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Financial development and energy security in the Asia-Pacific region: The long run and short run perspectives

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ABSTRACT

This study examines the long- and short-term effects of financial development on energy security for middle-income countries across the Asia-Pacific region. Using various co-integration estimators, our results show that financial development not only intensifies the overdependence of these economies on fossil fuels but also indirectly makes them sensitive to shocks coming from energy demand and supply. The rapid growth of the urban population increased power demand and, therefore, made these countries rely on unsustainable sources of energy as the most viable solution. Findings from our short-run analysis not only strengthen the results obtained from the long-run equations but also provide many interesting insights. First, a fossil-reliant economy is proven to be detrimental to the development and availability of renewable energy by indirectly making projects entailed with their use economically infeasible. Second, financial development and fossil energy usage are two key forces explaining the rapid growth of these economies.

1. INTRODUCTION

The energy crises in early 2021 and 2022 have raised energy security for countries whose growth is primarily underpinned by the use of fossil fuels, particularly those in the Asia-Pacific region. As the price of gas repeatedly hits record highs, numerous sectors in these countries, especially those with relatively developed industrial, utilities, and energy sectors, are under enormous pressure, while some companies are on the verge of discontinuing operations. The rise in gas prices also increases the overall price of related goods and services, which presumably makes the inflation rate soar, similar to the first oil crisis in 1973. However, the concern is not only the surging inflation rate but also the livelihoods of poor people. They are sensitive to income shocks caused by illness, loss of employment, and macroeconomic shocks. Government planners have made efforts to prevent adverse consequences as energy demand continues to rise, such as in the UK, where firms working in utilities are stripped of the ability to react to surging input prices, forcing them to sustain supply unprofitably. Also, in India, the Ministry of Power and Renewable Energy requested all thermal power plants to increase their stockpiles of coal because 16 out of 135 electricity producers ran out of stock and the others struggled with only four days of stock remaining (Skidmore, 2021). However, the problem is only one component of a greater concern for energy security, which is one of seventeen sustainable development goals set by the United Nations.

The 2021 crisis is expected to last only for the short term, as the energy supply needs time to catch up with the strong rebounding demand post-COVID-

19. At the peak of the pandemic, energy use and demand fell sharply while production quantities remained high among OPEC, which caused the prices of oil and gas to tumble. Their price began soaring and showed no sign of ceasing when the demand started tracking back and surpassing where it was before the COVID-19 breakout (Helman, 2021). Many of the underlying factors leading to this upheaval are less obvious and persistent than the incoordination between forces making up the market.

First is the fossil fuel-reliant economy. Over the last two decades, growth patterns observed among emerging countries such as India, China, Vietnam, and Indonesia are explained mainly by the export of wide-ranging labor-intensive products such as garments, chemicals, automobiles, and electronic components. Firms that specialize in these goods consider local workers as a major factor in production, which means the cost of exported goods is dominated primarily by the cost of labor rather than a reasonable proportion between labor and the depreciation or amortization of tangible and intangible assets. As a result, a wave of migrants is flocking into big cities as the number of working opportunities increases, immensely pressuring the urban landscape. According to the United Nations, 80 percent of the Asia-Pacific population lives in cities, and this region is home to 13 of the world's 22 megacities (UN, 2013). As such, the urbanizing process provoked the unsustainable development of countless industries, such as heavy industry, transportation, and even construction, in a way that made them not only inseparable from the sources of non-renewable energy but also responsible for their energy inefficiency. This point is strengthened because in the period 2015–2017, the region's total revenue from transportation, construction, natural resources, and utilities was over 6,000 billion dollars, which was six times its value during 1995–1997 (Tonbey et al., 2019). Therefore, developing sustainable alternative energy is the theme that would never reduce heat and attract critical views from both government planners and scholars.

Second, because of the development of the financial sector, carbonization has sped up faster than ever. Foreign direct investment (FDI) and low lending interest rates have also significantly contributed to the miraculous growth of the Asia-Pacific region. For the last two decades, decreasing lending interest rates and financial deregulation have explained the mushrooming of firms in various sectors, especially in basic materials. Specifically, since financial services are more accessible, firms are more likely to expand their production by hiring more labor, which increases the demand for energy in the short run as more people move to the cities and depreciates the value-added capital investment. Similar to the case of FDI inflows, the most attractive projects to investors are those specializing in the manufacturing of labor-intensive goods, as they are the most lucrative. These facts coincided with the modern theory of finance and growth, which emphasizes that financial development precedes and provokes economic progression through financial reorganization. However, the debate on the environmental externalities of this growth model is still unsettled and remains controversial in the literature.

On the one hand, more advanced and eco-friendly technologies would help accelerate decarbonization and promote energy security if policies, such as tax incentives and financial deregulation, were favorable and attractive to foreign investors (Zhang & Yang, 2020; Vo et al., 2020). Financial reform is underpinned by the argument that it helps to guide and direct the attention of the energy sector to greener sources of energy by reducing the external cost of funding (Nasreen et al., 2017; Levine, 2005). Loosening financial constraints means firms are more easily gaining loans for expanding production, or consumers find it easier to increase their consumption. Both contribute to increased energy waste. While one makes production more energy-consuming, the other increases greenhouse gas emissions and energy demand (Gomez & Rodriguez, 2016; Sadorsky, 2010). As such, better-designed financial policies would optimize energy usage and, therefore, create room for renewable energy development.

This study aims to provide empirical evidence, both in the short and long run, that the financial sectors in middle-income countries in Asia, such as China, Indonesia, India, Malaysia, Philippines, Bangladesh, Thailand, Russia, and Vietnam, handle the overdependence on fossil energy, making those economies vulnerable to short-term shocks such as the one in late 2021. This study also answers several questions that we might think are supportive to government planners in diverting future financial flows to renewable energy projects and proposing more sustainable energy policies. Such questions encompass: to what extent does financial development influence the energy security of the region? Why do the use of fossil fuels and urbanization not only contribute to energy insecurity but also stifle the development of alternative energy sources? Our study will address these issues using fully modified Ordinary Least Squares (OLS) Regression/dynamic OLS (DOLS) and Panel - Vector Autoregressive Model (P-VAR). Our sample data comes from nine Asian middle-income countries over the period 2000–2020, not only because they capture most fossil energy demand and CO_2 emissions globally but also because they are considered to apply the finance-led-growth theory relatively successfully in practice.

The following sections are then structured: The next section will provide related theories of the nexus between financial development and energy security. Then we will discuss the method and data used for the long- and short-term analyses. After that, based on the empirical results, we will interpret and compare them with other studies in this area. Finally, we will suggest some policies to achieve inclusive energy security and simultaneously achieve net-zero carbon emissions by 2050.

