The Relationship between Financial Development and Renewable Energy Consumption in South Asian Countries

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The Relationship between Financial Development and Renewable Energy Consumption in South Asian Countries

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Abstract

We analyse how the financial development and green energy use are linked to the countries of South Asia from 1990 to 2018. Domestic credit to the private sector and renewable energy consumption is being used in this paper as indicators of financial development and the use of renewable energy. On the indication of cross-sectional dependency among the variables of the models, we apply second generation panel unit root tests and cointegration tests to check the stationarity properties and long-run cointegration relation among the variables. We find that variables are stationary at the first difference, and long-run cointegration exists. By applying robust dynamic heterogeneous and cross-section augmented estimators, we find that increase in GDP increases renewable energy consumption by 1.56-0.50%; however reduces by 0.07-0.03% after certain thresholds. Furthermore, increase in financial development, on average, reduces the propensity of renewable energy consumption by 0.15-0.07% in the long-run. On the other hand, the Dumitrescu-Hurlin panel causality test shows a unidirectional relationship from GDP to financial development and financial development to renewable energy consumption but not vice versa. We suggest that the selected countries revisit and restructure the renewable energy policy and emphasise institutional reforms to strengthen renewable energy development in the upcoming years.

Keywords: Renewable Energy, Financial Development, Sustainability, Institutional Reforms, South Asia

JEL Classification: Q 41, Q42, Q43, Q48

1. Introduction

Energy has been playing a significant role when it comes to the world's economic growth. Among others, Rehman et al. (2019) and Amin and Rahman (2019) explicitly highlight that also energy tends to play a major role in shaping country's many social aspects. Besides, given the importance of energy within the economies, Amin (2015) points out that historically economies that achieved growth beyond subsistence level have at least ensured minimum level of energy for the consumers and producers. In recent decades, the continuing demand has grown and continues to grow with a significant rate. According to the British Petroleum's recent statistics (BP, 2020), world energy demand has an increasing trend. Since 2010, observed average growth of 1.6%. In 2018, the average growth rate of energy demand was 2.05%. Additionally, the energy demand will increase by nearly 1.3% if the current consumption pattern prevails as well as no policy changes are considered. The increasing demand for energy is partially attributed to population growth, changing lifestyles, improvements in production, and economic development. It is very important to indicate that the larger shares in the world energy mix are still occupied by three types of fossile fuels, namely oil, gas, and coal. According to the International Energy Agency's latest statistics (IEA, 2020), the combined share of oil, gas, coal in the world energy mix is 84.30%.

Recent statistics reveal that nearly 80% of electricity generation depends on fossil energy (REN21, 2017). The environmental impact of using this large amount of fossil energy to cater to our needs is detrimental. Existing literature shows that high use of fossil energy pollutes the air and the water, loses wildlife and habitat, damages public health, and global warming emissions. Global CO_2 emissions from fossil fuels burning amounted to 37.15 Gigatons ($GtCO_2$) in 2018, according to Global Carbone Project (GCP) figures for 2019. China and India from the Asian area generated roughly 35% of the total carbon dioxide emissions from fossil fuels. Moreover, the electricity sector alone is responsible for emitting 44% of the total CO_2 in 2018 (IEA, 2019).

Energy production and supply have always been challenging in South Asian countries. From the Renewable Energy Status report of 2019 (REN21, 2019), it was found that Bangladesh imports 17%, India imports 34%, Pakistan imports 24%, and Sri Lanka imports 50% of their total energy use. Shukla, et al. (2017) described in their paper that almost all South Asian countries depend on a single source of energy, which at least provides 50% of their total energy. Only Nepal uses hydropower as its primary energy source, and more than 90 % of electricity production comes from hydropower. Except for Nepal, other South Asians are using significantly less renewable energy for electricity generation. It is not unknown that natural resources will not last forever. Energy diversification is very much needed for any country to survive, which has paved the way for renewable energy.

Renewable energy helps improve energy resilience, address environmental degradation, and assure global energy security by its inexhaustibly and decentralized character which was point out at Amin et al. (2018). However, setting up renewable technology for energy production is very costly. It requires high start-up costs, enormous R&D spending, and a very long operation. A sound financial system is also essential in this context to ensure the efficient discovery and financing of prices, market liquidity, and risk management (Kamp and Forn, 2016; Khan et al., 2014). Wurgler (2000) observed that highly established financial structures raise investment in rising industries and decrease investments in underdeveloped financial systems. Therefore, in an atmosphere where green energy projects have been strongly promoted, financial growth would play a significant role.

Several studies have been done to determine the correlation between economic growth, financial development, and energy use. Nevertheless, the studies have provided conflicting results. There are, sadly, very few studies exploring the role of financial growth in renewable industry production. Regardless of diverse views regarding the connection between financial development and renewable energy use, Sonntag-O'Brien and Usher (2004), Brunnschweiler (2010), Burakov and Freidin (2013), Shahbaz et al. (2013), Lin et al. (2015), Hassine (2017), Yazdi and Shakouri (2017), and Ali, et al. (2018) find that a developed financial system is very much necessary for the development of the renewable industry. The unidirectional causality of green energy uses to private sector loans, as proxies of financial growth, is noticed by Hassine (2017). Rasoulinezhad and Saboori (2018) describe the short-run unidirectional relationship between financial transparency, economic growth, and renewable energy. Eren et al. (2019) also reveal unidirectional causal links that extend from financial growth to renewable energy use and GDP growth in the long-run. Ali et al. (2018) indicated that Asian countries had bidirectional relationships with low, middle and high-income economies with financial growth and renewable energy variables. Yazdi and Shakouri (2017) develop bidirectional ties between financial growth and the use of renewables. Burakov and Freidin (2013) fail to causal effect on renewable energy usage as a result of financial progress.

