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Decomposing Scale and Technique Effects of Financial Development and Foreign Direct Investment on Renewable Energy Consumption

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Abstract: This paper contributes to literature by divulging the nature of scale and technique effects on renewable energy consumption, considering foreign direct investment (FDI) and financial development as considerable factors of renewable energy demand. The data for 39 countries over the period of 2000-2019 is used for empirical analysis. In doing so, second generation methodological approaches are applied to decompose scale and technique effects. The empirical results show the presence of cointegration between the model parameters, in the presence of cross-sectional dependence and structural breaks. Further, financial development is positively linked with renewable energy consumption. Foreign direct investment and renewable energy demand are positively linked. Composition effect has negative effect on renewable energy consumption. Economic growth and fossil fuel consumption have positive impact on renewable energy consumption. Long run estimation results indicate that renewable energy-FDI and renewable energy-financial development associations are U-shaped. It indicates that the scale effects exerted by FDI and financial development are overridden by technique and composition effects, and hence, the demand for renewable energy and consequential renewable energy consumption rises with the progression of economic growth. Based on this, policy suggestions are provided for these nations to ascertain sustainable development through bringing forth transformations in the energy policies.

Keywords: Scale and Technique Effects, Financial Development, Foreign Direct Investment, Renewable Energy Consumption

I. Introduction

Energy consumption is considered as a major driver of economic growth and development of a nation. Hence, the Sustainable Development Goals (SDG) progress report 2020 has identified energy as an enabler of sustainable development, while stressing on the goal 7.1, i.e., *Universal Access to Energy* (United Nations, 2020). However, the report also highlights the issue of energy security around the world. The energy transition assessment report by International Institute of Sustainable Development highlights the energy security issues characterized by dependence on fossil fuel-based solutions, and consequential need of renewable energy solutions (IISD, 2019). As the world is experiencing an energy transition, the role of renewable energy is being recognized as a major policy instrument. This renewable energy-oriented policy realignment entails suitable financing mechanisms. According to UNDP, annual investment of $442-650 billion on renewable energy projects is required to meet the objectives of SDG 7, whereas enhancement of energy efficiency will require $560 billion, and inclusive electrification will require $52 billion (UNDP, 2021). Yet, the presence of a gap in annual financing is gradually turning out to be a major deterrent in the global energy transition. One of the major reasons behind the prevalence of this gap is the risk associated with renewable project finance. For mitigating this risk, interventions are required in the form of public financing though local financial institutions and external financing (UNDP, 2019).

In this regard, financial institutions and foreign direct investment (FDI) can be recognized as key policy actors in stimulating renewable energy generation. Financialization through these two channels will have their impacts on the overall energy generation scenario. So, for directing the financialization towards renewable energy generation projects, the effects of financialization on nonrenewable and renewable energy generation projects need to be isolated. Following the seminal work of Copeland and Taylor (1994), isolation of these impacts can be explained. The initial phase of energy generation was characterized by nonrenewable energy solutions. Energy being a major factor of production, boosting economic growth entailed financialization towards the development of nonrenewable energy solutions. Thus, the economy of scale was realized by mobilizing finances through financial institutions and acquiring factors of production via FDI for energy generation. However, the scaling up of the energy generation process exerted negative environmental externality by causing environmental degradation. This is when financial development and FDI are said to have exerted *Scale Effect* on the economy. This Scale Effect can be discussed in line with the *Limits to Growth* approach by *Club of Rome* economists (Meadows et al. 1972). The seamless consumption of natural resources might cause harm to the developmental trajectory, and this argument indicated the unsustainability of the Scale Effect. With gradual liberalization of international trade, composition of production started transforming towards becoming environment-friendly, through reallocation of resources. Herein, financial mobilization exerts the *Composition Effect* on the economy. Still, financialization impacted both the high and low energy-intensive sectors via energy generation. Henceforth, the *Composition Effect* exerted by financial development and FDI cannot be measured, as the difference between expansion and contraction of both the sectors might have contradicting impacts on environmental degradation. In continuation of this process, further specialization in trade activities and rise in cost-competitiveness might reduce the cost of environment-friendly technologies. At this stage, mobilization of finances towards energy generation will gradually result in cleaner energy, and the negative environmental externalities exerted by the prevailing energy generation process will be gradually internalized by improving environmental quality. Therefore, during this stage, financial development and FDI can be said to have started exerting the *Technique Effect* on the economy. Hence, in order to finance the renewable energy projects, impacts of financialization should be isolated into the *Scale* and *Technique* Effects, as shifting from Scale to Technique effect might denote the demand-side transition of energy generation scenario. The isolation of these two effects needs realignment of the prevailing energy policies, and there comes the role of the present study.

