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Sustainable financial inclusion as a source of green environment? Evidence from selected regional comprehensive economic partnership countries

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ABSTRACT

The role of sustainable financial inclusion is considered crucial for attaining energy efficiency. It is vital for acquiring low carbon energy sources for an economy. This study attempt to integrate financial inclusions as a major defining factor of efficient energy combined with the role of economic growth, environment-related technologies, and the human capital index for RCEP countries from 2004 to 2019. The Westerlund error correction cointegration test is adopted for co-integration purposes, while the augmented mean group (AMG) method is carried for short-run and long-run analysis, and the dynamic ordinary least square (DOLS) test is used to ensure the robustness of the model. The outcomes indicate that financial inclusion induces a positive impact on renewable energy efficiency and ensures low energy sources for RCEP economies. Further, the role of economic growth, environment-related innovation, and human capital is also important for achieving energy efficiency. Furthermore, in the short-run, the Dumitrescu and Hurlin (*Economic Modelling*, 29(4), 1450–1460, 2012) panel heterogeneous non-causality test underscores causal bi-directional relationship among these variables. Based on these findings, the policymakers ensure improvement in the financial system and promote financial inclusion to increase energy efficiency and improve their citizen's living standards.

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1. Introduction

Financial inclusion enhances energy efficiency through developing new markets and raising funds for clean energy products that are both economical and replicable, primarily for lighting and cooking in impoverished countries. Financial institutions, in collaboration with states and other bodies, could serve an important in funding and deploying enhanced energy products. Besides efforts to educate customers on the potential and viability of clean energy products, rendering the items physically

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accessible, and funding product purchases, a system of financial institutions may pull ahead in the finance and marketing of sustainable energy devices (Boutabba et al., 2020).

The process of expansion is inextricably linked to financial development. Financial inclusion is an important aspect of financial growth since it helps financial sectors and institutions grow. Financial inclusion is a notion that has been around since the early 2000s, when research identified financial exclusion as a key source of poverty (Chibba, 2009; Liu et al., 2021; Schumacher et al., 2020).

Sustainable financial inclusion (FIN) is considered important for achieving low carbon energy sources and ensuring energy efficiency. FIN is not a narrow area, it incorporates many financial sectors and the role of these sectors is crucial in achieving a sustainable environment. The FIN phenomenon means access of businesses and individuals to financial services i.e., in terms of investment, transfer, transaction, insurance and credit (Bank, 2018). FIN, recover individual's lives, support businesses and enable economies to build renewable energy technologies for both generation and consumption. Businesses through FIN gain higher profits, competitiveness and growth which can more easily increase renewable shares and reduce transaction costs. However, there is still a long way to access clean sources of energy in some countries, and for wider adoption of renewable energy, technology requires the upfront cost of investment and a high level of financial inclusion for Regional Comprehensive Economic Partnership (RCEP) countries. Recently, the financial service provider was involved in demonstration projects to smooth financial services access for renewable energy sources. Subsequently, FIN has a positive impact on return and substitutes the costly traditional energy with reliable and affordable sources. An adapted financial system could overcome the financial barriers and offer specific loan packages for access to renewable energy products.

A stable economy enables improvement and achieves sustainable growth in different macro sectors i.e., household, business, government, energy, foreign trade and the international finance sector (Cui et al., 2022; Shahzad et al., 2022). More precisely, the renewable energy and economic growth relation contested extensively among scholars and reached a conclusion; that, sustainable GDP growth creates opportunities to invest more in renewable energy sector (Taghizadeh-Hesary et al., 2021). Recently, industrialized and emerging economies increased their interest to enrich renewable sources by investing in solar, wind, hydro, biomass and geothermal power. These substantial interests are better poised to prosper from technological advancements and largely bestowed with a naturally dispersed renewable source (Shahzad et al., 2021). Thus, many developing countries experience adequate, reliable and affordable energy, in conformity with social and environmental requirements (Ghazouani et al., 2021; Rafique et al., 2021).

Similarly, environment-related technologies (ERTI) have a significant impact on energy consumption both in long run and short run. Economies are more stimulated by ERTI, which increases in renewable energy consumption of industries, businesses and households. ERTI includes; waste-to-energy, recycling, elimination of industrial emissions, natural gas boilers, emit free vehicles and waves energy generation (Ji et al., 2021a; Rizvi et al., 2021). Literally, ERTI affects the increase in demand for

renewable energy, since most of these technologies are formed from renewable sources and ultimately help to protect the environment. This condition leads to high demand of renewable energy consumption in developed economies (Paramati et al., 2022; Shahzad et al., 2022).

At the micro-level, the evidence is exit that human capital Index (HCI) reduces aggregate energy consumption, i.e., well-educated individuals/families are more environmentally responsive, denotes they are consuming less energy and in the same way, firms with well-skilled management are more energy efficient (Fatima et al., 2021; Shahzad et al., 2020). This relation is mediated via technology, income and input complementarity. Likewise, rapid economic growth leads to encouraging renewable energy commercial viability to meet market demand. As such, human capital would have a significant impact on renewable energy use through the income channel (Mirza et al., 2020a; Yao et al., 2019).

This study focuses on RCEP countries (Australia, China, South Korea, Japan, New Zealand, Singapore, Thailand, Vietnam, Philippines, Myanmar, Indonesia, Laos, Malaysia, Cambodia and the Brunei-Darussalam), which collectively account for about 29% (\$25.8 trillion) of global GDP, 30 per cent (\$2.3 billion) of the world's population and 25 per cent (\$12.7 trillion) of international trade in goods and services. The RCEP create the world's leading trading bloc and set the stage for participants to integrate their economies more deeply. The members also use its policies as a steppingstone for pursuing economic changes and increasing industrial competitiveness. Members of the RCEP are expected to earn \$174 billion in actual income by 2030, which is equal to 0.4 percent of the members' combined GDP. The plus three countries would profit the most, with the PRC likely to reap \$85 billion, Japan \$48 billion, and the Republic of Korea \$23 billion. Other countries that would benefit significantly from the RCEP include Indonesia, Malaysia, Thailand, and Vietnam. The RCEP would also result in significant new trade between the plus three countries. The ASEAN countries' free trade deals with non-ASEAN countries come before RCEP, and ASEAN's already substantial economic convergence means that the marginal gain of RCEP for trade between them will be minimal (Kang et al., 2020; RCEP, 2019).