This study is unique in many respects. As we know, firstly, no attempt has been made to identify the relationship between financial growth and renewable energy usage in South Asia which is a small and well-known cohort from Asia's list of rising and developing nations, due to current international events (Schwab, 2018). In the existing literature (Zhang and Liu, 2019; Topcu and Payne, 2018) revisiting concerns at macro level in different smaller sub-cohorts is common to get profound insight and tailored time-variant policy implications. Second, we utilize the symmetrical and asymmetric econometric technologies established lately for analyse the long term links between the variables of interest, which allow for heterogeneity and cross-sectional dependency. Third, we are also introducing non-linear effects into the model to help understand the relationship between financial development, green energy use, and fossil fuel use. Fourth, we validate our results with time series country-level results. Fifth, we aim to present a few policies for sustainable growth in South Asia based on the findings.

To find out that if countries have any cross-sectional dependency, cross-sectional dependence tests are conducted. Second generation panel unit root tests are conducted to make sure our variables are stationary. In order to establish the significant, long-term co-integration of the variables, cointegration tests (Second generation) were also used. Next Dynamic Ordinary Last Square (PDOLS), which was expanded by the common pattern, is being implemented for estimating long-run coefficients of variable interest by the pool mean group (PMG), Panel Autoregressive-Distributive Lag (Panel ARDL), and Continuously Updated Fully Modified OLS (Cup-FMOLS).). In addition, ARDL and NARDL models at country level were used to monitor and corroborate the results obtained from the panel set-up. Finally, the Dumitrescu-Hurlin causality test has tested causalities among variables. The analysis covers data from 1990 to 2018.

The remaining paper is structured as follows: In Section 2, the literature review is described; Section 3 is the approach adopted by the data, and Section 4 discusses results. Section 5 finally concludes the paper with some important policy recommendations.

2. Literature Review

The use of renewable energy continues to grow, and renewable energy adaptation continues to have a significant economic impact. Much work has been performed to relate financial development to economic growth and the use of energy. The results of the tests, though, are incompatible (Table 1). Unfortunately, there is minimal scrutiny of the role of financial growth in green energy.

Sonntag-O'Brien and Usher (2004) suggested that the degree of financial growth of renewable energy projects can be critical. For example, renewable energy projects are pretty expensive. These include high start-up costs, long-term loan repayments, and significant research and development expenditures. An established financial system could channel funds effectively to the renewable energy industry. On the other hand, an underdeveloped financial system can prevent, even when necessary, the creation of new projects.

The first Brunnschweiler's (2010) research on the effect of financial intermediation on the production of sustainable energy sources was a compilation of panel data forecasts from 1980–2006. The effect on non-OECD developed and emerging countries was investigated. Additionally, international investment is concentrated in the financial sector in these countries as stock and bond markets are not well developed, and risk capitalism is not nice at all. Their findings suggested that the energy firms of the less developed economies rely mainly upon international funding for new ventures.

Lin et al. (2015) examined, using information from 1980 to 2011, the factors in renewable electricity which affected China's use of renewable electricity in China. The Johansen methodology for cointegration and the Vector Correction Model (VECM) are used to examine the long and short-run relation between the variables. Different explanations are depending on the conclusions of the analysis. First, actual GDP per capita supports the clean energy contribution to China's total electricity use. Secondly, international investment and trade-opening reduce the share of clean energy in the general use of electricity. Thirdly, however, financial performance with the minimal effect would have a substantial and vital influence on the share of power in renewable energy. Fourthly, the impact of renewable energy is enormous from traditional fossil fuels.

The causal links of renewable energy use, real GDP, trade, and financial growth were examined in Gulf Countries of Cooperation by Hassine (2017). The causalities from using renewable energies to private sector loans are unidirectional; private sector finance is being used as a financial growth unit. The study also reveals essential and positive long-term impacts from the production of renewables to finance.

Rasoulinezhad and Saboori (2018) studied the long-term and causal relations between economic development, the Chinese Index as an agent for financial accountability, and renewable and fossil fuels use in the 12 Commonwealth countries. A two-phase economic growth and financial openness forum on fossil fuels usage of renewable resources reveal the findings of the two-phase Engle & Granger causality test and the Dumitrescu-Hurlin causal test. Ali et al. (2018) studied the relationship between financial growth, commercial health, clean energy, tourism, and overall reserves. The outcomes panel Granger Causalities from VECM revealed the bidirectional relationship between the low-, medium- to high-income countries in Asia between financial development and the renewable energy variables.

The long-term management of sustainable energy use, financial sustainability, and economic growth in India from 1971 to 2015 is discussed by Eren et al. (2019). Unidirectional causal relations between financial growth, green energy use and GDP can be found in the Granger causality test under VECM. The hypothesis of conservation in India advocates unidirectional causalities from financial development to clean energy.

Burakov and Freidin's (2017) using Vector Error Correction method analysed the causal association between financial development, economic development, and Russian clean energy use. They believe that growth in the finance sector will help green energy technology. On the other hand, developing clean energy options would contribute to economic growth and financial security.

Shahbaz et al. (2013) study on Indonesia's example concluded that domestic GDP and demand growth contribute to greater CO2 emissions, and they are being limited by financial progress and liberalisation. It was also observed that financial growth leads to the spread of sustainable energy from renewable energies. Yazdi and Shakouri (2017) explored the causal link between green energy and economic development and Iranian globalisation in the quarter 1992-2014. Granger's causality studies demonstrate a two-way causality between the use of renewable energy, economic growth, and financial progress.