2. LITERATURE REVIEW

Economic historians have shown that the financial breakthrough was one of many fundamental factors that marked the commencement of the British Industrial Revolution in the mid-18th century (Nguyen et al., 2020; Hodgson, 2021) and the Southeast Asian recovery in the late-20th century (Park & Lee, 2001). The energy revolution we expect to witness could be similar to some extent to the two previous revolutions, where capital flows were increasingly directed to the energy sector. However, the expectation sits uncomfortably with the facts from the Asia region, where environmental quality has significantly declined as greenhouse gas emissions increase and there are still people without access to electricity. These stylized facts again lit up scholarly enthusiasm at the nexus between energy and finance. However, the channels through which they affect each other remain controversial and amorphous, as various external factors need to be controlled. As discussed in the introduction, we categorized the current literature into two mainstreams, each discussing how financial development monotonically influences energy usage differently.

First is the group of studies that support the scale effect, which is the negative relationship between financial development and energy security. These are the ones that follow the modern theory of finance and assume that the development of the financial sector is not directly linked to energy waste, since their connectedness is via economic growth. As such, inefficient energy usage is explained by the increasing activities because of economic expansion, whose occurrence owes to the mobilization of capital (Nguyen et al., 2021). Using panel data that contains 22 emerging economies over the period 1990–2006, Sadorsky (2010) provides empirical evidence that financial development promotes the consumption of fossil energy. The author argues that as financial services become more pervasive and cheaper to access; they enable users to consume big-ticket items, such as cars or houses. Financial development also catalyzes the establishment and enlargement of micro and small enterprises by enhancing their access to external financing channels. To the group of Gulf Cooperation Council (GCC) and Sub-Sahara African (SSA) countries, Al-mulali and Lee (2013) and Al-mulali and Sab (2013) find that the empirical evidence implies that the financial deepening exerts a positive influence on economic growth by increasing energy consumption, both in the short and long run. Chang (2015) and Furuoka (2015) apply heterogeneous panel techniques and validate that credit expansion leads to energy intensification across countries in Asia. Their findings also support the feedback effect between the two, which means financial development also receives influence as energy demand increases. Nassani et al. (2017) conclude that the efficiency of financial intermediaries gives rise to fossil energy consumption and transportation growth in the group of BRICS countries. Omri et al. (2015) divert their interest to the group of Middle East and North Africa (MENA) countries, which have been the major suppliers of fossil fuels in various forms, such as oil, coal, and gas. The authors found trade and financial development; both give rise to CO_2 emissions in the long run, but their effect is not unambiguous for the entire sample except Qatar, Algeria, and Bahrain. In the broader context, Ziaei (2015) discovers that the shock derived from the energy demand disproportionately affects the financial breadth and depth of all countries in Europe, Asia, and Oceania. The study also confirms that there are feedback effects between financial development and energy consumption in the long run.

Xu (2012) and Ren et al. (2014), two studies that look at the big-picture effects of financial development on a single country, say that FDI inflows in China are to blame for the wasteful use of natural resources and rising greenhouse gas emissions. Resonating with the case of China, Kakar et al. (2011), Komal and Abbar (2015), and Abbasi and Riaz (2016) found similar evidence in Pakistan, where FDI plays a crucial role in promoting economic growth and energy consumption. In their empirical attempt to explore the interrelation of the trio of economic growth, financial development, and CO_2 emissions among GCC countries, Bekhet et al. (2018) found that financial development exerts upward pressure on energy consumption and, therefore, contributes to the carbonizing process. However, evidence of the scale effect exists only in the Kingdom of Saudi Arabia, Oman, Bahrain, and Qatar. Kwakwa (2020) suggests that urbanization, affluence, trade, and financial development should increase CO_2 emissions in Tunisia. The author also found that electricity, fossil fuel consumption, and energy use contribute to the degradation of environmental quality.

Moving to the other group of studies, they argue that financial development, in terms of being more integrated and efficient, is indispensable for innovations in the private sector. This is known as the technical effect, and it is more straightforward than the scale effect discussed above because capital flows are directed and mobilized to support decarbonization. As the financial sector becomes more integrated and developed, energy-saving and energy-efficient technologies will follow FDI to environmental projects. These scholars argue that the mechanism through which financial development impacts today's energy sector is similar to one used in 1775 during the Industrial Revolution. Tamazian et al. (2009) found empirical evidence among BRICS countries that the financial development proxied by the stock market value, FDI inflows, current account, and the extent of openness exerts a downward effect on CO_2 emissions, while economic growth intensifies the energy demand. These authors also argue that since the financing of projects using greener innovations does require a means for diversifying risks, the extent of capital mobility is fundamental to sustainable energy plans. Schwerhoff and Sy (2017) underscore the role of renewable energy in achieving the sustainable goals set by the United Nations in Africa. These authors also stress the regulatory and political risk factors, which can inflate the cost of setting up the initial infrastructure used for extracting energy. Using a sample that includes most OECD countries over 2004–2017, Wang et al. (2019) emphasize that technological breakthroughs are mandatory for any country to gain green growth, even those countries that currently possess high green productivity. Furthermore, emerging industrialized countries with lower green productivity also need to focus on not only the R&D activities of disruptive technologies but also the balance between the expansion of the industrial sector and the quality of the ecosystem.

Wang and Jin (2007) and Zhao and Yang (2020) looked at the effect in a specific setting and found evidence that FDI has a positive effect on technology in China across a range of business types and provinces. They also found that the privatization and securitization of state-owned firms also positively impact their environmental performance. Using the autoregressive distributed lag (ARDL) estimator, Shahbaz et al. (2013a) discovered that the extent of trade openness in South Africa correlates negatively with the amount of CO_2 emissions. Analogous conclusions are also reached within the context of Malaysia, where Shahbaz et al. (2013b) found that trade and FDI both decelerate environmental degradation in the long run. Additionally, their short-run analysis confirms the unidirectional relationship between financial development and energy intensity. Emir and Bekhun (2018) direct their interest to Romania, a country that exhibited a sharp increase in energy consumption during the 1990s–2014, and find that the surge of renewable energy consumption accompanies long-run growth.

The above overview of the literature on financial development and energy security not only substantiates the urge to conduct this study but also highlights the empirical analysis described in the next few sections. We think that most of the work that has been done so far has focused on the long-term effects of economic growth and development, but it has neglected to look at how each factor in the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model affects other factors in the short term. We think that using both long-run and short-run methods would help us better understand why energy crises happen repeatedly or why energy security is so affected by financial growth, which is said to only last for a short time and is usually blamed on supply and demand not matching up.

3. METHODOLOGY AND DATA

3.1. Methodology

3.1.1. The cointegration test

Previous work done on the long-run relationship between the efficiency of the financial market and energy consumption found that these two are cointegrated. This means the disturbance vector obtained from the long-run equation between a set of cointegrated vectors has to be stationary. Co-integration testing is fundamental and should be done beforehand to acknowledge a suitable experimental setup. There are three widely adopted versions of the co-integration test: Pedroni (1999, 2004), and Westerlund (2005). They are appealing and highly regarded for allowing the heterogeneity of co-integrating vectors, which are commonly seen when pooling countries with different socio-economic backgrounds (Westerlund, 2007). Instead of going into the derivation of the test statistics, we will discuss the strengths and weaknesses of each of those tests. Please note that all of them try to prove the error term denoted as ε_{it} from the co-integration equation is a stationary process.

$$y_{it} = X'_{it}\varphi_i + \varepsilon_{it} \quad (1)$$

Let us begin with the Kao test, where he assumed that all the co-integration vectors were the same across the panel. Here, we have $\varphi_i = \varphi$ and by estimating the equation 1, he obtains the error term $\hat{\varepsilon}_{it}$ and then applies the Dickey-Fuller test or Augmented Dickey-Fuller test to the vector. Pedroni, on the other hand, allows each panel to have its co-integrating vector, and several test statistics come up by applying the Phillip-Perrons and Dickey-Fuller stationary tests. Lastly, the Westerlund test of cointegration. It is similar to the Pedroni test in that it allows the difference of co-integration vectors. What makes it different from the Pedroni test is that it is non-parametric since it does not require the second regression on stationarity.

