian countries.

Keywords: Financial development, renewable, Asia.

1. Introduction

In the process of economic development in each country, the financial market has played an important role in moving capital flows in the economy. Developed countries often have developed financial markets and favorable capital mobility with low transaction costs [1]. In contrast, less developed countries often have underdeveloped financial markets; the costs of accessing capital are often higher and

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accordingly reduce the competitiveness of businesses and economies [2].

The world is facing many changes due to climate change that has caused many environmental consequences in recent years. The environment is increasingly polluted because economic activities increase carbon emissions as well as pollute the land and water environment. Therefore, this negatively affects human health and increases costs to the economy. Countries must reduce the negative impact of environmental pollution in order to protect the earth against climate change, while maintaining economic growth in the current period as well as ensuring sustainable development in the future.

Financial markets have the ability to connect savings and investments. Efficient financial markets mean lower transaction costs and lower costs for businesses to access capital. In particular, the financial market can focus on investment projects that use energy-saving and high technology content, thereby reducing negative impacts on the environment. Moreover, financial markets have the ability to allocate capital and prioritize investments using renewable energy sources for environmental protection and sustainable development.

Previous studies have also suggested that a relationship exists between financial development and renewable energy consumption. However, this effect can be positive or negative and depends on the economic situation of each country [3-5]. The positive effects of financial development on renewable energy consumption are confirmed in 34 middle-income countries, in studies conducted in Turkey [3, 4]. However, Saygin and Iskenderoglu [5] argue that if a country develops a stock market, it is likely to stimulate the use of renewable energy to a higher degree when developing a commercial banking system, and they assert that the impact of financial development and the use of renewable energy depends on how firms in the country raise capital.

Located in a dynamic development region, Southeast Asian countries have maintained high economic growth throughout the period 1990-2020. In addition, Southeast Asian countries are increasingly linked together in trade, economy, investment, labor, and politics in the Association of Southeast Asian Nations (ASEAN) and the ASEAN Economic Community (AEC). Meanwhile, China, Japan and South Korea are major economies in East Asia in particular and Asia in general. By geopolitical advantage, Southeast Asian countries and China, Japan, and South Korea maintain a close dialogue mechanism (called ASEAN+3). Those connections affirm that Southeast Asian and East Asian countries have a mutual influence in many economic aspects. In previous studies, no research on the relationship between financial development and renewable energy consumption has been carried out in this area. Therefore, to fill the research gap, the author evaluated the impact of financial development on renewable energy demand in Southeast Asian and East Asian countries. The research results aim to provide policy implications in maintaining financial market development towards sustainable development and environmental protection.

In addition to the first part about the discussion of statement problems, Part 2 of the research discusses the relationship between financial development and renewable energy consumption. Part 3 discusses data collection and research methodology. Finally, the research discusses the results in Section 4, and conclusions and policy implications are presented in Section 5.

2. Financial development and renewable energy consumption

It is evident that economic factors, for example, financial development, economic growth, inflation and interest rates have an impact on renewable energy [6]. Carrying out specific research, the empirical evidence of Shahbaz et al. [3], Mukhtarov et al. [4], Saygin and Iskenderoglu [5] suggested that a relationship exists between financial

development and renewable energy consumption. Specifically, the higher financial development is associated with a higher efficiency of the financial market; therefore, the market has the ability to allocate capital to efficient projects, in which priority is given to projects that have less harmful effects on the environment.

Research in 34 middle-income countries suggested that a long-term relationship exists between financial development and renewable energy consumption, and it is bidirectional. In particular, financial development has the potential to improve renewable energy consumption because financial markets are able to provide financial resources and that increases demand for renewable energy [3]. Countries should increase public-private partnerships to promote renewable energy consumption and limit fossil energy use. In addition, economic growth has a negative impact on renewable energy use, while inflation has no impact on renewable energy. Indeed, economic growth requires countries to have enough energy sources, but in reality, fossil energy is still an important energy source. It is important to note that renewable energy comes at a high cost, so it can be a financial burden on businesses in the short term.