For 198 nations, Scholtens & Veldhuis (2015) performed a panel regression to determine the effect on the renewables industry of the developed financial market. According to the results, the financial sector has a beneficial influence on investments in renewables, but the share of renewable resources is unfavourable. Finally, the finance sector supports spending on renewable energy but is much more likely to be spent on conventional resources. The impact of private loans on renewable capacity is 11.3% and even more so for non-hydro power, where a one-unit rise in private loans results in an increase in non-hydro power capacity by 21.6%. This implies that financial intermediaries will channel funds to renewable energy investors apart from the central bank.

The relationship of financial growth to energy use has already been investigated by Sadorsky (2011) for Central and Eastern Europe. It was found that an increase in financial growth leads to a rise in energy demand. On the other hand, Furuoka (2015) found out from Asian countries that a developed financial system does not lead to an increase in energy consumption. It was the opposite, where the increase in energy consumption was leading to a developed financial system. The increase in energy consumption is determined by economic factors like price income level, price of energy, etc. Amin and Mahmood (2018) found out in Bangladesh that financial development has a positive influence on energy consumption. It was also found that energy consumption has a significant effect on improving financial development.

Given the above, we can note that the relationship of renewable energy consumption with the financial development of the countries of Southern Asia does not exist in detail, and that determines the novelty of this research. Given that financial investment is much needed to grow renewable energy, finding out what relationship these two factors have in South Asian countries would be very helpful.

Table 1: Summary of the Literature

Study	Time Period	Country	Method	Result
Lin et al. (2015)	1980-2011	China	Johansen methodology for cointegration and the Vector Correction Model	International investment reduces the share of clean energy. the effect on renewable energy is enormous from traditional fossil fuel
Hassine (2017)	1980-2012	Gulf Countries	Engle and Granger and Pedroni cointegration tests	The causalities from the use of renewable energies to private sector loans are unidirectional. The study also reveals important and positive long-term impacts from the production of renewables to finance.
Rasoulinezhad and Saboori (2018	1992–2015	12 Commonwealth countries	Engle and Granger causality test and the causal test of Dumitrescu-Hurlin.	The key observational findings show that all the factors have bidirectional relationship.
Ali et al. (2018)	1995-2015	19 Asia cooperation dialogue members	Granger Causalities test and VECM	Bidirectional relationship between the low-, medium- to high-income countries in Asia between financial development and the renewable energy variables.
Eren et al. (2019	1971-2015	India	Granger Causalities test and VECM	Unidirectional causal relations between financial growth, green energy use and GDP was found.
Burakov and Freidin's (2017)	1997-2017	Russia	Vector Error correction method	Growth in the finance sector will help green energy technology. Developing clean energy options would contribute to economic growth and, therefore to financial security.
Shahbaz *et al*. (2013)	1975-2011	Indonesia	VECM Granger causality technique and ARDL	Financial growth leads to the spread of sustainable energy from renewable energies.
Yazdi and Shakouri (2017)	1992-2014	Iran	Granger's causality test	The causality between green energy use, economic development, and financial success are bidirectional.
Furuoka (2015)	1980-2012	Asian countries	Dumitrescu and Hurlin causality test	A developed financial system does not lead to an increase in energy consumption. An increase in energy consumption was leading to a developed financial system.

Amin and Mahmood (2018)		Bangladesh		Financial development has a positive influence on energy consumption. Energy consumption has a significant effect on improving financial development.

3. Data and Methodology

This research uses annual data for the period 1990-2018. Data on domestic credit to the private area, which is used as a financial development proxy, annual GDP, renewable energy consumption and fossil fuel consumption are obtained from the World Development Indicators (World Bank, 2019).

Following Eren et al. (2019) and Burakov and Freidin (2017), we aim to analyse the model expressed by equation (1).

$$REC_{it} = f(FD_{it}, Y_{it}) \tag{1}$$

In this model, REC_{it} = renewable energy consumption, FD_{it} = Financial development, Y_{it} = GDP (economics growth). Also, we extend our analysis by investigating the relationship between fossil energy and financial development following the same framework. The result of this study will help distinguish between the green and fossil energy impacts of financial growth. Equation (2) shows the model considering fossil fuel energy.

$$FEC_{it} = f(FD_{it}, Y_{it}) \tag{2}$$

We transform the equations (1) and (2) into a log-linear format for the estimation purpose. Equation (3) and (4) shows the log-linear transformation of both the models. One of the advantages of using a log-linear equation is that the estimated coefficients can be expressed as elasticities (i.e., percent change), which is very effective in policy implications. Also, such transformation reduces the skewness that exists in the variables.

$$lnREC_{it} = \alpha + \beta lnFD_{it} + \gamma lnY_{it} + \varepsilon_{it} \tag{3}$$
$$lnFEC_{it} = \mu + \delta lnFD_{it} + \vartheta lnY_{it} + \omega_{it} \tag{4}$$

3.1 Cross-Sectional Dependency Tests

Breusch-Pagan LM (Breusch and Pagan, 1980), Pesaran's Cross-Sectional Dependence (Pesaran, 2004), Pesaran Scaled LM (Pesaran, 2004) tests are applied to investigate possible inter-dependence among the variables within the regions as it has been shown by many studies often data of economic variables are inter-related across the region.