3.1.2. The FMOLS/DOLS estimators.

As we expect our financial development indicators and energy security to be long-run correlated, the next step is to quantify to what extent and in which direction they interact. In such a case, if we assume that the vectors ε_{it}, v_{it} are groupwise uncorrelated, strictly stationary, and asymptotically distributed with zero means, the ordinary least squares (OLS) estimator is then consistent, and its parametric assumptions still hold. But if the innovations occurring in x_i do help to define the future value of y_i or mathematically speaking $Cov(\varepsilon_{it}, v_{it}) \neq 0$, then the OLS estimator is said to be inconsistent (Kao & Chiang, 2000). Under that circumstance, the fully modified OLS (FMOLS) and dynamic OLS (DOLS) estimators are more prosperous in coping with co-integrated vectors. While the former specializes in autocorrelation and endogeneity (Zhao & Yang, 2020), the latter is more efficient in working with heterogeneous panels (Kao & Chiang, 2000). We will briefly describe below how each of these estimators is derived to highlight their advantages in comparison with their counterparts and the motivation behind their usage.

Beginning with the FMOLS estimator, let us assume that the matrix $w_{it} = (\varepsilon_{it}, v'_{it})'$ follows the $MA(q)$ process that could be mathematically expressed by the lag polynomial $w_{it} = \sum_{j=0}^{q\to\infty} C_{ij}\, L^j u_{it}$ with $C_i(1) \neq 0$ and u_{it} is a white noise sequence. Then, the long-run covariance matrix from the equation (1) denoted as $\mathbf{\Omega}_i$ is defined as $\mathbf{\Omega}_i \equiv C_i(1)C_i(1)' = \sum_{j=-\infty}^{\infty} E(w_{it}w'_{i,t+j}) = \begin{pmatrix} \omega^2_{i\varepsilon\varepsilon} & \omega'_{i\varepsilon v} \\ \omega_{iv\varepsilon} & \mathbf{\Omega}_{ivv} \end{pmatrix}$. The $\mathbf{\Omega_{ivv}}$ is expected to be nonsingular as v_{it} is non-stationary. On that premise, the FMOLS first adjust the endogeneity in the equation (1) caused by the misspecification of innovative factors v_{it} by subtracting both sides of the equation 1 to $\widehat{\omega}'_{i\varepsilon v}\widehat{\mathbf{\Omega}}^{-1}_{ivv}v_{it}$. Then, the panel FMOLS estimator is given by

$$\hat{\beta}_{FM} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} X^*_{it}X^{*\prime}_{it}\right)^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T} X^*_{it}\hat{y}^*_{it} - T\widehat{\omega}_{iv\varepsilon}\right)\right]$$

Where $X^*_{it} = X_{it} - \bar{X}_i$ is the matrix of regressors that has been groupwise demeaned for eliminating unobserved time-invariant factors. $\hat{y}^*_{it} = y_{it} - \widehat{\omega}'_{i\varepsilon v}\widehat{\Omega}^{-1}_{ivv}v_{it}$ is the column vector that has been corrected for endogeneity. $T\widehat{\omega}_{ive}$ is the correction term for the autocorrelation, whose $\widehat{\omega}_{iv\varepsilon} = \widehat{\Delta}_{i\varepsilon v} - \widehat{\Delta}_{i\varepsilon}\widehat{\mathbf{\Omega}}^{-1}_{ivv}\widehat{\omega}_{iv\varepsilon}$. In sum, the FMOLS is designed to properly handle the autocorrelation and also endogeneity by sequentially correcting the cointegrated vectors for each one of them. These are its strengths, but they are also its weaknesses. Since it undergoes corrections twice, it induces a huge bias in working with a small sample (Kao and Chiang, 2000).

Moving to the DOLS estimator, which focuses on adding lags and leads of the endogenous vectors $\Delta X_{it} = v_{it}$ as explanatory variables. The panel DOLS estimator is provided as:

$$\hat{\beta} = \left(\sum_{i=1}^{N}\sum_{t=1}^{N} W_{it}W_{it}'\right)^{-1}\left(\sum_{i=1}^{N}\sum_{t=1}^{N} W_{it}y_{it}'\right)$$

Where $W_{it}' \equiv (X_{it}', \mathrm{v}_{it}')'$, $\hat{\beta} = \begin{pmatrix}\hat{\beta}_{DOLS}\\ \hat{\gamma}\end{pmatrix}$. Initially, we can see that the DOLS estimator is relatively easier to compute compared to the FMOLS. That makes it better for working with small samples (Kao & Chiang, 2000) and produces a less biased estimator in either heterogeneous or homogenous samples in contrast to its counterpart, though they share similar asymptotic properties.

3.1.3. PVAR - Forecast variance decomposition

As mentioned earlier, the long-run analysis might not be adequate to capture the story behind the nexus between financial development and energy security. To be specific, the co-integration estimators can only show how the dependent variable reacts to the unitary change of those regressors in the long run, not its time sensitivity to the innovative factors v_{it} embedded in x_{it}. As such, the problem urges us to use the forecast error variance decomposition (FEVD), which builds on the premise of the panel vector autoregressive model (PVAR). Below is the demonstration of how we break down the variance of y into smaller components that were captured by the innovative factor of each explanatory variable.

In the previous sections, we assume that the matrix of column vectors $x_{it} = x_{i,t-1} + v_{it}$ is non-stationary. This assumption is too restrictive and arbitrary since we have ignored the impact of lags in higher order. Therefore, let us assume x_{it} is endogenous and generally follows the $AR(p)$ process, then we could rewrite x_{it} into $x_{it} = \sum_{j=0}^{p}\varphi_j L^j x_{i,t-j-1} + v_{it}$ or $x_{it} = \phi(L)x_{i,t-1} + v_{it}$, where L is the backshift operator and v_{it} is found to be white noise. The impact of external unitary shock from v_{it} during the period $t-s$ $(s < t)$ could be modeled as:

$$\beta^{s+1}\, x_{i,t-k-1} + \sum_{k=0}^{s}\beta^k v_{it}$$

where $\beta = \sum_{j=0}^{p}\varphi_j L^j$. Let assume that $y_{it} = Cx_{it} + \varepsilon_{it} = C\beta^{s+1}x_{i,t-k-1} + C\sum_{k=0}^{s}\beta^k v_{it} + \varepsilon_{it}$. Then the total variance of y_{it} resulted from shock in v_{it}, which occurred at time $t-s$ is calculated below:

$$V_s = C\left(\sum_{k=0}^{s}\beta^k(\beta^k)'\right)C' \quad (3)$$

If an impulse also comes from ε_{it}, the equation (3), which already describes the total variance of y_{it} attributed to the innovative factors in x_{it} can be modeled as:

$$V_s = C\left(\sum_{k=0}^{s}\beta^k(\beta^k)'\right)C' + \sum_{k=0}^{s} e_k'P'P\, e_k$$

where $P = C\Lambda^{-\frac{1}{2}}$ is the modal matrix of Σ, which is the variance and covariance matrix of the residuals. Finally, the general form of variance in y_{it}, which is attributable to the change in x_{itl}, could be mathematically expressed as:

$$FEVD_s = \frac{V_{ls}}{V_s} = \frac{C\left(\sum_{k=0}^{s}\beta^k I_k^l(\beta^k)'\right)C' + \sum_{k=0}^{s} e_k'P'P\, e_k e_l}{V_s = C(\sum_{k=0}^{s}\beta^k(\beta^k)')C' + \sum_{k=0}^{s} e_k'P'P\, e_k} \quad (4)$$

where I_k^l and e_l is respectively the $k \times k$ and $T \times 1$ selection matrix.

3.2. *Data*

3.2.1. Financial development proxies

The literature has described financial development as more likely a multifaceted phenomenon (Nguyen et al., 2020). As a result, indicators used by previous empirical studies to represent it are proven to be divided. First, let us take an overview of the definition and which proxies for financial development have been selected to capture it by previous studies. According to the World Bank (2020), the degree of financial development is more or less reflected by the efficiency of the financial institutions that provide a variety of financial services and capital markets. Demirguc-Kunt and Levine (2007) defined the five functions of the financial sector that directly contribute to economic growth, which are: (i) efficiently mobilizing and allocating capital, (ii) stimulating trading and diversification, (iii) boosting the exchange of goods and services, (iv) providing a supervisory mechanism for firms that have already been financed and (v) encouraging savings. Jahan et al. (2019) argued that at least four qualities of the financial system reflect its financial development: access, depth, efficiency, and stability. In more detail, the greater extent of financial development is similar to the greater ubiquity of financial services, less market friction, and volatility. The numbers represented in Table 1 are a quick summary of empirical attempts that use different macro indicators as proxies for financial development.

Table 1. Summary of indicators used for representing financial development

No.	Authors	Proxies for financial development	Data
1	Shahbaz et al. (2013a), Haseeb et al. (2018), Ahmad et al. (2018), Ziaei (2015), Nassani et al. (2017), Kwakwa et al. (2020), Rakpho et al. (2020).	Per capita access to domestic credit of the private sector, domestic credit provided by the banking sector	World Bank
2	Sadorsky (2011, 2010), Zhao and Yang (2020), Ziaei (2015), Saidi and Hammami (2015), Abbasi and Riaz (2016), Rakpho et al. (2020)	Stock market capitalization, stock market volume, and stock market turnover	World Development Indicator
3	Vo et al. (2021)	Liquid liabilities to GDP, deposit money bank assets to GDP, private credit by deposit money bank to GDP, stock market turnover	World Bank
4	Furuoka (2015), Zhao and Yang (2020), Xu (2012), Ren et al. (2014), Abbasi and Riaz (2016), Shahbaz et al. (2013b)	FDI inflows	Bureau Statistic in China/World Bank
5	Zhao and Yang (2020)	Ratio of credit to debit	Bureau Statistic in China
6	Nassani et al. (2017), Al-mulali and Sab (2012), Tang and Tan (2012), Nassani et al. (2017).	Gross savings, broad money as a percentage of GDP, M2, M3 money supply as a percentage of GDP	World Bank

In our study, we use the four indicators that are most reflective of the definition of financial development and are commonly seen in empirical studies on its relationship with energy consumption. They are (i) market capitalization as a percentage of GDP, (ii) broad money as a percentage of GDP, (iii) FDI inflows as a percentage of GDP, and (iv) gross savings as a percentage of GDP. All of them are collected from World Development Indicators. However, two problems relating to the usage of those proxies are well articulated by Tang and Tan (2012), Zhao and Yang (2020), and Nguyen et al. (2021). They are the correlation between the included components and the arbitrary weight allocated to each of them in the calculation of the financial development index. To overcome these problems, we applied principal component analysis (PCA), which is specialized in dealing with correlation and also minimizes the distortion of the data. The following equations describe how the index is derived:

$$PC_m = \sum_{n=1}^{4} Loadings_n \times determinant_n$$

$$FD_{i,t} = \sum_{m=1}^{M_i} PC_m \times IVC_m$$

Where $Loadings$ are the eigenvectors of the variance and covariance matrix of the four variables that we used to construct the financial development index. IVC_m is the variance contribution of the m^{th} eigenvector. They are sorted in descending order of eigenvalue. Table 2 below represents the number of components taken for the calculation of the financial development index of each country.

Table 2. The number of components taken into calculation and the variance contribution

Country name	Country Code	IVC	No Comp
Bangladesh	BGD	0.90	2.00
China	CHN	0.87	2.00
Indonesia	IDN	0.90	2.00
India	IND	0.93	3.00
Malaysia	MYS	0.92	3.00
Pakistan	PAK	0.94	2.00
Philippines	PHL	0.98	3.00
Rusia	RUS	0.97	3.00
Arab Saudi	SAU	0.97	2.00
Thailand	THA	0.94	3.00
Turkey	TUR	0.95	3.00
Vietnam	VNM	0.92	2.00

Notes: The number of selected components (the fourth column) is determined by the total variance contribution (the third column), which is above 85 percent following the suggestion of Vo et al. (2021), Zhao and Yang (2020). All the variables are standardized to optimize the PCA performance (Shlens, 2005).

3.2.2. Others included variables and model specification

As suggested by the overview of empirical evidence in the previous sections, we assume that financial development causes increasing dependence on fossil energy and indirectly crowds out the development of other greener energies. What can be witnessed over the previous decade is that economic progression and urbanization had a positive effect on energy intensity but also made those economies reliant on that source of power. As such, we would like to examine that effect and validate our assumption. The later section focuses on analyzing the model described as follows:

$$ENE = \beta_0 + \beta_1 UB + \beta_2 GDPP + \beta_3 Fossil + \beta_4 FD + \varepsilon$$

Where ENE are two energy security measures including the energy intensity measured by the total energy consumed per capita and how much of total power has been produced using renewable alternatives. Given the definition of energy security, we see that non-renewable energy sources such as wind, water, or tidal energy contribute a huge part to the uninterruptedness of energy usage. However, that is only a short-term vision. Energy security could be understood in the long term as the efficient consumption of power. It implies that our use of power can be sustained intergenerationally. We could not achieve that target with non-renewable sources because they will eventually deplete, and the environmental side effects accompanied by their use are huge. Given the model, we can test the following two hypotheses.

H1: Financial development negatively impacts the use of renewable energy.