Global warming has caused many bad effects on human life. To reduce the effects of this phenomenon, countries need to reduce fossil energy consumption. Encouraging the use of renewable energy is the best solution to protect the environment and limit the effects of climate change. In the case of Turkey, financial development has an important impact on promoting the use of renewable energy. Specifically, a 1% increase in financial development can increase renewable energy consumption by 0.21%. Therefore, countries should develop financial markets to support the use of renewable energy in order to protect the environment and sustainable development [4].

Another study carried out in 20 emerging countries between 1990 and 2015 found a positive effect of financial development on renewable energy consumption. In the case of financial development that is measured by stock market capitalization. However, financial development is measured by the combination of the stock market and banking, and financial development has no impact on renewable energy consumption [5]. Thereby, financial development through the stock market has a more pronounced impact on renewable energy consumption than financial development through the expansion of bank credit. This reflects the characteristic that enterprises raising capital on the stock market are more likely to stimulate renewable energy than enterprises raising capital through the banking sector. Or, it can be said that enterprises that are able to raise capital on the stock market often have a lower level of fossil energy consumption or have a higher ability to invest in renewable energy sources than enterprises that raise capital in the banking sector. Another possibility is that a negative impact of financial development on renewable energy consumption can be found, as in the previous study [7]. In particular, financial development based on the stock market has a negative impact on renewable energy use in the short term.

Recent studies also indicate that the urbanization rate also has an impact on renewable energy consumption [6, 8]. In fact, the urbanization rate has a stimulating effect on both non-renewable energy consumption and renewable energy consumption, but has a larger impact on non-renewable energy consumption than renewable energy consumption [6]. However, the urbanization rate has no impact on renewable energy use, but has an impact on non-renewable energy consumption [8]. The authors believed that China needs to have a policy to limit the impact of non-renewable energy use by encouraging industries to use renewable energy. Similarly, in the case of ASEAN, ASEAN countries are dependent on fossil energy, which is a reason for these countries to switch to renewable energy [9]. Economic growth, trade expansion, and fossil energy use are the main causes of environmental pollution in ASEAN.

The trend of shifting to renewable energy will become urgent and important in the future development orientation in ASEAN.

3. Data collection and research methodology

3.1. Data collection

The research adopted the secondary data sources collected by the World Bank and the General Statistics Office of each country for the period 1990 to 2020. The data used in this study include renewable energy consumption (REC) expressed as a percentage of the total energy used. Financial development is obtained by the criterion: expanded money supply or domestic credit to the private sector provided by banks. In addition, the data have been collected for economic growth as per capita income at fixed prices in 2010, and for inflation and lending interest rates in the banking system. Further, the urbanization rate is collected from the Statistics Offices of relevant countries. The data sources are presented in Table 1.

Table 1: Variables used in the model

Variable	Description	Measurement	Source
REC	Consumption of renewable energy	%	World Bank
FD	Financial development, as measured by (1) expanded money supply or (2) domestic credit to the private sector	% GDP	World Bank Central Banks of Countries
GDP	Per capita income	US$	World Bank International Monetary Fund
INF	Inflation	%	World Bank International Monetary Fund
INT	Lending Interest rates	%	World Bank International Monetary Fund
URB	Urbanization rate	% population	Statistics Offices of Countries

Source: Authors.

3.2. Research methodology

Based on previous studies, there is a relationship between financial development and renewable energy consumption [4-6], expressed through the regression equation as follows:

$$REC_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 GDP_{it} + \beta_3 INF_{it} + \beta_4 INT_{it} + \beta_5 URB_{it} + \varepsilon_t$$

To evaluate the robustness of the estimated model, we use two proxies for the variable FD, including (1) expanded money supply (FD1), or (2) domestic credit to the private sector (FD2). Therefore, the research will replace each representative variable of FD and perform regression; the regression equation is:

Case 1: The variable FD is represented by an expanded money supply (FD1).

$$REC_{it} = \beta_0 + \beta_1 FD1_{it} + \beta_2 GDP_{it} + \beta_3 INF_{it} + \beta_4 INT_{it} + \beta_5 URB_{it} + \varepsilon_t$$

Case 2: The variable FD is represented by domestic credit to the private sector provided by banks (FD2).