The importance of financial inclusion cannot be neglected because this facilitates day-to-day life, as well as guiding families and businesses with planning for anything from long-term goals to crises. People with bank accounts are abler to use other financial resources such as; insurance credit, expand the business, invest in education or health, mitigate risk and respond to financial shocks which ultimately improve overall life quality. Since 2010, over 55 economies have pledged to promote financial inclusion with more than 60 lunching or implementing national strategies (Bank, 2018). Some previous studies studied the impact of financial inclusion on climate change, economic growth, poverty, energy poverty and financial efficiency (Le et al., 2019; T. H. Le et al., 2020). However, there is no empirical study found that explored the relationship between financial inclusion and renewable energy efficiency or generation either for RCEP or other countries. Therefore, this study aims to investigate the impact of financial inclusion on renewable energy consumption in the presence of GDP, environment-related technologies and human capital index for RCEP

economies covering 16 years from 2004 to 2019. Our study contributes to the existing literature threefold. First, the study used financial inclusion index as an influential factor and examine its impact on renewable energy efficiency for RCEP economies. Second, utilized latest panel data set for RCEP economies because these countries have free trade agreement (FTA) which significantly adds to financial services and both non-renewable and renewable energy consumption. Third, we also used environment-related technologies, GDP growth and human capital index in explaining renewable energy consumption. To achieve aforesaid objectives an advanced panel data method is carried out, the Pesaran (2004) test is used for cross-section dependence, while Pesaran and Yamagata (2008) method is to see slope homogeneity and Pesaran (2007) panel unit root test is employed for stationarity of the data. Westerlund (2007) test is adopted for testing long-run relations among understudy consider variables. For the long-run estimation augmented mean group (AMG) is used along with dynamic ordinary least square (DOLS) for robustness check. Finally, Dumitrescu and Hurlin (2012) causality technique gauges the causal relationship between renewable energy and its determinants. The long and short-run estimates indicate that financial inclusion, GDP, environment-related technologies and human capital index encourage renewable energy consumption.

The rest of the article is structured as follows. A review of the literature is given in Sec. 2. Methodology and data are covered in Sec. 3. Estimation techniques are addressed are in Sec. 4, while results discussion is presented in Sec. 5. Finally, Sec. 6 includes the study conclusion and provides policy recommendations.

2. Literature review

Financial inclusion is becoming significant in the development process of renewable sources due to rapid changes in banking system and globalization of economies around world. The rising demand for renewable energy is supplemented via well-functional financial system and a number of former studies inquire the impact of financial inclusion on growth, energy poverty, income inequality and poverty. However, academic research on the effect of financial inclusion in renewable energy consumption is scant. In this section we attempted to recap the previous literature in terms of financial inclusion and renewable energy consumption.

For instance, Emara and El Said (2021) studied financial inclusion and economic growth relation through general method of moments technique with the role of governance from 1990 to 2018 for 44 emerging markets and MENA countries. The study found that financial inclusion induces a positive impact on GDP growth but requires regulatory supervision with the patronage of the decree of law, contract enforcement, and control of corruption, political stability and judicial independence. Further, the results indicate that firms' access to finance is based on strong institutions, and improved governance will help MENA region to increase access financial to services.

Similarly, Vo et al. (2021) analyzed the linkage between financial inclusion and financial market stability for 3071 banks from 2008 to 2017 in Asian region. The paper indicates that higher-level financial inclusion achieves financial stability in banking sector, leading to superior bank resilience. In addition, financial inclusion

reduces cost, increases revenue and enlarges bank's market share. Additionally, Dogan et al. (2021) examined financial inclusion effect on energy poverty for Turkey using the 2108 household budget and consumption expenditure surveys. The study concluded that financial inclusion alleviates energy poverty significantly in female-headed family, while through health and income financial inclusion influence energy poverty. Based on the estimation results Vural (2021) explored the impacts of economic growth, trade, technological innovation and pollution on renewable energy production for selected Latin American economies over the period 1991 to 2014. The author specified that technological innovation, GDP per capita and trade carry positive significant impact on renewable energy per capita production.

Wang et al. (2021) studied the impacts of financial development and economic growth on renewable energy consumption for China during the period 1997 to 2017. The results indicate that financial development alleviates while economic growth stimulates renewable energy consumption, while short-run relationships, on the other hand, suggest that economic growth and financial stability have opposing effects on green energy demand. To check financial development effect on renewable energy consumption Anton and Afloarei Nucu (2020) investigated panel data for 28 European Union countries from 1990 to 2015 by employing fixed-effect model. They perceived that all three dimensions i.e., bond market, banking sector and capital market positively affect renewable energy shares.

Additionally, the findings indicate that the growth of financial markets has little effect on green energy use in the new EU associate States. Similarly, in case of global 55 countries T. Le et al. (2020) analyzed the connection of financial development and renewable energy deployment through a generalized method of moments (GMM) from 2005 to 2014. The study observed that financial development is determined renewable energy deployment, and this effect is insignificant for low and middle-income while significant for high-income but countries. Ji and Zhang (2019) investigated the importance of financial development on renewable energy growth used macro-level data for China. The study concluded that financial improvement efficiently contributes to renewable energy growth, while capital market demonstrated is the most important factor.

Su et al. (2021) examined panel data set through cross-section augmented autoregressive distributed lag (CS-ARDL) method for OECD economies from 1990 to 2018 and considered the role of eco-innovation and fiscal decentralization in renewable energy growth. They found that, eco-innovation and fiscal decentralization encourage renewable energy consumption. Li et al. (2020) looked at the various determinants of renewable energy consumption, such as energy productivity, energy prices, human capital and eco-innovation for OECD economies over 1990 to 2017. The author concluded that, eco-innovation, human capital, energy productivity and energy prices are key elements elucidating renewable energy consumption.

Some scholars went on to explain the role of financial inclusion and its linkages and conduits for fostering a healthier environment. It is also believed that green finance is helping to achieve environmental quality and increase the renewable energy efficiency for instance; Ferrat et al. (2021), Naqvi et al. (2021), Ji et al. (2021b), and Ielasi et al. (2018).

On the heterogeneous effect between eco-innovation, human capital, renewable energy consumption Khan et al. (2020) analyzed the case of G-7 countries over 1995 to 2017 by employ augmented mean group (AMG) and cross-section autoregressive distributed lags (CS-ARDL) method. The empirical findings supported that renewable energy is enhanced by human capital, eco-innovation, energy prices, and R&D investments, while financial growth reduces renewable energy consumption. Most recently, Eren et al. (2019) investigated financial development and economic growth impact on renewable energy consumption for India during the period 1971 to 2015. Their findings revealed that financial development and economic growth have a positive significant impact on renewable energy consumption. Moreover, the findings of the causality test indicate that renewable energy consumption is motivated by financial development, and there is bi-directional causal relationship between renewable energy consumption and economic growth in India.

The majority of the research studies are attributed to renewable energy consumption, as derived from the aforementioned literature. Several studies examined financial development and renewable energy consumption. For instance, Tao et al. (2022), Anton and Afloarei Nucu (2020), Ji and Zhang (2019), Vo et al. (2021), and Wang et al. (2021) financial inclusion, human capital, GDP growth and eco-innovation technologies and renewable energy consumption. None of the studies, however, looked at the effect of financial inclusion on renewable energy consumption in RCEP economies.

3. Methodology and data

3.1. Theoretical framework

This portion describes the theoretical mechanism by which financial inclusion, GDP, environment-related technologies as along with human capital, influence renewable energy consumption. Renewable energy consumption shield the proportion of gross domestic energy usage from renewable sources to overall gross inland primary energy consumption measured for a calendar year (IEA, 2020). This determines business with sustainability building renewable production by constructing particular facilities i.e., solar panels and wind farms, acquiring power purchase contracts and renewable energy certificates (RECs) for procuring renewable energy electricity.