Although development and deployment costs of renewable energy is declining, investment in the renewable energy projects is below the expected level. The 2016 renewable energy investment assessment report by the International Renewable Energy Agency shows that risks associated with renewable energy projects create a disruption in renewable energy financing (IRENA, 2016). These risks can be political and legislative risks, risk of transmission loss, currency exposure risk, refinancing risk, and liquidity risk. Presence of these risks is restricting the private sector investments in the renewable energy generation sector. In order to cover these risks and restore the confidence of investors, policymakers need to intervene. This policy intervention calls for the strengthening of financialization channels by isolating the scale and technique effects exerted by these channels. This isolation of effects might help in realizing a novel policy framework for addressing the objectives of SDG 7. For developing this policy framework, the sample countries are chosen based on Renewable Energy Country Attractiveness Index (RECAI). As these countries are considered pioneers in the field of renewable energy development and deployment, hence, addressing the policy issue for these countries might be considered as a benchmark for the other nations facing similar issues with financing renewable energy projects. Figure-1 shows the comparison between the per capita average renewable energy consumption between the sample RECAI countries and the world. It is evident that the average renewable energy consumption in the sample RECAI countries is higher than the global average over the last two decades. Therefore, the policy-level solution of the financialization issue in these countries might be relevant for the other economies, and that is the focus of the present study.

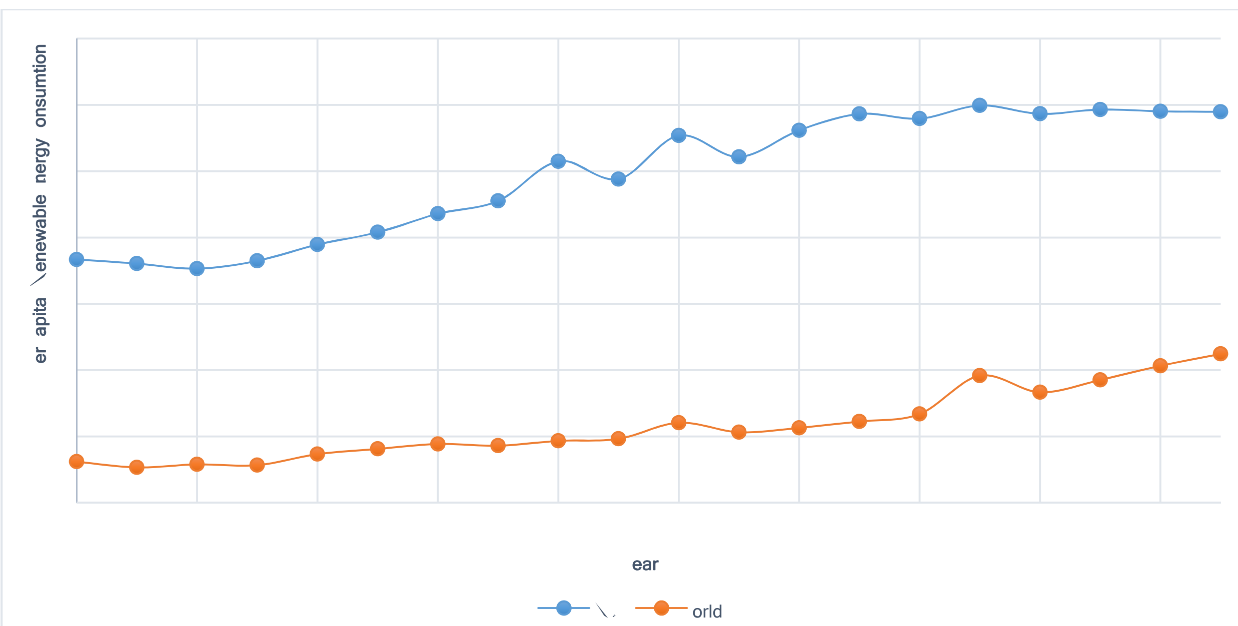

Figure-1: Comparison of Average Per Capita Renewable Energy Consumption between the RECAI countries and the World (Source: World Bank, 2020a)

In view of the persisting financialization issue, a policy-level reorientation is necessary. This policy recommendation might be beneficial for other nations in addressing the issues of financing the renewable energy development projects. This policy-level solution might give a direction towards attaining the objectives of SDG 7, along with betterment of environmental quality and consequential attainment of the SDG 13, i.e., climate action. In this pursuit, the present study empirically assesses scale and technique effects exerted by financial development and FDI on renewable energy generation in the RECAI countries. Isolation of these two impacts might help in developing a policy framework to mobilize the finances towards renewable energy development. This policy framework also shows a way to internalize the negative environmental externalities exerted by the existing energy consumption pattern. Designing this SDG-oriented policy framework by isolating the scale and technique effects of financialization channels has not been attempted in the academic literature, and there lies the policy level contribution of the study.