$$REC_{it} = \beta_0 + \beta_1 FD2_{it} + \beta_2 GDP_{it} + \beta_3 INF_{it} + \beta_4 INT_{it} + \beta_5 URB_{it} + \varepsilon_t$$

4. Regression results

4.1. Descriptive statistics

Table 2 presents descriptive statistics of the variables used in the regression model. Regarding renewable energy consumption, ASEAN+3 countries have an average renewable energy consumption of 17.3533% of total energy consumption, the highest level is 76.0816% for Vietnam in 1990 and the smallest is 1.9554% for Malaysia in 2010. This shows that there are countries that do not use renewable energy at times, while countries exist that have a high level

of renewable energy use in their total energy consumption. In terms of financial development, the expanded money supply (FD1) averaged 101.3434% of GDP, while domestic credit to the private sector provided by banks (FD2), averaged 82.3768% of GDP. In terms of economic growth, the average growth rate in ASEAN+3 is 4.96%, including countries with very high growth rates, e.g. 17.29% for Mongolia in 2011, or very low growth rates, e.g. minus 13.12 % for Indonesia in 1998. In terms of urbanization rate, Singapore has an urbanization rate of 100%, while other countries, such as Vietnam and the Philippines, have low urbanization rates

Table 2: Descriptive statistics

Var.	Mean	Std.dev	Min	Max	Skew.	Kurtosis
REC	17.3533	18.567	1.9554	76.0816	1.005	3.1466
FD1	101.343	58.7157	19.5664	280.868	0.5438	2.6835
FD2	82.3768	58.3399	13.6569	217.761	0.14	1.9127
GDP	4.9687	4.1999	-13.127	17.2907	-0.8779	5.1056
INF	5.4867	16.8148	-1.7103	268.151	12.9179	195.671
INT	8.9448	7.6707	0	48.0625	1.8123	7.5286
URB	59.3572	22.9473	20.257	100	0.2729	1.9703

Source: Calculation from Stata.

4.2. Correlation matrix

Table 3: Correlation analysis

Var.	REC	FD1	FD2	GDP	INF	INT	URB
REC	1.0000						
FD1	-0.4357* (0.0000)	1.0000					
FD2	-0.5315* (0.0000)	0.8639* (0.0000)	1.0000				
GDP	0.1872 (0.0009)**	-0.1743 (0.0021)	-0.1628 (0.0041)	1.0000			
INF	0.0303 (0.5969)	-0.2292* (0.0000)	-0.2274* (0.0001)	-0.10*** (0.0655)	1.0000		
INT	0.3144* (0.0000)	-0.5209* (0.0000)	-0.5323* (0.0000)	0.09*** (0.0992)	0.0791 (0.1650)	1.0000	
URB	-0.7926* (0.0004)	0.4060* (0.0000)	0.5190* (0.0000)	-0.2201* (0.0001)	-0.09*** (0.0844)	-0.3130* (0.0000)	1.0000

Note: ***, **, * are significance levels at 10%, 5% and 1% respectively.
Source: Calculation from Stata.

Table 4: Variance Inflation Factor (VIF)

Variable	VIF	1/VIF	VIF	1/VIF
FD1/FD2	1.60	0.624716	1.82	0.550461
INT	1.40	0.714036	1.40	0.713041
URB	1.25	0.796998	1.41	0.709921
GDP	1.09	0.919902	1.08	0.928177
INF	1.08	0.922314	1.08	0.925292
VIF mean	1.29		1.36	

Source: Calculation from Stata.

Table 3 presents the correlation matrix of the variables in the regression model. Only the pair of variables FD1 and FD2 have a high correlation coefficient of about 0.8639, so when performing the regression at the same time, these two variables are likely to have multicollinearity. However, FD1 and FD2 are two representatives of the financial development variable, so when performing the regression, each variable will be performed and thereby eliminate the phenomenon of multicollinearity. Moreover, Table 4 shows that the VIF coefficients of the independent variables are all less than 10, and the mean value is less than 2, so multicollinearity does not occur.