According to the theoretical argument, renewable energy growth increases energy efficiency while branching out the energy atmosphere and dropping non-renewable energy production and Carbon footprint. The rise in renewable investment and use is linked to rapid economic prosperity, financial liberalization and capital stock acquisition resulting from multiple structure reforms and political revolutions over the last four decades (Koengkan, 2018; Koengkan et al., 2020). Energy schemes generally demand large sums, which procedures in developing countries, in turn, can hardly afford on their own. In particular, financial inclusion is strongly tied to funding renewable energy (Mirza et al., 2020b).

In principle, financial inclusion might have both negative and beneficial consequences on CO₂ emissions. On the one hand, financial inclusion empowers firms and individuals to get wide facilities to effective and economical financial plans, making

green technology investments more realistic. In this context, diverse financial systems have a constructive impact on nature by expanding access, availability, and adoption of improved environmental policies that lessen climate change contributions. Financial development is plainly an intrinsic part of the growth cycle, and financial inclusion is an integral aspect of financial development. Financial development stimulates the economy, which has a constructive influence on efficiency. Access to financial entities can also reduce energy usage by enabling individuals and organizations to obtain credit, which encourages investment and increases demand for energy-related items. Conversely, financial inclusion brings economic units to provide more energy-efficient operations and commodities. Financial inclusion enhances the viability of adopting green technology by providing easy access to financial schemes, and by promoting financial inclusion, clean energy technology can be reached, because integrated financial institutions have a wider influence on environmental practices (T. H. Le et al., 2020; Liu et al., 2021; Umar et al., 2021b; Zhang et al., 2021).

When it comes to, RE projects do have a substantial setup cost compared to projected monetary yields and pay-back times entailing durable maturity loans. As an outcome, major regional and global donors opted out energy project financing and investment in this field has writhed to take off again (Tharakan et al., 2007; Tirpak & Adams, 2008). Lack of financial inclusion delays the financing renewable projects and creates a twofold problem: firstly, firms seek for long-term loans for renewable energy which are inversely proportional on the banking system development. The banking system is the primary source of funding in developing economies and access to credit mainly for small-and-medium firms is a severe problem. Secondly, renewable technology ventures contend against fossil fuel projects, which have a lower up-front cost, stronger proven record faster lead times and often favorable government enforcement, thus financial inclusion removes the financial obstacles for national and multinational firms to finance renewable projects (Brunnschweiler, 2010; Naqvi et al., 2021).

Additionally, a well-functioning and unregulated financial inclusion should be critically valuable for credit allocation to renewable projects in developing economies, where capital markets are indeed limited and bond or stock finance is challenging or hard to obtain. Financial inclusion is might guarantee renewable energy promotion and the existence of sufficient funding frameworks should be seen in the light of a well-designed RE policy system (Ji et al., 2021b). Similarly, the extent of the impact of GDP on renewable energy adoption is determined by the country's economic structure, the affordability of conventional energy sources (e.g., energy technology costs fossil fuel prices,) and whether the required equipment and resources are imported or domestically sourced. According to the economic mechanism inspired by modern contract theory, a mature financial system can solve moral hazards and adverse selection issues, lowering firms' cost of raising foreign capital. Moreover, evidence found that investment in clean energy technologies or any other technology will have a greater positive impact if the technology is developed domestically underneath the proper market conditions and expertise availability (Li et al., 2021; Sadorsky, 2009a; Umar et al., 2021a, 2021c).

Formed on theoretical context, the study employs four regressors as our key explanatory variables for the predictor variable, namely renewable energy consumption. The data for renewable energy consumption is obtained from. Financial

inclusion, GDP, environment-related technologies and human capital index data is obtained from World Bank, IMF, OECD and Penn World Table 10.0. Accordingly, the model's general specifications given are as follows:

Model 1

$$REC_{it} = f(FIN_{it}, ERTI_{it}, HCI_{it}) \quad (1)$$

where i = cross-section or RCEP i.e., Australia, China, South Korea, Japan, New Zealand, Singapore, Thailand, Vietnam, Philippines, Myanmar, Indonesia, Laos, Malaysia, Cambodia and the Brunei-Darussalam; t = time period from 2004 to 2019. Equation (2) comprises another explanatory variable GDP, which intensely determines renewable energy consumptions given is as follows:

Model 2

$$REC_{it} = f(GDP_{it}, ERTI_{it}, HCI_{it}) \quad (2)$$

where GDP_{it} = gross domestic product (measured at constant US 2010 prices). The regression form for Eqs. (1) and (2) is as follows:

Model 3

$$REC_{it} = \gamma_{1it} + \gamma_{2it}FIN_{it} + \gamma_{3it}GDP_{it} + \gamma_{4it}ERTI_{it} + \gamma_{5it}HCI_{it} + \omega_i + \delta_{it} \quad (3)$$

where REC_{it} = renewable energy consumption (% of gross final electricity consumption); FIN_{it} = financial inclusion, the index is designed by combining parameters including such commercial bank institutions, commercial bank branches, outstanding deposits with commercial banks (% of GDP), ATMs per 100,000 adults, and outstanding commercial bank loans (% GDP); $ERTI_{it}$ = environment-related technologies measured as an indicator of eco-innovation, % of all technologies and HCI_{it} = human capital index; ω_i = refers to a cross-section and δ_{it} denote error term. Table 1 displays the list of variables and their descriptions.

Table 1. Data sources and variables.

Variables	Unit	Data source	Expected signs
REC	% of total final energy consumption	https://databank.worldbank.org/source/world-development-indicators#advanced DownloadOptions	–
FIN	Institutions of commercial banks, Branches of commercial banks, Outstanding deposits with commercial banks (% of GDP), Numbers of ATMS per 100,000 adults and outstanding loans from commercial banks (% GDP)	https://data.imf.org/	Positive
GDP	Measured at constant US 2010 prices	https://databank.worldbank.org/source/world-development-indicators#advanced DownloadOptions	Positive
ERTI	Development of environment-related technologies, % all technologies as a measure for eco-innovation	https://stats.oecd.org/#	Positive
HCI	Human capital index	https://www.rug.nl/ggdc/productivity/pwt/?lang=en	Positive

Source: Eviews and Stata.