The significance of the financial development index could support the hypothesis. As we mentioned in the literature review, from a total investment point of view, renewable energy projects are less competitive in terms of internal rate of return and payback period than those that use fossil energy. Those non-renewable sources are much cheaper and require less initial investment and R&D, which are not commonly seen in middle-income countries. Given that argument, we expect that financial development will lower the share of renewable energy.

H2: Financial development raises the level of energy consumption.

Middle-income countries often have a relatively inexpensive source of labor, which severely affects the choice of capital structure. For example, if the marginal cost of labor is lower than the cost of capital, firms will use more labor instead of capital, which is represented by state-of-the-art production technologies. We assumed that every firm acts in their best interest, and therefore they will use more labor compared to capital, and those less developed technologies would drive the energy use.

Other explanatory variables are urban population, GDP per capita, and fossil energy consumption. UB denoted in the above equation is the urbanization measured by the ratio between urban population and total population. $GDPP$ is the GDP per capita. FD is the index representing financial development. $Fossil$ is the use of fossil energy per capita. All of them are collected in the World Development

Indicators for the period 2000 - 2020. $\beta_1, \beta_2, \beta_3, \beta_4$ are the long-run elasticity of energy security attributable to each explanatory variable. The descriptive statistics are provided in the table below.

Table 3. The descriptive statistic of variables used for the regression

Country	Energy intensity	Renewable energy	Urban population	GDP per capita	Financial development	Fossil energy
Bangladesh	7.463 (0.32)	0.990 (0.35)	30.603 (4.6)	6.719 (0.59)	-0.614 (0.42)	7.453 (0.32)
China	9.867 (0.36)	8.483 (2.96)	48.961 (8.01)	8.244 (0.84)	0.331 (0.5)	9.767 (0.33)
Indonesia	8.828 (0.12)	4.666 (1.95)	49.611 (4.56)	7.696 (0.61)	-0.167 (0.57)	8.780 (0.11)
India	8.495 (0.23)	7.251 (1.00)	31.051 (2.24)	6.987 (0.53)	0.165 (0.51)	8.407 (0.22)
Malaysia	10.403 (0.11)	3.753 (1.76)	70.313 (4.74)	8.931 (0.38)	0.583 (0.43)	10.365 (0.1)
Pakistan	8.234 (0.11)	11.183 (1.89)	35.015 (1.28)	6.834 (0.39)	-0.826 (0.46)	8.100 (0.11)
Philippines	8.289 (0.13)	15.286 (2.16)	46.047 (0.58)	7.594 (0.45)	-0.309 (0.44)	8.123 (0.15)
Russia	10.900 (0.05)	6.238 (0.43)	73.805 (0.43)	8.919 (0.68)	-0.064 (0.34)	10.772 (0.05)
Thailand	9.733 (0.17)	3.881 (1.54)	42.531 (6.34)	8.352 (0.45)	0.130 (0.44)	9.693 (0.16)
Turkey	9.749 (0.19)	12.415 (2.98)	70.676 (3.56)	9.008 (0.41)	-0.805 (0.18)	9.616 (0.17)
Vietnam	8.705 (0.48)	18.980 (3.22)	30.589 (4.04)	7.205 (0.79)	-0.655 (0.48)	8.494 (0.47)

Notes: The variables GDP per capita, energy intensity and fossil fuel consumption are in natural logarithmic form. Reported in parentheses are standard deviation.

4. RESULTS

Before moving to the long- and short-run analysis, we conducted some preliminary tests to identify suitable approaches for short- and long-run analysis. First, we find the Pearson pairwise correlation and variance inflation factors to see if there is any multicollinearity. This is because multicollinearity is thought to make ordinary least squares less useful and increase the chance of making type I and type II errors. Table 4 below shows the pairwise correlation and the variance inflation factor of the included variables.

Table 4. Pearson pairwise correlation between included variables

	VIF	Fossil	UPOP	GDPP	FD
Fossil	5.71	1.000			
UPOP	5.41	0.877	1.000		
GDPP	7.81	0.886	0.889	1.000	
FD	1.26	0.351	0.138	0.273	1.000

The unconditional linear correlations give us a first glance at the interactions between variables prior to accounting for the influences of others. Significant correlations between fossil fuel energy usage, energy intensity, and the use of renewable energy imply the potential interaction among them in middle-income countries across the Asia Pacific. Second, Table 4 also suggests that the economies of these countries are driven mainly by non-renewable energy. The report from variance inflation factors (VIF) shows that the problem of multicollinearity between the explanatory variables is of no serious concern since they are all below 10. However, it is hasty and deceptive to draw such conclusions without ruling out other effects such as the stationarity or the Granger causation between financial development and GDP.

The detection of co-integration is a prerequisite to choosing a suitable analytical approach. It is not necessary for the variables to be stationary to be included in the long-run equation. As a matter of fact, the act of taking either the first or second difference to make a stationary process dampens the co-movements among variables. Reported below are the Pedroni and Westerlund test results for co-integration between the variables described in Section 3.

The statistics of the two tests show that the residuals from the long-run regression between energy security, the use of renewable energy, GDPP, urbanization, and financial development are just random noise. In other words, the upward or downward trends of our explanatory variables could at least explain the movement of energy security.

Table 5. The cointegration tests

	Dependent variables	
	Energy intensity	**Renewable energy usage**
Kao		
Dickey-Fuller t	-2.438*** (0.007)	-3.037*** (0.000)
Augmented Dickey-Fuller t	-2.569*** (0.005)	-3.678*** (0.000)
Pedroni		
Modified Phillips-Perron t	0.709 (0.239)	1.080 (0.140)
Phillips-Perron t	-8.826*** (0.000)	-8.652*** (0.000)
Augmented Dickey-Fuller t	-5.710*** (0.000)	-4.822*** (0.000)
Westerlund		
Variance Ratio	-1.393* (0.082)	-1.310* (0.095)

*Notes: Reported in parentheses are p-values. Where * denotes the statistical significance at 10%, ** denotes the statistical significance at 5%, and *** denotes the statistical significance at 1%*

Cross-sectional dependency and slope heterogeneity are two problems that have come up because panel settings are becoming more popular. Both deteriorate the consistency of long-run estimators, including fixed and random effects (Balgati & Liu, 2015). The former problem relates to the misspecification of unobservable factors due to mistakes or the unavailability of the data. With the presence of cross-sectional dependence, regressors on the right-hand side are no longer exogenous since they are correlated with the common factors (Pesaran, 2004). As a result, not only are standard homogeneous estimators such as fixed and random effects inconsistent but so are heterogeneous models such as the mean group estimator. The latter problem is the slope heterogeneity caused mainly by the socio-economic differences between cross-sectional units. They cause inferences based on estimated coefficients from one country to be inapplicable to other countries. Standard pooled estimators such as fixed and random effects return implausible or evenly biased results (Bersvensend & Ditzen, 2021). Therefore, to decide which estimator is appropriate for our specified models, we expand the preliminary testing by employing the test of slope homogeneity developed by Pesaran and Yamagata (2008). The Delta statistic and its adjusted version are reported below for the parametric assumption of the error term.