3.2 Panel Unit Root Tests

This paper includes CADF and CIPS suggested by Pesaran (2007). Both measures have a cross-sectional presumption of dependency. The CADF and CIPS testing processes are identical, but the only difference is that CIPS has a cross-cutting sectional average of CADF testing. Let's assume, x_{it} it is the target variable, and ε_{it} is the error, and we can write a normal ADF frame-dependent equation. This is the following equation:

$$\Delta\tau_{it} = \alpha_i + \beta_i \tau_{i,t-1} + \rho_i T + \sum_{j=1}^{n} \theta_{ij} \tau_{i,j-1} + \varepsilon_{it} \tag{5}$$

The first differentiated operator Δ is indicated in equations (5). α and T are both the intercept and the time trend. The null hypothesis of the experiments believed that individuals are not stationary in the panel dataset. For both experiments, at least one individual is stationary in the dataset.

3.3 Cointegration Tests

We have used the Durbin-Hausman test (Westerlund, 2008), one of the second generation panel cointegration tests, and the cross-sectional dependency issue was augmented. In addition, no previous knowledge about the integration order is needed for the Durbin-Hausman evaluation. Two tests are categorised for the Durbin-Hausman method. The Durbin-Hausman Panel (DHp) and the Durbin-Hausman Group (DHg) test are used in this context. The following can be described for both DHp and DHg:

$$DH_p = \hat{S}_n(\tilde{\vartheta} - \hat{\vartheta})^2 \sum_{i=1}^{N} \sum_{t=2}^{T} \hat{e}_{i,t-1} \quad (6)$$
$$DH_g = \sum_{i=1}^{N} \widehat{S_\iota} (\widetilde{\vartheta_\iota} - \widehat{\vartheta_\iota})^2 \sum_{t=2}^{T} \hat{e}_{i,t-1} \quad (7)$$

DH_p tests $H_o: \vartheta_i = \vartheta = 1$ for all cross-sections against $H_1: \vartheta_i = \vartheta < 1$ for all cross-sections in the panel dataset. In the equation (6), $\tilde{\vartheta}$ and $\hat{\vartheta}$ are considered as respectively Pooled IV and pooled OLS estimators. Moreover, $\widehat{S_n} = \frac{\widehat{\omega}^2{}_N}{(\sigma_N^2)^2}$ with $\widehat{\omega}_N^2 = \frac{1}{N}\sum_{i=1}^{N} \widehat{\omega}_i^2$ and $\widehat{\sigma}_N^2 = \frac{1}{N}\sum_{i=1}^{N} \sigma_i^2$. In contrast, DH_g tests $H_o: \vartheta_i = 1$ for all cross-sections against $H_1: \vartheta_i < 1$ for the panel data collection for at least one cross-section. Similar to equation (6), in equation (7) $\widehat{\vartheta_\iota}$ and $\tilde{\vartheta}_i$ are considered as respectively Pooled IV and pooled OLS estimators. Next, let us define that the variance of estimator for $\widehat{S_\iota} = \frac{\widehat{\omega}^2{}_i}{(\sigma_i^2)^2}$ and $\widehat{\omega}_i^2$ is consistent over a long period of time.

The LM Bootstrap panel cointegration test has also been used to check the cointegration relationship. Westerlund (2006, 2005) showed that asymptotic distribution in the panel cointegration test could lead to bias results due to weaker empirical distribution approximation. To address the issue, Westerlund and Edgerton (2007) suggested a new version of LM test of McCoskey and Kao (1998) with the bootstrap application. The following setup can obtain the LM static.

$$LM = \frac{1}{NT^2} \sum_{i=1}^{N} \sum_{t=1}^{N} \widehat{\omega}_i{}^{-2} S_{it}^2 \quad (8)$$

In equation (11), the long-run variance is $\widehat{\omega}_i{}^{-2}$ and S_{it} is the process of a partial sum of $\widehat{e}_{it}$.

3.4 Estimation of Cointegrating Factors

To enhance the cross-sectional dependency assumption, we use the Continuously Updated Fully Modified Estimator (Cup-FM), following Bai et al. (2009). Suppose we have a multifactor model, stationary dependent variables, and a set of m stationary global components.

$$E_{jt} = \gamma Y_{jt}{}^2 + \beta Y_{jt} + \varepsilon_{jt} \to x'_{jt} + \varepsilon_{jt} \quad (9)$$

Where,

$$\varepsilon_{jt} = \lambda'_j F_t + u_{jt} \quad (10)$$
$$x'_{jt} = x'_{j\,t-1} + \epsilon_{jt} \quad (11)$$
$$F_t = F_{t-1} + \eta_{jt} \quad (12)$$

Cup-FMOLS also modifies the traditional panel bias over iterations. By resolving the following two equations iteratively, the Cup-FMOLS can be achieved.
Pesaran et al. (1999) proposed the Pool Mean Group (PMG) panel ARDL model. One of the main benefits of PMG ARDL panel evaluation is that the integration order can be used. In the following equation, the model (p, q) can be defined, wherein T is set to be large enough to match the model for each category.

$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \vartheta'_{ij} X_{i,t-j} + \tau_i + \varepsilon_{it} \tag{13}$$

The design provides the following representation for the correction of errors.

$$Y_{it} = \varphi_i\left(Y_{i\,t-1)} - X'_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q-1} \vartheta'_{ij} X_{i,t-j} + \tau_i + \varepsilon_{it} \tag{14}$$

Where, disequilibrium parameter is characterised by φ i, which captures the long-term shift speed. In this report, we will only examine the effects of a long-term estimate. We have tested potential nonlinearity with the asymmetric ARDL panel (NARDL). This technique has the (if any) influence of positive and negative shocks to explanatory variable on the dependent model variable. ARDL model's asymmetrical variant can be described as follows,

$$\Delta Y_{it} = \tau_i(Y_{i,t-1} - \vartheta_{0i} - \vartheta_{1it}^{+}\varphi_{i,t-1}^{+} - \vartheta_{2i}^{-}\varphi_{i,t-1}^{-} - \vartheta_3\omega_{it}) + \sum_{j=1}^{N1} \lambda_{ij}\Delta Y_{i,t-j} + \sum_{j=0}^{N2} \gamma_{ij}^{+}\Delta\varphi_{t-j}^{+} + \sum_{j=0}^{N2} \gamma_{ij}^{-}\Delta\varphi_{t-j}^{-} + \mu_i + \varepsilon_{i,t} \tag{15}$$