4. Econometric techniques

We carried our analysis on advanced econometric techniques to obtain more accurate and reliable results, therefore the slope homogeneity and cross section dependence test is applied in the first step. These two methods' ignorance in panel data estimation leads to inconsistent results (Campello et al., 2019). Hence, the Pesaran and Yamagata (2008) test check the slope homogeneity and Pesaran (2004) test is applied for cross-section dependence (CD). The second step is to search for unit root process or stationarity of panel data until the cross-section dependency results are obtained. Many researchers concerned about the problem of non-stationarity in panel data. The existing literature on non-stationarity in panel data is classified into sub three categories: first, second, and third generation panel unit root tests. These categories further specified based on the solution of various issues that addressed by each approach, such as Levin et al. (2002), Choi (2001) and Maddala and Wu (1999) deal with non-stationarity in a homogeneous panel, and Im et al. (2003) heterogeneous panel. In contrast to first generation tests introduced by Levin et al. (2002) and Maddala and Wu (1999), the Pesaran (2007), Choi (2006), and Moon and Perron (2012) second generation panel tests not just to tackle the issue cross-section dependence and yet also fix the heterogeneity between units. After, the unit root or stationarity identified, we use standardized or updated version of Swamy's (1970) test by Pesaran and Yamagata (2008) to determine if the slope is homogeneous or heterogeneous. Because of existence of cross-section dependence and size properties distortion the first generation cointegration methods by Pedroni (2004), Larsson et al. (2001), Westerlund (2005), and McCoskey and Kao (1998) are failed to deliver consistent estimations, further, Pedroni (2001) and Kao et al. (1999) both assume no cross-section dependency among cross-section under considerations. Considering these issues we employ heterogeneous estimation Westerlund and Edgerton (2008) method where there is cross-section dependency, heterogeneity, and non-stationarity in the data. The majority of recent research has relied on the first generation cointegration techniques. These traditional cointegration procedure such as; FMOLS, DOLS and ARLD cointegration approaches presume that cross-sections are distinct. However, the assertion can be criticized because variables including such renewable energy consumption and financial inclusion cause cross-section error terms to be dependent. Due to these considerations this, study employs the augmented mean group (AMG) pioneered by (Eberhardt & Teal, 2010). The AMG technique is effective in a number of functions. For instance, this approach is applicable in absence of endogeneity, non-stationarity, and heterogeneity and cross-section dependence heterogeneity/endogeneity. In addition, the AMG methods address correlation, particularly between the cross-sections. The AMG estimator practices a two-step approach to measure the dynamic unobserved common effect and includes dynamic the common effect parameter to account for cross sectional dependency. To begin, it applies time dummies to the algorithm and uses the first variance OLS to estimate the result.

$$\Delta y_{it} = \delta_{ii} + \varphi_i \Delta x_{it} + \sigma_i f_t + \sum_{t=2}^T \theta_t \text{DUMMY}_t + \varepsilon_{it} \quad (4)$$

where $\Delta =$ distinct operator; $\theta =$ time dummies coefficient and stated as the dynamic common process (Eberhardt, 2012). The group-specific regression analysis is augmented by either an explicit factor or a unit coefficient that is applied to each group member. By deriving the AMG equation from the dependent variable, the imposition of a unit coefficient is accomplished. The AMG mean group estimator calculation approach given is as follows:

$$\text{AMG} = N^{-1} \sum_{i=1}^N \tilde{\varphi}_i \quad (5)$$

where $\tilde{\varphi}_i =$ coefficients of the estimates.

The study further employs Kao and Chiang (2001) parametric dynamic (DOLS) approach to assess the robustness of the models. Pedroni (2001), further proposed that DOLS estimator parametrically avoided endogeneity and liner correlation problems. Finally, the Dumitrescu and Hurlin (2012) panel granger is used to determine causal relationship between variables and its course. The D-H test is placed on discrete Wald statistics of Granger (1969) non-causality averaged across the cross-section units. The D-H panel causality test linear panel regression model is as follows:

$$y_{it} = \varphi_i + \sum_{j=1}^J \omega_i^j y_{i(t-j)} + \sum_{j=1}^J \theta_i^j x_{i(t-j)} + \varepsilon_{it} \quad (6)$$

where $\omega_i^j =$ autoregressive parameters; $\theta_i^j =$ regression coefficient estimates which are expected to differ across cross-sections and y and $x =$ observables.

5. Results and discussions

The Pesaran (2004) cross-section dependence test Pesaran and Yamagata (2008) slope heterogeneity test empirical results are provided in Table 2. It is critical to tackling cross-section dependence in panel data; else bias cointegration and unit root analysis may occur. According to empirical findings, all variables such as REC, FIN, GDP,

Table 2. Slope heterogeneity and cross-section dependence check.

Pesaran and Yamagata (2008) Heterogeneity test		
Model(s)	Delta tilde (p-value)	Adjusted delta tilde (p-value)
Model 1	7.708*** (0.000)	9.296*** (0.000)
Model 2	8.919*** (0.000)	10.756*** (0.000)
Model 3	6.824*** (0.000)	8.632*** (0.000)
Pesaran (2004) Cross-section dependence test		
REC _{it}	FIN _{it}	GDP _{it}
-1.767*	4.616***	11.788***
ERTI _{it}	HCI _{it}	
5.151***	5.175***	

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Eviews and Stata.

Table 3. Pesaran (2007) Unit root test.

Variables	Level	First difference
REC _{it}	-2.175	-4.520***
FIN _{it}	-2.437	-2.981**
GDP _{it}	-2.637	-2.836*
ERTI _{it}	-1.686	-2.971**
HCI _{it}	-1.816	-2.771*

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%. All the variables are tested with trend and intercept.

Source: Eviews and Stata.

Table 4. Westerlund (2007) Cointegration.

Model(s)	G _t	G _a	P _t	P _a
Model 1	-4.575***	-9.812***	-8.621***	-13.271***
Model 2	-3.356***	-7.361***	-5.783**	-8.568***
Model 3	-4.821***	-8.263***	-7.532***	-10.241***

Note: ***, ** and * is for 1%, 5% and 10% significance level.

Source: Eviews and Stata.

ERTI and HCI is reject the null hypothesis of no cross-section dependence at 1% significance level. This verified the existence of cross-section dependence in the panel data. Further, in the presence of cross-section dependence and heterogeneity we employed Pesaran (2007) panel unit root test for validating stationarity properties of the variables. Furthermore, Pesaran and Yamagata (2008) methods reflected to see whether the slope coefficients are heterogeneous or homogenous, since assuming homogenous slope coefficients shall lead to erroneous estimation results. The null hypothesis for Δ and $adj \Delta$ is rejected at 1% significance level in Models 1, 2 and 3.

Table 3 postulates the outcome of the panel unit root test including level and first difference, the null hypothesis deny the problem of no unit root or stationarity while the alternative hypothesis supports non-stationarity or unit root problem. The alternative hypothesis of Pesaran (2007) test is rejected in the first difference for all variables such as REC, FIN, GDP, ERTI and HCI at 1%, 5% and 10% significant level. The results further validate that the study interest variables are lack of unit root problems. Yet, variables in level are not statistically significant, thus we cannot reject the alternative hypothesis.

The empirical findings for Westerlund (2007) with a null hypothesis of no cointegration among variables in the presence of cross-section dependence, heterogeneity and serial correlation are provided in Table 4. Based on observation the null hypothesis of no cointegration among variables is rejected. This reveals that the cointegration relationship is exist among REC, FIN, GDP, ERTI and HCI at 1% and 5% significance levels respectively. Since the cointegration of all variables has been established, we now focus on the long and short-run relationships between renewable energy consumptions and its predictors.