Table 6. Slope homogeneity test of Pesaran and Yamagata

	Energy intensity	**Renewable energy usage**
Delta	-0.509 (0.611)	1.407 (0.159)
Adjusted Delta	-1.053 (0.292)	1.608 (0.108)

*Notes: Reported in parentheses are p-values. The null hypothesis is that the slope coefficients are homogenous. ***, **, * respectively denotes the failure to reject of H_0 at 1%, 5%, and 10 %.*

The test statistics suggest that the coefficients of our models described above are homogenous from one country to another. We use the DOLS and FMOLS estimators, which are well known and often compared to find the cointegrated relationship between macroeconomic variables because the long-run elasticities are the same. They both address the inefficiency of OLS in the long-run estimation discussed in Section 3. However, the DOLS produces less biassed coefficients than the FMOLS because of how it deals with small samples (Kao and

Chiang, 2000). Table 7 below shows the panel DOLS and panel FMOLS for two proxies of energy security.

Initially, the coefficients estimated by FMOLS and DOLS show no sign of conflict. We notice that fossil-based energy reduces not only the share of renewable energy but also induces energy inefficiency in the Asia-Pacific middle-income countries. Using fossil energy hinders the employment of other types of energy and exacerbates all kinds of pollution that have been pervasive in recent years. The answer to the heavily fossil-reliant economy lies in the political and economic role of energy itself. It is not easy to transition away from non-renewable energy, a source that promises to bring wealth and global influence to those formerly known as small nation-states. Statistically, the one percent increase in used fossil fuels raises the power consumed per capita by 0.98 percent as to the DOLS estimator, and the effect slightly reduces as to the FMOLS estimator.

To the effect of intraregional migration, waves of migrants seeking working opportunities are found to increase the energy intensity. It is understandable as the more people concentrated in the city, the higher the use of energy for daily necessities. The FMOLS shows that a one percent increase in the urban population intensifies the use of energy by 0.28 percent. We could also understand it as people flocked into big cities. The upsurge in power demand leads to energy inefficiency since we have to rely on unsustainable sources of power to meet that demand. As such, it limits the potential for not only development but also the deployment of other eco-friendly energy since the current extraction facilities and pipelines make fossil fuels more financially feasible than any other types of energy. Great energy demand is also found to place tension on the environment, infrastructure, and public health, which is manifested by the surging level of anthropogenic emissions including sulfur dioxide (SO_2) and carbon dioxide (CO_2). Together with vehicle exhausts, these substances are villains for air pollution, which is a serious concern in the megacities of these countries in the sample, especially China, India, and Vietnam.

Table 7. Long run estimation – the FMOLS, DOLS estimators

	DOLS		FMOLS	
	Energy intensity (Y1)	**Renewable energy consumption (Y2)**	**Energy intensity (Y1)**	**Renewable energy consumption (Y2)**
Urban population	0.000 (0.224)	-0.223 (-0.497)	0.32*** (11.02)	0.29*** (1.2e+6)
GDP per capita	0.027*** (2.188)	-6.845** (-1.954)	0.04*** (7.08)	-0.08*** (2.2e+6)
Financial development	0.026*** (3.441)	-5.133** (-2.558)	0.01*** (5.21)	-0.74*** (-1.4e+6)
Fossil energy consumption	0.982*** (29.202)	-9.656 (-0.861)	0.81*** (133.83)	-18.74*** (-4.0e+6)

Notes: Reported in parentheses are t-statistics. Where * denotes the statistical significance at 10%, ** denotes the statistical significance at 5%, and *** denotes the statistical significance at 1%

The effect of income on the efficiency of energy usage is that the growth in the long run slightly makes the use of energy inefficient. It is because to produce more output; we need more energy as input, and those economies in the sample have not reached the state in which they enjoy the economy of scale. If they do, then to produce more products, they will need less or even the same level of input. For a one percent increase in GDP per capita, the energy used by one person increases by 0.03 percent for both estimators. We can also see the impact of economic growth in the long run on the use of renewable energy, according to the second regression. Economic progress negatively affects the deployment of greener alternatives, and the more we develop, the more we depend on non-renewable sources of power. At this point, our hypothesis of fossil-reliant economies is substantiated by the negative signs of both GDP per capita and fossil fuels. Fossil fuel has also been indicated as a reason for energy waste.

Let us come to our variable of interest. Both estimators suggest that financial development, in general, is restrictive to the development of renewable energy across countries in the Asia Pacific. Several factors account for this negative correlation, but we assume it is mostly induced by the three following reasons: First, fossil-based projects outweigh renewable-based ones in terms of cost of capital since the existing infrastructure, such as natural gas pipelines and coal-fired plants, supports the efficient extraction and usage of fossil energy. Renewable energy projects are often accompanied by large upfront capital costs. Most of it is later divided and transferred to the cost of production, which makes the final output less competitive than fossil-based projects unless they are supported by government policies such as feed-in tariffs (FIT). Second, a long payback period is also a reason that makes projects involving renewable energy less attractive. This factor negatively affects the net present value (NPV) of the investments and therefore makes them financially unfeasible for SMEs (small and medium-sized enterprises) and small mid-caps. Third, labor-intensiveness and low institutional quality are also responsible for the negative correlation between finance and the development of renewable energy. In detail, projects that direct their funds towards the adoption of more advanced, energy-efficient, and productive technologies are less captivating to investors compared to those that mainly employ local workers and use obsolete and polluted production methods. These projects are considered a double-edged sword since they both solve the employment issue and cause environmental problems. With the presence of bureaucracy, the payback period of projects using greener power sources is even longer since investors have to deal with tonnes of paperwork in order to obtain permission to construct the necessary facilities required for future iteratations. In sum, the unit increase in financial development induces a 5.1 percent reduction in renewable energy usage, as shown by the DOLS estimator. This figure is minus 1.74 percent for the FMOLS estimator. Both estimators support our hypothesis that financial development increases the energy intensity of the Asia-Pacific region. In other words, the financial system acts as a channel to direct money.