The modification correction speed is in Equation (17) is τ_i, μ_i the basic group effect, further explanatory variables are described by the value ω_{it}, and φ^{+} and φ^{-} are the positive and negative shocks to every variable of explanation φ^{+} and φ^{-} is defined as follows,

$$\varphi_t^{+} = \sum_{k=1}^{t} \Delta\varphi_{i,k}^{+} = \sum_{k=1}^{t} \max(\Delta\varphi_{i,k}, 0) \tag{16}$$
$$\varphi_t^{-} = \sum_{k=1}^{t} \Delta\varphi_{i,k}^{-} = \sum_{k=1}^{t} \min(\Delta\varphi_{i,k}, 0) \tag{17}$$

The Dynamic OLS (DOLS) was expanded to Kao and Chiang for panel analysis (2001). The outcome of the estimate is the following equation.

$$Y_{it} = \beta_i X_{it} + \sum_{j=-q}^{q} \vartheta_{ij} \Delta X_{it+j} \delta'_{li} D'_{li} + \varepsilon_{it} \tag{18}$$

Here q indicates the lag or lead order that is usually selected by info criteria. The benefit of DOLS is the monitoring of endogenousity in the model by increasing the correct lead and lagged differences of the variables. . Throughout addition, a similar trend in time helps address cross-sectional dependence problems (Mark and Sul, 2003).

3.5 Dumitrescu -Hurlin Panel Causality Test

Following confirmation of the cointegrating relationships and estimation of long-lasting elasticities, the causality test Dumitrescu-Hurlin is used to validate the causality of the variables involved. In the case of cross-dependence, this test enables parameter coefficients to shift throughout the cross-sections in a reasonable small data panel collection (Dumitrescu and Hurlin, 2012). The test is applied to an uneven and heterogeneous model and to situations in which T>N or T<N are applied.

The null hypothesis is defined as $H_0\colon \beta_i = 0$ implying that no homogeneous Granger Causality for the cross-sectional units.

Otherwise, $H_1\colon \begin{Bmatrix} \beta_i = 0 & \forall_i = 1,2, \ldots \ldots \ldots . N \\ \beta_i \neq 0 & \forall_i = N+1, N+2, \ldots \ldots \ldots . N \end{Bmatrix}$ assumes no less than a causal link in the information. It also limits strongly the number of the panel units identifying the conclusion that such a null hypothesis was rejected

4. Empirical Results

4.1 Cross-Sectional Dependency Tests

In Table 2 below, we can see that the selected variables have cross-sectional dependency across the countries according to Breusch-Pagan LM and Pesaran scaled LM. We can say that no cross-sectional dependency can be found only in the Pesaran CD test for model 1, but the test suggests inter-dependency in model 2's variables.

Table 2: Cross-Sectional Dependency Tests

Tests	Test Statistics Model 1	Test Statistics Model 2
Breusch-Pagan LM	283.1447***	168.79***
Pesaran scaled LM	48.95630***	35.51***
Pesaran CD	-1.521657	1.92**

*Note: The confidence rate of 99% and 95% is marked with *** and ** respectively. The null hypothesis for these experiments is that residuals are not reliant on the alternate hypothesis of cross-sectional dependency of residuals.*

4.2 Panel Unit Root Test

The stationary measurement of Pesaran CADF and CIPS unit root test variables is highlighted in Table 3. Both experiments show that both variables are stationary at the first difference but non-stationary at levels. It implies that variables follow I (1) process.

Table 3: Panel Unit Root Test

CIPS

Variable	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
LNFD	-2.084	-1.714	-4.423***	-4.336***
LNREC	-1.919	-2.519	-5.223***	-5.152***
LNGDP	-1.86	-2.12	-4.59***	-5.10***
LNFEC	-2.45	-2.78*	-5.96***	-6.01***

CADF

Variable	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
LNFD	-0.701	1.677	-2.871***	-1.350*
LNREC	0.142	-0.752	-1.878**	0.053
LNGDP	-1.67	-2.23	-2.48**	-3.18***
LNFEC	0-.90	-1.20	-2.33*	-3.12**

*Note: 99% and 95% confidence rates are marked with *** and **, respectively. Critical values are not stated, but may be delivered on request for reasons of brevity.*

4.3 Cointegration Test

To see that if our variables from both models are cointegrated in the long-run, we have conducted Durbin-Hausman and LM Bootstrap panel cointegration tests. When we look at Table 4, we claim that variables are cointegrated in the long-run. The results allow us to investigate the long-run granger causality as well as estimation of long-run coefficients of the concerned variables.

Table 4: Panel Cointegration Test Results

Model	LM Bootstrap Test		Durbin-Hausman Test	
	Intercept	Intercept and Trend	DH_Group	DH_Panel
Model 1	22.34	25.08	8.93***	10.60***
Model 2	10.34	9.08	2.93*	6.60**

*Note: The confidence rate of 99%, 95% and 90% is marked with ***, ** and * respectively.*

4.4 Estimation of Cointegrating Factors

To find out what kind of effect GDP and developed financial system will have on renewable energy consumption in the long-run, we have used the PDOLS, PMG ARDL, and FMOLS. Looking at the results obtained in Table 5, we can see a non-linear effect of GDP on renewables energy consumption (inverted 'U'). We find that a 1% increase in GDP will lead to an increase in renewable energy consumption; however, the square term of GDP will decrease the renewable consumption. The estimated GDP coefficients for renewable energy consumption stay between 1.56 and 0.50, and the coefficient of squared GDP stays between -0.03 to -0.01. Then again, a 1% increase in financial development will decrease renewable energy consumption, where the coefficient of financial development ranges between -0.15 and -0.07.