Table 5 illustrates the empirical outcome of the augmented mean group (AMG) model. The results indicate that financial inclusion has a pragmatic impact over renewable energy consumption with a coefficient of 0.13% and 0.107%, at 1% level of significance. This indicates that 1% increase in financial inclusion, rise the renewable energy consumption at a rate of 0.13% and 0.107% (Model 2 & Model 3). The FIN significantly benefits renewable energy development, especially in emerging markets,

Table 5. Empirical findings using AMG.

Variable(s)	Model 1 coefficients [Std.error] (Z – stats)	Model 2 coefficients [Std.error] (Z – stats)	Model 3 coefficients [Std.error] (Z – stats)
FIN _{it}	0.130*** [0.0241] (5.39)	–	0.107*** [0.0201] (5.32)
GDP _{it}	–	0.942*** [0.1052] (8.95)	1.33*** [0.2140] (6.21)
ERTI _{it}	0.058*** [0.0056] (10.35)	0.0394*** [0.0101] (3.90)	0.0631*** [0.0132] (4.78)
HCI _{it}	0.452*** [0.0782] (5.78)	0.412*** [0.0927] (4.44)	0.519*** [0.1392] (3.72)
Constant	0.719*** [0.2011] (3.57)	0.870*** [0.1472] (5.91)	0.792*** [0.1120] (7.07)
Wald-test	20.26***	13.37***	16.87***
RMSE	0.0052	0.0043	0.0053

Note: ***, ** and * is for 1%, 5% and 10% significance level. RMSE shows root mean square error.

Source: Eviews and Stata.

and has become the ever more essential source of financing. Since, FIN encourages developing economies to adopt innovative renewable technologies, which results in a high share of clean energy consumption. In general, the financial system growth helps renewable energy projects in obtaining capital (availability) and enabling investors to make higher risk adjusted yields. Besides, promoting FIN mean fund availability, government assistance and financing options from banks which boosts manufacturing and industrial activities which may lead to higher renewable energy consumption. The high initial capital cost, extreme knowledge asymmetry and highly specific properties in the renewable energy sector lead to costly external funding, which stymies renewable energy implementation, therefore supporting clean technology requires well-functioning financial markets that encourage debt and equity funding. In particular, economies with mature financial inclusion, in fact, have convenient access to external funding. Thus, results in greater financial progress are attributed to significantly faster growth in renewable energy industries, which usually rely heavily on the external fund. Whereas FIN reforms are allied to development in green energy sector that are less reliant on external financing, the impact is relatively marginal. Specifically, the growth overall financial inclusions promote renewable energy sectors that required heavy financing fund. This effect has been observed previously by Brunnschweiler (2010) and Pfeiffer and Mulder (2013).

Similarly, GDP growth on the other hand, is strongly related to renewable consumption. The results indicate that 1% rise in GDP growth escalates renewable energy 0.94% at 1 per cent level of significance. This shows that variation in GDP i.e., promotion in the capital market, labor, import & exports and advanced financial system affect the renewable consumption. The GDP growth is widely known to include increases in FDI flow, banking industries and capital market dynamism, favorable regulatory climate and high production capacity. As a result, sustainable GDP growth will further boost renewable energy consumption in RCEP economies (Sadorsky,

2009b). Likewise, favorable economic policies and viability of economic growth which provide further support expected to increase the production and use of renewable energy and ultimately tackle possible constraints such as; financial and legal, technological, physical and finally ontological and social constraints. Moreover, economic growth inevitably leads to increased renewable use and playing the most important role in fostering renewable energy use in these economies. These results are identical to those of Al-Mulali et al. (2013) and Tugcu et al. (2012).

By the same token, environment-related technologies influence renewable energy consumption with a coefficient of 0.58% at 1% significant level. This assumes that, 1% progress in ERTI leads to 0.58% increases in the flat of renewable energy consumption at 1% significant level. Theoretically, in order to achieve a circular (sustainable) economy need more econ-innovation to adopted which substitutes the labor force and resulting in higher renewable energy consumption. The ERTI serve as driving factor for companies to pursue clean energy by lowering manufacturing cost and ensuring compliance eco-system. Further, organizations and individuals are compelled to be the leaders of eco-innovation to gain a competitive edge and allow the development of innovative green technologies which ultimately required clean energy consumption. To this end, it is reasonable to believe that ERTI inspires businesses to switch to RELC in order to improve their image in the eyes of their stakeholders. This study results are close to those of Li et al. (2020) and Khan et al. (2020)

Finally, the impact of the human capital index over renewable energy consumption is viable. It shows that 1% development in the human capital will escalate the consumption of renewable energy 0.45% at 1% level of significance in RCEP economies. On the basis of theoretical notion, better-educated individuals, families and managers are eco-friendlier, energy efficient and use less dirty energy. Human capital has potential to minimize the non-renewable energy consumption by encouraging clean technologies, while also has the capabilities to rise renewable energy consumptions leading to the green production process, replacement of advanced technologies and pursuing sustainable economic growth. Moreover, the influence of human capital through renewable consumption is about; technological effect, income effect and symmetry between human capital and physical capital inputs in the factor of production. This study results are close to those of Yao et al. (2019) and Alvarado et al. (2021).

The robustness effects from the dynamic ordinary least square (DOLS) approach are seen in Table 6. The DOLS confirms a positive association between financial inclusions and renewable energy consumption with the coefficient of 0.13% and 0.06% respectively. Further, a positive relation is observed between GDP growth and

Table 6. Robustness check using DOLS.

Variable(s)	Model 1 coefficients	Model 2 coefficients	Model 3 coefficients
FIN _{it}	0.134***	–	0.064***
GDP _{it}	–	0.981***	1.231***
ERTI _{it}	0.0750***	0.173***	0.256***
HCI _{it}	0.494***	0.422***	0.397***
Constant	0.931***	0.881***	0.701***

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Eviews and Stata.

Table 7. Panel causality test.

Dumitrescu Hurlin panel causality			
H_0	Wald – Stats	\bar{Z} – Stats	p -value(s)
FIN–REC	4.645***	3.600	0.000
REC–FIN	6.574***	2.594	0.009
GDP–REC	7.468***	4.066	0.000
REC–GDP	5.747***	3.762	0.000
ERTI–REC	4.704***	1.382	0.166
REC–ERTI	7.825***	3.405	0.000
HCI–REC	6.382***	3.122	0.000
REC–HCI	5.112***	3.998	0.000

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.

Source: Eviews and Stata.

REC with coefficients of 0.98% and 1.12% respectively. Similarly, environment-related technologies and Human capital are positively associated with renewable consumptions with coefficients of 0.75% and 0.49% respectively. The findings of the robustness test validate results obtained from the augmented mean group (AMG) method.

Eventually, Table 7 shows the implications of the Granger DH causality test indicate that shifts in financial inclusions, GDP, environment-related technologies and human capital index in RCEP economies trigger renewable energy consumptions. Any policy that specifies these factors has a substantial impact on renewable energy consumption, while any favorable policy to encourage renewable energy consumption has no impact on these variables. Our observational findings indicate that all explanatory variables Granger cause renewable energy consumption in RCEP economies and vice versa at 1% level of significance.