Table 8. The robustness check – FMOLS, DOLS estimators

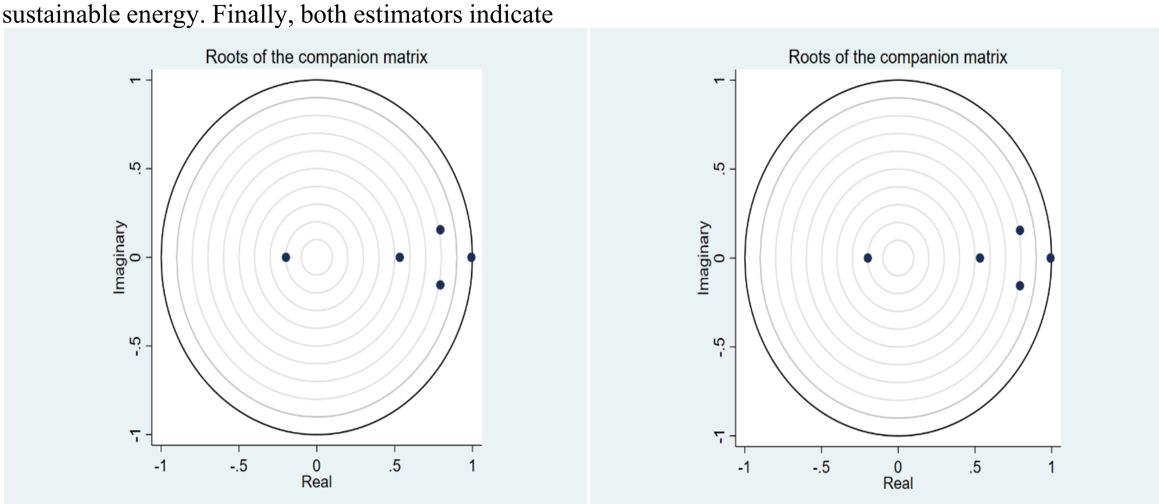
	DOLS							
	Energy intensity				**Renewable energy consumption**			
	MKC	**BMN**	**GSV**	**FDI**	**MKC**	**BMN**	**GSV**	**FDI**
Urban population	-0.001	-0.004**	-0.002*	-0.002	-0.279	-0.465*	-0.335	-0.342
	(-0.849)	(-2.303)	(-1.999)	(-1.317)	(-0.801)	(-1.715)	(-1.556)	(-1.434)
GDP per capita	0.036***	0.069***	0.047***	0.043***	-3.265	-5.350**	-3.047**	-4.131**
	(-2.976)	(5.495)	(5.529)	(5.103)	(-1.040)	(-2.566)	(-2.249)	(-2.548)
Financial development	-0.022***	0.008	0.003	0.022***	-1.769	-4.108**	-3.182***	-0.921*
	(-4.287)	(0.633)	(0.569)	(8.018)	(-1.340)	(-2.008)	(-3.761)	(-1.733)
Fossil energy consumption	1.011***	1.022***	1.004***	0.990***	-7.913	-0.312	-6.579*	-5.636
	(31.407)	(38.097)	(45.767)	(46.371)	(-0.931)	(-0.070)	(-1.685)	(-1.377)
	FMOLS							
	Energy intensity				**Renewable energy consumption**			
	MKC	**BMN**	**GSV**	**FDI**	**MKC**	**BMN**	**GSV**	**FDI**
Urban population	0.01***	-0.001***	0.08***	0.01***	0.22***	8.30***	0.58***	0.38***
	(97.26)	(-4.23)	(3.67)	(-2.0e+4)	(30.91)	(104.7)	(18.05)	(27.71)
GDP per capita	0.01***	0.01***	0.02***	0.02***	0.60	-0.5***	-1.11***	-0.49***
	(3.15)	(9.53)	(5.20)	(57.935)	(1.51)	(-167.97)	(-3.30)	(-3.00)
Financial development	0.01***	-0.02***	0.01***	0.01***	-0.30*	-1.95***	-0.39***	-0.23***
	(4.61)	(-10.74)	(3.15)	(2.4e+5)	(-1.99)	(-35.18)	(-2.53)	(-6.71)
Fossil energy consumption	0.83***	0.87***	0.90***	0.88***	-17.91***	-16.65***	-19.90***	-19.95***
	(273.73)	(407.73)	(132.91)	(1.3e+7)	(-34.63)	(-265.27)	(-38.70)	(-49.74)

Notes: where * denotes the statistical significance at 10%, ** denotes the statistical significance at 5%, and *** denotes the statistical significance at 1%. MKC is the abbreviation of market cap as a percentage of GDP, and BMN is broad money as a percentage of GDP. GSV denotes the gross saving as a percentage of GDP. FDI stands for the FDI inflow as a percentage of GDP.

The composite index of financial development in Table 7 is made up of four different measures: gross saving, market capitalization, FDI inflow, and broad money as a percentage of GDP. It is used to do long-term regressions. We would want to check the robustness of the above analysis using the same technique and model specification. This time, we use components of financial development as its proxy. Table 8 below reports the results of the robustness check.

At first glance, it looks like the way our explanatory variables affect our dependent variables—that is, energy intensity and renewable energy usage—is the same as in Table 7. As we alter different proxies for financial development, fossil energy proves to be an unsustainable power source since it not only crowds out the development of other greener energies, but its utilization is also less efficient and leads to environmental degradation. The effects of financial factors, financial resources coming from civil savings, money supplies, and FDI, are not supportive of the development of sustainable energy. It is understandable in the cases of Asia-Pacific middle-income countries such as China, Vietnam, and India since the existing infrastructure and the high marginal cost of production per unit of labor compared to capital allow fossil-based projects to have not only a lower cost of capital but a shorter payback period than projects using sustainable energy. Finally, both estimators indicate that the use of energy becomes more efficient as the economy expands.

We are going to look at how stable our results from the FMOLS and DOLS are by using the forecast error variance decomposition in the next section. This method also provides information on the sensitivity of energy security to changes in other independent variables. It also tells us that with abnormal shocks applied to each impulse variable, they are likely responsible for causing much volatility in the response variable. This method is built on the premise of the PVAR model, which means we have to establish the state-space model before computing the volatilities of each response variable. The lag applied to all variables included in the state-space models is set to 1, and we also use the lag values from 1 to 4 as instruments. Last, for our system of equations to be stable, the eigenvalues of all eigenvectors, or their modulus, must be less than 1 or lie within the unit circle. Therefore, reported in Figure 1 below are the computed eigenvalues for the two equations of energy security:

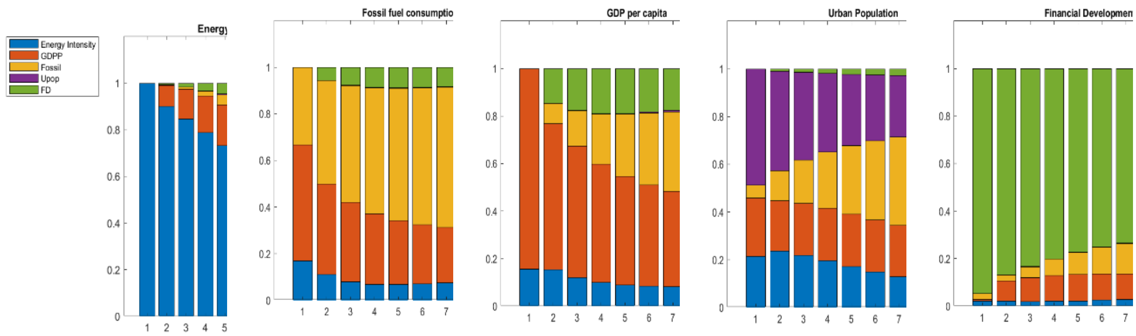


Energy intensity Renewable energy usage

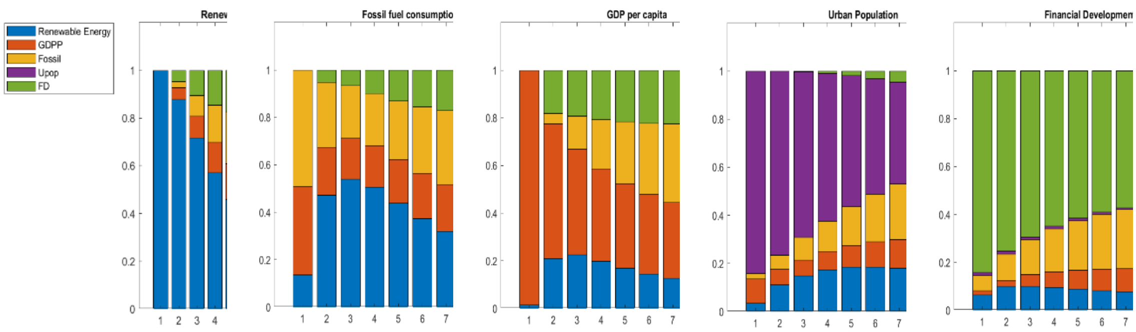
Figure 1. The eigenvalues of the systems of equations

As seen from Figure 1, the modulus of all eigenvectors is less than one, which assures the stability of our PVAR models. Figure 2 below shows the results of FEVD as depicted in the equation 4.