On the other hand, the effect on fossil energy use by GDP and financial growth can be seen in Table 6. According to the PDOLS, PMG ARDL, and FMOLS estimation results, a 1% increase in GDP will lead to an increase in fossil energy consumption by 4.20%, 2.17%, and 1.75%, respectively long-run. It is also worth mentioning that similar to the renewable energy model, an increase in squared GDP will reduce fossil energy consumption, indicating a non-linear relationship. The coefficients of the squared GDP as per the PDOLS, PMG ARDL, and FMOLS are -0.01, -0.03, and -0.02. Besides, financial development is positively associated with fossil energy consumption. 1% increase in financial development will boost fossil energy consumption by 0.28%, 0.25%, and 0.22%, respectively, as per the PDOLS, PMG ARDL, and FMOLS estimation methods.

Table 5: Estimation of Cointegrating Factors of Model 1

Variables	PDOLS	PMG ARDL	FMOLS
LNGDP	0.50 (0.16)***	1.56 (0.66)**	0.85 (0.13)***
$LNGDP^2$	-0.01 (0.001)***	-0.03 (.0.1)**	-0.02 (0.002)***
LNFD	-0.15 (0.02)***	-0.12 (0.02)***	-0.07 (0.001)***
Inflection Point for GDP [exp (β1/2β2)]	19.87	23.78	19.96
Turning Point	0.42	21.25	0.47

*Note: The confidence rate of 99%, 95%, and 90% are marked with ***, **, and *, respectively. Itandard errors are in parenthesis. The Error Correction Term (ECT) for ARDL (PMG) is -0.36**. Turning point values are in constant billion (2010 USD).*

Shukla et al. (2017) have shown that most South Asian countries depend on fossil fuel for electricity generation, such as Bangladesh, India, Pakistan, and Sri Lanka. We argue that since these South Asia countries depend heavily on traditional energy for most economical and household activities, an advanced financial structure would eventually lead them to further invest in the traditional system to ensure better access to electricity rather than renewable energy. Hence, growth in financial progress will harm the use of renewable energy unless there is a systematic change in the energy policy orientation.

Table 6: Estimation of Cointegrating Factors of Model 2

Variables	PDOLS	PMG ARDL	FMOLS
LNGDP	4.02 (2.17)*	2.17 (1.17)*	1.75 (0.25)***
LNGDP^2	-0.07 (0.04)*	-0.03 (0.02)*	-0.03 (0.004)***
LNFD	0.28 (0.07)***	0.25 (0.06)***	0.22 (0.02)***
Inflection Point for GDP [exp (β1/2β2)]	25.47	27.94	28.11
Turning Point	115.28	1368.63	1624.74

*Note: The confidence rate of 99%, 95% and 90% is marked with ***, ** and *, respectively. Standard errors are in parenthesis. The Error Correction Term (ECT) for ARDL (PMG) is -0.23**. Turning point values are in constant billion (2010, USD)*

Following Rafiq and Bloch (2016), we also use the NARDL to verify if financial development has an asymmetric impact on the level of energy consumption. To simplify, estimators like PDOLS, PMG ARDL, and FMOLS only show how changes in the financial development will influence the consumption of renewable and fossil energies symmetrically; however, sometimes, because of asymmetric effect resulting from uncovered components, the result of positive and negative effect may not be the same. Table 7 illustrates the impact on the level of long-run renewable energy use and fossil fuel consumption from both the positive and negative components of financial development. We can see that a positive shock of financial development will decrease renewable energy consumption by 0.10%, and a negative impact of financial development will increase renewable consumption by 0.13%. However, the asymmetrical impact on the use of renewables due to financial development is not valid because the Wald tests of equality support the null hypothesis of symmetric effect. We can reject the null hypothesis of symmetric effect with a 10% significance level for fossil fuel consumption. According to the estimates, a positive shock of financial development will increase fossil energy consumption by 0.22%, whereas a negative shock will reduce the consumption of fossil energies by 0.09% in the long-run.

Table 7: Panel NARDL Estimation

Variables	Model 1	Model 2
LNGDP	1.20 (0.61)***	0.07 (1.05)
LNGDP^2	-0.02 (0.01)**	-0.001 (0.02)
LNFD$^+$	-0.10 (0.01)***	0.22 (0.06)***
LNFD$^-$	-0.13 (0.04)***	0.09 (0.04)**
Inflection Point for GDP [exp (β1/2β2)]	23.03	25.84
Turning Point	10.11	166.45
W_{LR} (Openness$^+$= Openness$^-$)	1.76	2.54*
ECT	-0.41***	-0.38***

*Note: The confidence rate of 99%, 95% and 90% is marked with ***, ** and *, respectively. tandard errors are in parenthesis. Turning point value is adjusted in USD (constant in 2010 USD).*

By analysing panel data, we have identified the correlation between our variables however not every nation can have identical co-integrated relationships because of the effect of unobserved components (Westerlund et al., 2015).[1] Therefore, we aim to review the cointegrated linkage between our variables at the country level for further robustness check of our results by following the discussion of Salim et al. (2019); from Table 8, we can see the country-level NARDL and ARDL long-run estimation results. We can see that in all the nations co-integration exists at varying levels of importance.[2] In addition, both ADRL and NARDL estimates indicate negative and substantial error correction conditions (or adjustments speed) in different levels; however, they vary across the countries. From renewable energy's perspective (model 1), all the countries show the asymmetric relationship among the variables of interest, suggesting similarity with the conclusion of our panel NARDL results reported in Table 7. According to the estimated results, a 1% increase in financial development will decrease renewable energy consumption by 0.43%, 0.36%, 0.21%, 0.14%, and 0.11% for Bangladesh, India, Pakistan, Nepal, and Sri Lanka, respectively and vice versa.