6. Conclusion and policy recommendations

On the role of sustainable financial inclusion, this study analyses its effect on increasing or decreasing low carbon energy sources in the case of RCEP economies from 2004–2019. This study also traces the impact of other controlled variables like economic growth, environment-related technologies and human capital. The Pesaran (2004) test is used in this analysis to verify cross-section dependence, and Pesaran (2007) method is used to investigate the unit root mechanism in the data. Furthermore, this study applied Swamy (1970) and Pesaran and Yamagata (2008) to examine the slope homogeneity and focused on Westerlund's (2007) cointegration methods to examine the long-run relationship between variables. The results of the cointegration approaches revealed that there is a long-term relationship among variables.

The augmented mean group (AGM) test estimated coefficients confirmed that in both long and short-run financial inclusions induce a positive impact on renewable energy consumption followed by environment-related technologies, economic growth and human capital index in RCEP countries. Based on findings, financial inclusion is the primary engine of renewable energy promotion; thus, in order to increase the effect of financial inclusion on renewable energy use, the banking system should be targeted and improved in those areas that trigger delays in funding renewable projects. The credit constraint should be avoided, and practice special incentives for financing those companies which involved in clean technologies supply and

production. To help poor and economically marginalized elements of society deal with growing CO₂ emissions, policymakers must enhance access to and inclusivity of climate financing. Individuals, micro-, small-, and medium-sized businesses should have enough access to financial products and services so that they may implement local, small-scale mitigation and adaptation steps to reduce CO₂ emissions. These countries are further required to employ low-interest loans, feed-in tariffs, capital subsidies, tradable certificates and renewable portfolio standards for renewable energy generators.

In addition, develop the financial system which is likely to encourage the advancement of high-tech technologies such as green energy projects. Since financial inclusion allows firms to invest in the upside returns, and therefore investment in renewable energy projects does not raise the risk of financial distress. Moreover, despite the cost of financial inclusion, financial deepening policy should indeed be espoused for and instated by constructing concrete plans to enhance the role of financial inclusion in energy efficiency, such as credit for clean production, labor education and environmental sustainability, as well as credit restrictions for high-polluting firms. Further, a new partnership between the government, financial institutions, and industries should be designed to promote economic growth that is ecologically sustainable. In reality, the conversion to renewables must be spurred consecutively by legislative, economic, and industrial measures, namely establishing a priority on the reform agenda, raising the fairness of the financial system, and modernizing industrial technologies and structures.

Similarly, these countries would seek to bring expertise, which is based on specialized human resources, such as technology and creativity, which can help to increase renewable energy use. Furthermore, sustain the green growth and mediates which mediates the association among human capital and renewable energy consumption, so this can indirectly promote renewable energy consumption by leading to sustainable economic growth.

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References

- Al-Mulali, U., Fereidouni, H. G., Lee, J. Y., & Sab, C. N. B. C. (2013). Examining the bi-directional long run relationship between renewable energy consumption and GDP growth. *Renewable and Sustainable Energy Reviews*, 22, 209–222. <https://doi.org/10.1016/j.rser.2013.02.005>
- Alvarado, R., Deng, Q., Tillaguango, B., Méndez, P., Bravo, D., Chamba, J., Alvarado-Lopez, M., & Ahmad, M. (2021). Do economic development and human capital decrease non-renewable energy consumption? Evidence for OECD countries. *Energy*, 215, 119147. <https://doi.org/10.1016/j.energy.2020.119147>
- Anton, S. G., & Afloarei Nucu, A. E. (2020). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, 147, 330–338. <https://doi.org/10.1016/j.renene.2019.09.005>
- Bank, W. (2018). World development report 2019: The changing nature of work.

- Boutabba, M. A., Diaw, D., Laré, A., & Lessoua, A. (2020). The impact of microfinance on energy access: A case study from peripheral districts of Lomé, Togo. *Applied Economics*, 52(45), 4927–4951. <https://doi.org/10.1080/00036846.2020.1751800>
- Brunnschweiler, C. N. (2010). Finance for renewable energy: An empirical analysis of developing and transition economies. *Environment and Development Economics*, 15(3), 241–274. <https://doi.org/10.1017/S1355770X1000001X>
- Campello, M., Galvao, A. F., & Juhl, T. (2019). Testing for slope heterogeneity bias in panel data models. *Journal of Business & Economic Statistics*, 37(4), 749–760. <https://doi.org/10.1080/07350015.2017.1421545>
- Chibba, M. (2009). Financial inclusion, poverty reduction and the millennium development goals. *The European Journal of Development Research*, 21(2), 213–230. <https://doi.org/10.1057/ejdr.2008.17>
- Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance*, 20(2), 249–272. [https://doi.org/10.1016/S0261-5606\(00\)00048-6](https://doi.org/10.1016/S0261-5606(00)00048-6)
- Choi, I. (2006). Combination unit root tests for cross-sectionally correlated panels. In *Econometric Theory and Practice. Frontiers of Analysis and Applied Research* (Essays Honor Peter CB Phillips. Chap. 11, pp. 311–333). Cambridge University Press.
- Cui, L., Weng, S., Majeed, A., Zahid, M. R., & Shahzad, U. (2022). Exploring the role of renewable energy, urbanization and structural change for environmental sustainability: Comparative analysis for practical implications. *Renewable Energy*, 184, 215–224. <https://doi.org/10.1016/j.renene.2021.11.075>
- Dogan, E., Madaleno, M., & Taskin, D. (2021). Which households are more energy vulnerable? Energy poverty and financial inclusion in Turkey. *Energy Economics*, 99, 105306. <https://doi.org/10.1016/j.eneco.2021.105306>
- Dumitrescu, E.-I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling*, 29(4), 1450–1460. <https://doi.org/10.1016/j.econmod.2012.02.014>
- Eberhardt, M. (2012). Estimating panel time-series models with heterogeneous slopes. *The Stata Journal: Promoting Communications on Statistics and Stata*, 12(1), 61–71. <https://doi.org/10.1177/1536867X1201200105>
- Eberhardt, M., & Teal, F. (2010). Productivity analysis in global manufacturing production.
- Emara, N., & El Said, A. (2021). Financial inclusion and economic growth: The role of governance in selected MENA countries. *International Review of Economics & Finance*, 75, 34–54. <https://doi.org/10.1016/j.iref.2021.03.014>
- Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *The Science of the Total Environment*, 663, 189–197. <https://doi.org/10.1016/j.scitotenv.2019.01.323>
- Fatima, T., Shahzad, U., & Cui, L. (2021). Renewable and nonrenewable energy consumption, trade and CO₂ emissions in high emitter countries: Does the income level matter? *Journal of Environmental Planning and Management*, 64(7), 1227–1251. <https://doi.org/10.1080/09640568.2020.1816532>
- Ferrat, Y., Daty, F., & Burlacu, R. (2021). Short-and long-term effects of responsible investment growth on equity returns. *Journal of Risk Finance*, 23(1), 1–13.
- Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424–438. <https://doi.org/10.2307/1912791>
- Ghazouani, A., Jebli, M. B., & Shahzad, U. (2021). Impacts of environmental taxes and technologies on greenhouse gas emissions: Contextual evidence from leading emitter European countries. *Environmental Science and Pollution Research International*, 28(18), 22758–22767. <https://doi.org/10.1007/s11356-020-11911-9>
- Ielasi, F., Rossolini, M., & Limberti, S. (2018). Sustainability-themed mutual funds: An empirical examination of risk and performance. *Journal of Risk Finance*, 19(3), 247–261.
- Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74. [https://doi.org/10.1016/S0304-4076\(03\)00092-7](https://doi.org/10.1016/S0304-4076(03)00092-7)