4.3. Regression analysis

Table 5 indicates the regression results of the financial development relationship on renewable energy use in Southeast and East Asian countries. Through the least squares feasible estimation method, the estimation results suggest that financial development has a negative impact on renewable energy consumption. In addition, inflation and urbanization rates have negative effects on renewable energy consumption. There is no evidence of the impact of lending rates and economic growth on renewable energy use in Southeast and East Asia between 1990 and 2020. The results of the analysis also check for autocorrelation as well as heteroskedasticity; it is evident that this problem can be solved.

As suggested in the recent studies [10-12], the existing literature has analyzed a cross-section repeated over a number of years, called panel data. By analyzing the OLS regressions, it is biased on the assumptions as follows: no omitted variables and no dynamic and simultaneous endogeneity. In the case of an unobserved time-invariant characteristic of an entity correlating with independent variables, the OLS estimations are not consistent, and biased. The bias is even not reduced with a larger sample size [10]. Therefore, the system GMM should be focused on in order to correct for all kinds of endogeneity [11]. More specifically, the omitted variables are time-variant, which occur for short periods of time (T is small and N is large), and the lagged differences of the dependent variable and the independent variables can be used as an instrument in the analysis [11]. Accordingly, in this case, in six Southeast Asian countries (Vietnam, Indonesia, Malaysia, Thailand, and the Philippines) and three East Asian countries (China, Korea and Japan) in the period 1990 to 2020 (N = 9, T = 21), endogeneity is not a problem.

Normally, the panel data should be applied for the pooled OLS, fixed or random effects method (FEM or REM). However, these methods can cause heteroskedasticity and autocorrelation to occur in their techniques. In fact, heteroskedasticity occurs when different observations have different error variance. The estimators are biased and not efficient, and the estimated standard errors are not consistent, and the test statistics using the standard error is not valid. In addition, autocorrelation refers to the correlation of the same variables between two successive time intervals. Thus, FGLS should be considered for correcting autocorrelation and heteroskedasticity.

Another possibility is that the FGLS estimator cannot be estimated when T is less than N because the associated error variance-covariance matrix cannot be inverted [12]. Adversely, when $T \geq N$, FGLS should be considered, however, there may be relatively few observations per error variance-covariance matrix parameter. Therefore, it can underestimate the coefficients of standard errors, causing the hypothesis testing to be useless. To treat these problems, Moundigbaye et al. [12] believe that panel-corrected standard errors (PCSE) are suitable for the analysis.

According to the study of Xiong et al. [13], for long tables, PCSE regression can be used to check the robustness of the estimated model as suggested in Moundigbaye et al. [12], who believe that panel-corrected standard errors (PCSE) are suitable for the problems of error variance-covariance issues. Research results are presented in Table 6. The estimated results still

confirm that financial development has a negative impact on renewable energy consumption. Inflation and urbanization rate still have negative effects on renewable energy consumption, thereby confirming that the estimated results are reliable and stable.

Table 5: Regression results - dependent variable REC

Var.	FGLS		FGLS	
	(1)	(2)	(1)	(2)
FD1	-0.1377*		-0.0471*	
	(0.0000)		(0.0000)	
FD2		-0.1691*		-0.0582*
		(0.0000)		(0.0000)
GDP			-0.0469	-0.0300
			(0.7620)	(0.8450)
INF			-0.086**	-0.0900**
			(0.0250)	(0.0190)
INT			0.0313	- 0.0075
			(0.7450)	(0.9370)
URB			-0.5971*	-0.5714*
			(0.0000)	(0.0000)
_cons	31.3159*	31.2879*	58.0086*	56.6426*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
R adjusted square				
Wald Chi2	72.64	122.06	594.97	586.57
Pro > chi2	0.0000	0.0000	0.0000	0.0000
Number of obs	310	310	310	310
Number of groups	31	31	31	31
Heteroskedasticity	chi2 = 3691.9	chi2 = 3452.3	chi2 = 1338.1	chi2 = 1561.6
	(P = 0.00)	(P = 0.00)	(P = 0.00)	(P = 0.00)
Autocorrelations	F = 132.40	F = 83.187	F = 180.32	F = 123.90
	(P = 0.00)	(P = 0.00)	(P = 0.00)	(P = 0.00)

Note: ***, **, *** are significance levels at 10%, 5% and 1% respectively.
Source: Calculation from Stata.