On the other hand, none of the countries has asymmetric effect except Bangladesh for financial development and fossil energy consumption (model 2), which gives the intuition of a weak level of asymmetric effect in the panel NARDL in Table 7. For the case of Bangladesh, the asymmetric effect is present at a 1% significance level. A positive shock of financial development will increase fossil energy consumption by 0.34%, and a negative will reduce fossil energy consumption by 0.24%. We argue that a relatively smaller effect of the negative shock of financial development is due to consumer reluctance due to their preference and high skewness of fossil fuel in the primary energy mix. On the other hand, a 1% increase in financial development will symmetrically increase fossil energy consumption by 0.04%, 0.11%, 0.16%, and 0.17% for India, Pakistan, Nepal, and Sri Lanka. However, it is worth mentioning that for India, the coefficient is not significant.[3]

[1] Even if one or some cross-sections do not show a cointegration relationship, it has been shown that inference from the panel estimations tends to be valid.

[2] We consider Autoregressive-Distributed Lag (ARDL) Bounds test procedure.

[3] We suspect one of the possible reasons behind such an outcome is the relatively smaller country-specific data coverage (1990-2018), which is only 28 years.

Table 8: Country-Level NARDL and ARDL Estimations

Variable	Model 1: NARDL	Model 1: ARDL	Model 2: NARDL	Model 2: ARDL
Bangladesh				
LNGDP	0.47 (0.69)***	0.61 (0.06)****	8.28 (3.34)**	0.36 (0.05)***
$LNGDP^2$	-0.01 (0.002)***	-0.01 (0.003)***	-0.14 (0.06)**	-0.01 (0.002)***
LNFD		-0.43 (0.09)***		0.49 (0.06)***
$LNFD^+$	-0.51 (0.08)***		0.34 (0.08)***	
$LNFD^-$	-0.53 (0.26)*		0.24 (0.13)*	
W_{LR}	0.01		17.25***	
ECT	-0.82***	-0.67***	-0.83***	-0.43***
Cointegration	3.93*	4.78**	4.10*	16.82***
India				
LNGDP	-2.38 (7.13)	-8.63 (4.44)*	0.49 (0.20)**	4.52 (1.55)***
$LNGDP^2$	0.05 (0.12)	0.15 (0.07)*	-0.01 (0.01)*	-0.07 (0.27)***
LNFD		-0.36 (0.16)**		0.04 (0.06)
$LNFD^+$	-0.66 (0.48)		0.33 (0.18)*	
$LNFD^-$	0.99 (1.55)		-1.06 (0.73)	
W_{LR}	0.69		1.21	
ECT	-0.24*	-0.34**	-0.16*	-0.33**
Cointegration	4.22*	5.45**	3.19*	5.04**
Pakistan				
LNGDP	0.44 (0.09)***	0.58 (0.04)***	4.99 (1.81)**	0.20 (0.020)***
$LNGDP^2$	-0.11 (0.004)***	-0.02 (0.001)***	-0.09 (0.03)**	-0.001 (0.009)
LNFD		-0.21 (0.03)***		0.11 (0.03)***
$LNFD^+$	-0.34 (0.11)***		0.02 (0.29)	
$LNFD^-$	-0.20 (0.04)***		0.10 (0.02)***	
W_{LR}	1.26		1.07	
ECT*	-0.91***	-0.78***	-1.34***	-0.57***
Cointegration	5.86***	6.46***	7.38***	3.84*
Nepal				

LNGDP	0.24 (0.10)**	0.30 (0.07)***	1.53 (0.89)*	1.14 (0.83)*
$LNGDP^2$	-0.001 (0.005)	-0.002 (0.003)	-0.06 (0.04)*	-0.05 (0.03)
LNFD		-0.14 (0.05)**		1.16 (0.59)*
$LNFD^+$	-0.13 (0.05)**		1.17 (0.43)**	
$LNFD^-$	0.11 (0.04)***		0.96 (0.28)***	
W_{LR}	0.15		0.15	
ECT	-0.89***	-0.55***	0.86***	-0.30**
Cointegration	4.18*	3.87*	4.47**	3.68*
Sri Lanka				
LNGDP	0.50 (0.06)***	0.48 (0.02)***	0.28 (0.16)*	17.23 (5.85)***
$LNGDP^2$	-0.13 (0.003)***	-0.12 (0.001)***	-0.01 (0.008)	-0.35 (0.11)***
LNFD		-0.11 (0.03)***		0.17 (0.06)***
$LNFD^+$	-0.08 (0.03)**		0.15 (0.08)*	
$LNFD^-$	0.17 (0.16)		-0.16 (0.39)	
W_{LR}	0.36		0.58	
ECT	-0.94***	0.74***	-0.47***	-0.68***
Cointegration	4.90**	4.52**	5.93***	4.25*

*Note: The confidence rate of 99%, 95% and 90% is marked with ***, ** and *, respectively. Standard errors are in parenthesis. ECT (model 2) of Pakistan is more than 1 per cent, indicating instability of the economic system. Following Salim et al. (2019), we argue that the reason behind such a result is the lack of observation.*