- Ji, Q., & Zhang, D. (2019). How much does financial development contribute to renewable energy growth and upgrading of energy structure in China? *Energy Policy*, 128, 114–124. <https://doi.org/10.1016/j.enpol.2018.12.047>
- Ji, X., Chen, X., Mirza, N., & Umar, M. (2021a). Sustainable energy goals and investment premium: Evidence from renewable and conventional equity mutual funds in the Euro zone. *Resources Policy*, 74, 102387. <https://doi.org/10.1016/j.resourpol.2021.102387>
- Ji, X., Zhang, Y., Mirza, N., Umar, M., & Rizvi, S. K. A. (2021b). The impact of carbon neutrality on the investment performance: Evidence from the equity mutual funds in BRICS. *Journal of Environmental Management*, 297, 113228. <https://doi.org/10.1016/j.jenvman.2021.113228>
- Kang, J. W., Crivelli, P., Tayag, M. C., & Ramizo, D. (2020). *Regional comprehensive economic partnership: Overview and economic impact* (Vol. 2, pp. 1–8). Asian Development Bank (ADB).
- Kao, C., & Chiang, M.-H. (2001). On the estimation and inference of a cointegrated regression in panel data. In *Nonstationary panels, panel cointegration, and dynamic panels*. Emerald Group Publishing Limited.
- Kao, C., Chiang, M., & Chen, B. (1999). International R&D spillovers: An application of estimation and inference in panel cointegration. *Oxford Bulletin of Economics and Statistics*, 61(s1), 691–709. <https://doi.org/10.1111/1468-0084.0610s1691>
- Khan, Z., Malik, M. Y., Latif, K., & Jiao, Z. (2020). Heterogeneous effect of eco-innovation and human capital on renewable & non-renewable energy consumption: Disaggregate analysis for G-7 countries. *Energy*, 209, 118405. <https://doi.org/10.1016/j.energy.2020.118405>
- Koengkan, M. (2018). The decline of environmental degradation by renewable energy consumption in the MERCOSUR countries: An approach with ARDL modeling. *Environment Systems and Decisions*, 38(3), 415–425. <https://doi.org/10.1007/s10669-018-9671-z>
- Koengkan, M., Fuinhas, J. A., & Marques, A. C. (2020). The role of financial openness and China's income on fossil fuels consumption: Fresh evidence from Latin American countries. *GeoJournal*, 85(2), 407–415. <https://doi.org/10.1007/s10708-019-09969-1>
- Larsson, R., Lyhagen, J., & Löthgren, M. (2001). Likelihood-based cointegration tests in heterogeneous panels. *The Econometrics Journal*, 4(1), 109–142. <https://doi.org/10.1111/1368-423X.00059>
- Le, T.-H., Chuc, A. T., & Taghizadeh-Hesary, F. (2019). Financial inclusion and its impact on financial efficiency and sustainability: Empirical evidence from Asia. *Borsa Istanbul Review*, 19(4), 310–322. <https://doi.org/10.1016/j.bir.2019.07.002>
- Le, T., Nguyen, C. P., & Park, D. (2020). Energy Research & Social Science Financing renewable energy development: Insights from 55 countries. *Energy Research & Social Science*, 68, 101537. <https://doi.org/10.1016/j.erss.2020.101537>
- Le, T. H., Le, H. C., & Taghizadeh-Hesary, F. (2020). Does financial inclusion impact CO₂ emissions? Evidence from Asia. *Finance Research Letters*, 34, 101451. <https://doi.org/10.1016/j.frl.2020.101451>
- Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108(1), 1–24. [https://doi.org/10.1016/S0304-4076\(01\)00098-7](https://doi.org/10.1016/S0304-4076(01)00098-7)
- Li, J., Zhang, X., Ali, S., & Khan, Z. (2020). Eco-innovation and energy productivity: New determinants of renewable energy consumption. *Journal of Environmental Management*, 271, 111028. <https://doi.org/10.1016/j.jenvman.2020.111028>
- Li, J.-P., Naqvi, B., Rizvi, S. K. A., & Chang, H.-L. (2021). Bitcoin: The biggest financial innovation of fourth industrial revolution and a portfolio's efficiency booster. *Technological Forecasting and Social Change*, 162, 120383. <https://doi.org/10.1016/j.techfore.2020.120383>
- Liu, H., Yao, P., Latif, S., Aslam, S., & Iqbal, N. (2021). Impact of Green financing, FinTech, and financial inclusion on energy efficiency. *Environmental Science and Pollution Research*, 1–12.

- Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics*, 61(S1), 631–652. <https://doi.org/10.1111/1468-0084.0610s1631>
- McCoskey, S., & Kao, C. (1998). A residual-based test of the null of cointegration in panel data. *Econometric Reviews*, 17(1), 57–84. <https://doi.org/10.1080/07474939808800403>
- Mirza, N., Hasnaoui, J. A., Naqvi, B., & Rizvi, S. K. A. (2020a). The impact of human capital efficiency on Latin American mutual funds during Covid-19 outbreak. *The Swiss Journal of Economics and Statistics*, 156, 1–7.
- Mirza, N., Naqvi, B., Rahat, B., & Rizvi, S. K. A. (2020b). Price reaction, volatility timing and funds' performance during Covid-19. *Finance Research Letters*, 36, 101657. <https://doi.org/10.1016/j.frl.2020.101657>
- Moon, H. R., & Perron, B. (2012). Beyond panel unit root tests: Using multiple testing to determine the nonstationarity properties of individual series in a panel. *Journal of Econometrics*, 169(1), 29–33. <https://doi.org/10.1016/j.jeconom.2012.01.008>
- Naqvi, B., Mirza, N., Rizvi, S. K. A., Porada-Rochoń, M., & Itani, R. (2021). Is there a green fund premium? Evidence from twenty seven emerging markets. *Global Finance Journal*, 50, 100656. <https://doi.org/10.1016/j.gfj.2021.100656>
- Paramati, S. R., Shahzad, U., & Doğan, B. (2022). The role of environmental technology for energy demand and energy efficiency: Evidence from OECD countries. *Renewable and Sustainable Energy Reviews*, 153, 111735. <https://doi.org/10.1016/j.rser.2021.111735>
- Pedroni, P. (2001). Purchasing power parity tests in cointegrated panels. *Review of Economics and Statistics*, 83(4), 727–731. <https://doi.org/10.1162/003465301753237803>
- Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Economic Theory*, 20(3), 597–625.
- Pesaran, H. M. (2004). *General diagnostic tests for cross-sectional dependence in panels*. Cambridge Working Papers in Economics 435.
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22(2), 265–312. <https://doi.org/10.1002/jae.951>
- Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, 142(1), 50–93. <https://doi.org/10.1016/j.jeconom.2007.05.010>
- Pfeiffer, B., & Mulder, P. (2013). Explaining the diffusion of renewable energy technology in developing countries. *Energy Economics*, 40, 285–296. <https://doi.org/10.1016/j.eneco.2013.07.005>
- Rafique, M. Z., Doğan, B., Husain, S., Huang, S., & Shahzad, U. (2021). Role of economic complexity to induce renewable energy: Contextual evidence from G7 and E7 countries. *International Journal of Green Energy*, 18(7), 745–754. <https://doi.org/10.1080/15435075.2021.1880912>
- RCEP. (2019). Intersessional TNC Meeting and Related Meetings, which will be held in Jakarta in August 2019.
- ITNC. (2019). Sixth Intersessional TNC Meeting, 19 – 25 August 2019, Jakarta, Indonesia.
- Rizvi, S. K. A., Naqvi, B., & Mirza, N. (2021). Is green investment different from grey? Return and volatility spillovers between green and grey energy ETFs. *Annals of Operations Research*, 1–30.
- Sadorsky, P. (2009a). Renewable energy consumption, CO₂ emissions and oil prices in the G7 countries. *Energy Economics*, 31(3), 456–462. <https://doi.org/10.1016/j.eneco.2008.12.010>
- Sadorsky, P. (2009b). Renewable energy consumption and income in emerging economies. *Energy Policy*, 37(10), 4021–4028. <https://doi.org/10.1016/j.enpol.2009.05.003>
- Schumacher, K., Chenet, H., & Volz, U. (2020). Sustainable finance in Japan. *Journal of Sustainable Finance & Investment*, 10(2), 213–246. <https://doi.org/10.1080/20430795.2020.1735219>
- Su, C. W., Umar, M., & Khan, Z. (2021). Does fiscal decentralization and eco-innovation promote renewable energy consumption? Analyzing the role of political risk. *Science of the Total Environment*, 751, 142220.