Table 6: Stability test - dependent variable REC

Var.	PCSE	
	(1)	**(2)**
FD1	-0.0471	
	(0.0000)	
FD2		-0.0582*
		(0.0022)
GDP	-0.0469	-0.0300
	(0.8960)	(0.9340)
INF	-0.0866**	-0.0900**
	(0.0360)	(0.0135)
INT	0.0313	- 0.0075
	(0.8860)	(0.9710)
URB	-0.5971*	-0.5714*
	(0.0000)	(0.0000)

_cons	58.0086* (0.0000)	56.6426* (0.0000)
R adjusted square	0.6497	0.6542
Wald Chi2/F	35.70	35.08
Pro > chi2/ F	0.0000	0.0000
Number of obs	310	310

Note: **, * are significance levels at 5% and 1% respectively.
Source: Calculation from Stata.

4.4. Discussion

4.4.1. Financial development

Research results confirm that financial development has a negative and statistically significant impact on the ability to consume renewable energy. That is, financial development through expansion of the stock market or bank credit reduces renewable energy consumption in the ASEAN+3 countries. Indeed, the trend in the period from 1990 to 2020, when financial development in ASEAN+3 was expanding to meet capital needs in the economy, was that ASEAN+3 economies were still dependent on fossil energy sources. Renewable energy consumption as a proportion of total energy consumption has a decreasing role in most of the studied countries. Therefore, the financial market has not made practical contributions to promote renewable energy consumption. Financial resources still focus on energy-intensive or fossil energy projects. The results of this study are similar to those of Lahiani et al. [7]. The author argued that the financial market is not really efficient in allocating resources and even leads to unfunded financial resources for projects that use less energy or use renewable energy in order to maintain sustainable development.

4.4.2. Other factors

The research results also confirm a negative impact of inflation on renewable energy consumption. This means that the higher the inflation is, the lower is the possibility of using renewable energy in ASEAN+3. In fact, the cost of consuming renewable energy is often higher than that of fossil energy, if inflation occurs, it leads to an increase in production costs and makes the cost higher. This is the explanation: high prices reduce the ability to consume renewable energy, while price shocks make renewable energy production costs higher and businesses incur high costs and profits decrease [6]. The research also confirmed that the rate of urbanization has a negative impact on renewable energy use, as the higher urbanization rate leads to a higher energy demand. According to the assessment of Nathaniel and Khan [9], ASEAN countries are dependent on fossil energy and these countries should switch to using renewable energy instead of being too dependent on energy sources that pollute the environment. The rapid economic development and a high urbanization rate in many Asian countries has created pressure to ensure energy security. Countries should encourage the use of renewable energy in order to sustain sustainable development [8].

5. Conclusions

Financial markets have played a huge role in connecting savings and investment, and have helped governments direct investment flows to protect the environment. The countries of Southeast Asia and East Asia share many cultural and political similarities and interact with each other in economies and investments. Using 6 countries in Southeast Asia (Vietnam, Indonesia, Malaysia, Thailand, and the Philippines) and 3 countries in East Asia (China, Korea, and Japan) during 1990-2020, and the generalized least squares method, the research results show that financial development has a negative impact on renewable energy

consumption in 9 Southeast Asian and East Asian countries. Moreover, the inflation and urbanization rate reduce the possibility of consuming renewable energy. The study also found no evidence for the impact of economic growth and lending rates on renewable energy use.

The study has some recommendations as follows: First, countries should continue to implement financial market reforms towards efficiency. The financial market should give priority to allocating capital to environmentally friendly investment projects over projects that consume a lot of energy or have low technology content and cause harm to the environment. Second, countries need to keep inflation at a low level. Low inflation can create enterprises that are able to control price and interest rate shocks, thereby making their investment projects more efficient and such enterprises are more likely to apply their technology in business. Third, countries that increase their level of urbanization, especially substantive urbanization, are likely to support economic development and increase consumption of renewable energy.

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