The results are quite similar between the two systems of equations. All the variables follow the AR(1) process, which explains why the values of response variables $t = 0$ are mostly influenced by their prehistoric values. Moreover, the effects of other variables become visible after the two lags, which substantiates the choice for a lag order of 2 in the DOLS setting. Begin with the proxies of energy security; their forecast error variance is largely influenced by shocks applied in the past. If an abnormal shock that makes the use of energy more efficient, such as a technological breakthrough or the discovery of new energy, happened in the past, today's value of energy intensity would become 100, 90, or 80 percent more volatile as the impetus is at lag 1, 2, or 3. As the effect becomes less dominant, the effects of other macro variables become substantial. Economic development explains the constant 17 percent variation in energy intensity which is similar to the value of fossil fuel consumption, which captures up to 17 percent of the fluctuation in energy efficiency. However, the effect of financial development ceases merely at 5 percent and becomes detectable after lag 2. A similar conclusion is drawn for the case of renewable energy usage. Innovation that allows one particular renewable energy to become economically extractable and applicable at time $t-1$ will have a huge impact on the share of renewable energy at time t. Although average income proves to have a negligible impact on renewable energy (less than 15 percent according to Figure 2), its variation is mainly induced by the changes in financial development and fossil energy, which substantiate the FMOLS and DOLS results described in the previous section. Therefore, financial factors and the overdependence on fuel energy exert both long- and short-run impacts on the availability of other sustainable energy. This finding is crucial because it reveals the actual culprit for the recent energy crisis and other crises that will happen in the future. It is not fair for supply and demand to receive all that criticism; the problem lies with the economies of those countries.



a) First system of equations



b) Second system of equations

Figure 2. The forecast error variance decomposition

As for other variables, we also have many interesting findings from the PVAR, which could be summarized into four main points as follows: First, the controversial interrelation between financial development and growth in our study is second-ordered and univariate. This means that past financial reforms towards financial liberalization condition future economic growth, but the reverse is not true, at least with the nine middle-income countries in our sample. Our findings support the supply-leading finance propositions of McKinnon (1973) and Shaw (1973). Second, the use of fossil fuels in the past largely accounted for the variability of both financial development and GDP growth. Fossil-based projects are not only key drivers of the economy but are also attractive for both foreign and domestic investors. As such, these projects are the answer to the phenomenal growth rate and environmental degradation of Asia-Pacific countries. They helped solve the problems of poverty and underdevelopment that used to be dominant in countries in the previous decade and created a new challenge for today's generation, which is pollution. Last, the interaction between fossil fuels and other renewable energy is bivariate, which means they mutually contribute largely to each other's future volatility. It implies the need for other sources of sustainable energy to reduce the dominant and irreplaceable role of fossil fuels in these economies.

5. CONCLUSION

From this point, we learn from the empirical evidence that the over-dependence on fossil energy increases the economy's susceptibility to energy shocks. Pollution and fossil energy reliance are two visible externalities of the financial development in Asia's middle-income countries. In the long term, the results show that financial development contributes to economic growth by mobilizing necessary capital for innovations in underdeveloped sectors and making them less energy intensive. However, that current function is now misused and has proven to obstruct the opportunity to diversify the energy mix. On that basis, we propose several solutions that government planners should seriously consider to achieve more sustainable growth.

The first solution is to refrain from expanding credit on projects that use non-renewable energy as an input or induce significant environmental externality. For example, fossil fuel projects or firms in numerous countries, including the U.S. and Canada, are no longer entitled to financial support from commercial banks. Applying credit constraints to oil companies also signifies their transformation. They must choose between participating in carbon credits, which aim to completely offset greenhouse gas emissions, and living within their cash flow. Specifically, for every barrel produced by the driller, they have to pay a small amount of money to avert or compensate for the undesired environmental externality. That money is then used to fund other environmentally friendly programs, such as building solar power fields or large-scale tree planting. The plan is similar to the cap-and-trade system in that the government understands the marginal abatement cost and sets limits on different greenhouse gas emissions, like CO_2 or SO2, that come from human activities. Polluters are required to auction (or buy) those permits to maintain their level of emissions. However, in the context of our study, which includes various emerging markets, we prefer the carbon credits since the cap-and-trade system would more or less slow down economic growth and provoke more short-term energy shocks.

Second, shifting away from fossil fuels or diversifying the energy mix are two options to ensure energy security in both the long and short term. It can be said that reliance on a particular source of power creates more adverse effects on the economy than reliance on abundant sources (Schwerhoff & Sy, 2017). It should also be said that there are various kinds of renewable energy, but the most suitable in emerging countries in Asia are wind, tidal, geothermal, and solar energy. The countries in our sample are all coastal countries whose coastlines are the windiest in the world. A long coastline is suitable for exploiting tidal energy, which is more predictable yet expensive than solar and wind power. However, large initial investments and long payback periods compared to fossil fuels are two main obstacles to the pervasive usage of renewable energy since they lower the NPV of entire projects. Moreover, technological advancement does not make renewable energy economically competitive compared to fossil fuels and also enjoy economies of scale. Therefore, FIT is one solution that needs to be seriously considered by government planners. Since domestic investors and the current financial system are unfamiliar with projects that involve green power sources, the government should take risks by offering energy providers a long-term commitment. Such risks take various forms, but the three most commonly seen are guaranteed grid access, long-term contracts, and price difference coverage. The FIT scheme not only consolidates investors' confidence but also nurtures the incubation of eco-friendly technologies.

Last, these countries should consider altering their growth patterns by ceasing to exploit their inexpensive labor forces. Even though it was the best way for low-income countries to deal with poverty and underdevelopment, putting the idea into action had big economic effects because government planners did not think about the long term. Changing the proportion of production factors could reduce the level of energy intensity, increase environmental quality, and make room for the development of greener sources of power. As such, broadening financial access is vital for that transition since it provides the financial instruments for the private sector to engage in R&D and adopt new technologies.

Future studies may consider the study's limitations to be research gaps. First, our study takes a relatively small context, which contains middle-income countries in the Asia-Pacific region. Therefore, our study lacks generality, which may affect the robustness of the conclusions. Second, the study only provides empirical evidence of the nexus between financial development and energy security, which is not novel to the literature. Although the direction of the impact is mixed, the research question is common to numerous studies in the field.

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