- Shahzad, U., Ferraz, D., Doğan, B., & Aparecida do Nascimento Rebelatto, D. (2020). Export product diversification and CO₂ emissions: Contextual evidences from developing and developed economies. *Journal of Cleaner Production*, 276, 124146. <https://doi.org/10.1016/j.jclepro.2020.124146>
- Shahzad, U., Ferraz, D., Nguyen, H., & Cui, L. (2022). Investigating the spill overs and connectedness between financial globalization, high-tech industries and environmental footprints: Fresh evidence in context of China. *Technological Forecasting and Social Change*, 174(2), 121205. <https://doi.org/10.1016/j.techfore.2021.121205>
- Shahzad, U., Schneider, N., Ben, M., & Panth, P. (2021). How coal and geothermal energies interact with industrial development and carbon emissions? An autoregressive distributed lags approach to the Philippines. *Resources Policy*, 74(March), 102342. <https://doi.org/10.1016/j.resourpol.2021.102342>
- Swamy, P. A. V. B. (1970). Efficient inference in a random coefficient regression model. *Econometrica*, 38(2), 311–323. <https://doi.org/10.2307/1913012>
- Taghizadeh-Hesary, F., Rasoulinezhad, E., Yoshino, N., Sarker, T., & Mirza, N. (2021). Determinants of the Russia and Asia–Pacific energy trade. *Energy Strategy Reviews*, 38, 100681. <https://doi.org/10.1016/j.esr.2021.100681>
- Tao, R., Su, C.-W., Naqvi, B., & Rizvi, S. K. A. (2022). Can Fintech development pave the way for a transition towards low-carbon economy: A global perspective. *Technological Forecasting and Social Change*, 174, 121278. <https://doi.org/10.1016/j.techfore.2021.121278>
- Tharakan, P. J., de Castro, J., & Kroeger, T. (2007). Energy sector assistance in developing countries: Current trends and policy recommendations. *Energy Policy*, 35(1), 734–738. <https://doi.org/10.1016/j.enpol.2005.10.013>
- Tirpak, D., & Adams, H. (2008). Bilateral and multilateral financial assistance for the energy sector of developing countries. *Climate Policy*, 8(2), 135–151. <https://doi.org/10.3763/cpol.2007.0443>
- Tugcu, C. T., Ozturk, I., & Aslan, A. (2012). Renewable and non-renewable energy consumption and economic growth relationship revisited: Evidence from G7 countries. *Energy Economics*, 34(6), 1942–1950. <https://doi.org/10.1016/j.eneco.2012.08.021>
- Umar, M., Ji, X., Mirza, N., & Naqvi, B. (2021a). Carbon neutrality, bank lending, and credit risk: Evidence from the Eurozone. *Journal of Environmental Management*, 296, 113156. <https://doi.org/10.1016/j.jenvman.2021.113156>
- Umar, M., Rizvi, S. K. A., & Naqvi, B. (2021b). Dance with the devil? The nexus of fourth industrial revolution, technological financial products and volatility spillovers in global financial system. *Technological Forecasting and Social Change*, 163, 120450. <https://doi.org/10.1016/j.techfore.2020.120450>
- Umar, M., Su, C.-W., Rizvi, S. K. A., & Shao, X.-F. (2021c). Bitcoin: A safe haven asset and a winner amid political and economic uncertainties in the US? *Technological Forecasting and Social Change*, 167, 120680. <https://doi.org/10.1016/j.techfore.2021.120680>
- Vo, D. H., Nguyen, N. T., & Thi-Hong Van, L. (2021). Financial inclusion and stability in the Asian region using bank-level data. *Borsa Istanbul Review*, 21(1), 36–43. <https://doi.org/10.1016/j.bir.2020.06.003>
- Vural, G. (2021). Analyzing the impacts of economic growth, pollution, technological innovation and trade on renewable energy production in selected Latin American countries. *Renewable Energy*, 171, 210–216. <https://doi.org/10.1016/j.renene.2021.02.072>
- Wang, J., Zhang, S., & Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. *Renewable Energy*, 170, 897–904. <https://doi.org/10.1016/j.renene.2021.02.038>
- Westerlund, J. (2005). New simple tests for panel cointegration. *Econometric Reviews*, 24(3), 297–316. <https://doi.org/10.1080/07474930500243019>
- Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics*, 69(6), 709–748.

- Westerlund, J., & Edgerton, D. L. (2008). A simple test for cointegration in dependent panels with structural breaks. *Oxford Bulletin of Economics and Statistics*, 70(5), 665–704. <https://doi.org/10.1111/j.1468-0084.2008.00513.x>
- Yao, Y., Ivanovski, K., Inekwe, J., & Smyth, R. (2019). Human capital and energy consumption: Evidence from OECD countries. *Energy Economics*, 84, 104534. <https://doi.org/10.1016/j.eneco.2019.104534>
- Zhang, C., Liu, Z., Zeng, Y., Yang, O., & Iram, R. (2021). Energy policy and financial performance in China: Mediation effect of financial inclusion. *Environmental Science and Pollution Research*, 1–15.