4.5 Dumitrescu -Hurlin Panel Causality

After analyzing the marginal effects on response variables of the explanatory variables, we now examine the long-term relationship among variables. From Table 9, we can say that there is a unidirectional causal relationship from GDP to financial development but not vice versa. Then we can see a unidirectional causal relationship from financial development to renewable energy and fossil energy consumption. A lot of previous studies Lin et al. (2015), Rasoulinezhad and Saboori (2018), Eren et al. (2019), Burakov and Freidin's (2017), Shahbaz et al. (2013), Scholtens and Veldhuis (2015) have ensured these relationships. Furthermore, we observe that the causal relationship from GDP growth to renewable energy consumption is unidirectional, indicating the conservation hypothesis. However, we find evidence of growth hypothesis in the case of fossil energy and GDP. The long-run causality results also justify our proposed models are robust as there is no indication of reverse causality among the dependent and independent variables.

Table 9: Dumitrescu -Hurlin Panel Causality Test Results

Null Hypothesis	W-Statistic
LNGDP does not homogeneously cause LNFD	6.98^{**}
LNFD does not homogeneously cause LNGDP	4.16
LNREC does not homogeneously cause LNFD	4.09
LNFD does not homogeneously cause LNREC	8.32^{***}
LNREC does not homogeneously cause LNGDP	2.72
LNGDP does not homogeneously cause LNREC	5.78^{*}
LNFEC does not homogeneously cause LNDCPS	3.23
LNFD does not homogeneously cause LNFEC	8.02^{***}
LNFEC does not homogeneously cause LNGDP	4.45^{*}
LNGDP does not homogeneously cause LNF	3.44

*Note: The confidence rate of 99%, 95% and 90% is marked with ***, ** and *, respectively.*

5. Conclusion

It is worth noting that energy is a critical component of global economic growth. However, the way energy is being consumed (i.e., the skewness towards fossil energy) harms the environment, and day by day it's becoming costly. That's why it is essential to shift our consumption from traditional sources to renewable sources of energy. Since better financial structure increases the potentiality of new business and development of different commodity industries, this paper deals with the fundamental link in the Southern Asian countries between 1990 and 2018 between financial development and the use of renewable energy.

Given the stationary properties and cross-dependencies, empirical evidence suggests that financial development, energy consumption, and economic growth are cointegrated in the long run. We have identified unidirectional relationship from GDP to financial development and financial development to renewable and fossil energy usage in the long-run. From the long-run estimation results, it has been revealed that financial development is negatively associated with renewable energy consumption but positively associated with fossil energy consumption. A 1% improvement in financial development will tend to increase fossil energy consumption by 0.25% on average; however, it will reduce renewable energy consumption by 0.11% in the long-run. Country-level time series analysis was also done to fortify the panel results.

The results of this paper have some consequences for South Asian countries' investment-related economic policies and the renewables industry as it has brought a certain degree of insight from the financial development-energy nexus perspective. The negative relationship between financial development and renewable energy consumption indicates a gap in the renewable energy development policies. Apart from domestic renewable energy development agendas, Rafiq et al. (2016) and Pan et al. (2019) argue that strategies such as liberal trade regimes (bilateral or multilateral) and tailored financial incentives for clean technology and accelerating renewable energy should be considered. Furthermore, we propose that a regional integrated renewable energy act can be established through technical assistance, through the use of standard rules, sharing information and cooperating with other Southern Asian renewable firms. It can facilitate regional cooperation on the development of renewable energy for all selected South Asian countries.

Nevertheless, achieving greater success while executing the discussed policies, following Imam et al. (2019) we argue on the institutional robustness in the intuitional setup needs to be ensured given the common trait, which have been discussed in the earlier studies. Among others, Cai and Aoyama (2018); Vijay et al. (2015), and Ghafoor et al. (2016) show that an absence of a central system's administrative authority (i.e. fragmentation) prevents, and slows the formulation of the appropriate regulatory regime and execution framework. Furthermore, potential investments, especially in clean energy and demand side management also fall out due to lack of improper administrate mechanisms(Mittal et al., 2018, Amin et al., 2021). As the renewable energy augmentation process accelerates, detailed mechanisms and different financial schemes should be prepared so that financing on the renewable energy projects become less stringent.

An analysis of financial development and the connection between renewable energy at the disintegrating level may further this paper. Such analysis can provide meaningful insights on how financial development in the selected South Asian countries influences the consumption pattern of different types of renewable energies. Based on the results, different financial models can be prepared to boost the renewable energy industry development process. On the other hand, region-wise comparison of the relationship can be another avenue of extension that can reveal the differences in the energy policy regimes taken by the governments.

Ethical Approval

Ethical approval is not applicable for this paper since the analysis does not involve any test on animals or human subjects.

Consent to Participate

Consent to participate is not applicable for this paper due to the nature of the analysis. This is a purely empirical paper using secondary macroeconomic data.

Consent to Publish

Consent for publication is not applicable for this paper since the paper does not use any data or other instruments prepared by other individuals.

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Authors declare no conflict of interest.

Authors Contribution

SA generated the idea of the paper, formulated theoretical framework, conducted empirical part, and supervised the paper. FK conducted the empirical part, reviewed literature, and prepared parts of the paper. AR conducted the empirical part, reviewed literature, and prepared parts of the paper. All authors read and approved the final manuscript.

Availability of Data and Materials

The dataset of different variables generated and/or analysed during analysis are available in the World Development Indicators (WDI) repository.
Please follow the link: https://databank.worldbank.org/source/world-development-indicators

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