While developing the policy framework, it is assumed that the policy instruments might not influence the target policy parameter linearly. Hence, taking a cue from the Environmental Kuznets Curve (EKC) hypothesis framework (Shahbaz and Sinha, 2019), this study has hypothesized a quadratic association between financialization channels and renewable energy generation. This analytical framework helps in identifying the evolutionary impacts of policy instruments over a pool of countries. Identification of this evolutionary impact is necessary for isolating the scale and technique effects. Hence, choice of the analytical framework complements the policy-level contribution of the study. Now, assuming the sample countries are associated with each other via economic spillovers, the impact of this association might be reflected on the estimation outcomes. This issue has been controlled by the application of second-generation panel data methods. Therein lies the methodological complementarity of the study with its policy-level contribution.

II. Literature Review

We have divided literature into four competing nexuses based on the nature of the association between variables. These nexuses include: (i) financial development-energy consumption nexus, (ii) nexus between financial development and renewable energy consumption, (iii) foreign direct investment-energy consumption nexus, (iv) nexus between foreign direct investment and renewable energy consumption.

II.I. Financial Development-Energy Consumption Nexus

Financial development affects energy consumption via income effect, wealth effect, consumer effect and stock market effect. Empirically, various studies investigated the association between financial development and energy consumption by applying various econometric approaches but empirical results are still conflicting. For instance, in emerging economies, Sadorsky (2010) examined the relationship between financial development and energy consumption. The empirical results indicated that financial development leads to energy demand by stimulating economic activity. Similarly, Sadorsky (2011) applied GMM panel regression for examining the impact of financial development on energy consumption in the case of 9 Eastern and Central European frontier countries. The empirical findings show that financial development and energy consumption are positively linked but financial development has a substantial effect on energy consumption. Further, Shahbaz and Lean (2012) applied ARDL bounds testing approach for investigating the role of financial development in energy demand function for Tunisian economy. They found that financial development adds to energy consumption by stimulating the role of industrialization and urbanization. Their empirical analysis also confirmed the presence of a feedback effect between financial development and energy consumption. For Malaysian economy, Islam et al. (2013) applied multivariate function to examine relationship between financial development and energy consumption and noted that financial development declines energy consumption by increasing energy efficiency. Çoban and Topcu (2013) utilized GMM technique to examine the impact of financial development on energy consumption using data for EU nations over the period of 1990-2011. Their empirical evidence confirmed that financial development increases energy demand. Al-mulali and Lee (2013) applied different panel econometric methods such as panel unit root, Pedroni cointegration, dynamic OLS and Granger causality to investigate the impact of financial development on energy consumption for a panel of Gulf Cooperation Council nations. They found the presence of a long-run relationship between energy demand and its determinants. Their empirical evidence further confirmed that financial development has a considerable positive long-run impact on energy consumption. The causality analysis indicated the existence of a unidirectional causality running from energy consumption to financial development. Mahalik and Mallick (2014) applied ARDL bounds testing approach to test whether economic growth, total population, financial development affect energy consumption for Indian economy. Their empirical results show that energy consumption has a positive and significant effect on the population but financial development and economic growth decline energy consumption. In the case of Middle Eastern countries, Aslan et al. (2014) examined the empirical relationship between financial development and energy consumption for the period of 1980-2011 by applying panel cointegration, FMOLS and causality approaches. Their empirical evidence confirmed the long-run relationship between financial development, energy prices, energy consumption and income. They found that financial development is positively linked with energy consumption in the long-run. Their causality analysis indicated the presence of a unidirectional causality running from financial development to energy consumption. For SAARC countries, Alam et al. (2015) applied three different regression models, i.e. fixed effect, pooled least square and random effect for investigating the relationship between financial development, energy consumption, energy prices and economic growth covering the period of 1975-2011. Their empirical results indicate the long-run equilibrium relationship between energy demand and its determinants. They further noted that financial development leads to energy consumption. Furuoka (2015) examined the empirical nexus between financial development and energy demand for a panel of Asia economies. The empirical results indicate the presence of a long-run relationship between financial development and consumption of energy, and energy consumption causes financial development.

Mahalik et al. (2017) applied innovative accounting approach and combined cointegration test to investigate the linkage between financial development and energy consumption by considering capital, economic growth and urbanization as additional determinants of energy demand for Saudi Arabian economy. They found that financial development increases energy consumption and an inverted U-shaped relationship between financial development and energy demand also exists. Their empirical analysis further, reported the presence of unidirectional causality running from financial development to energy consumption. For a panel of 32 high-income nations, Topcu and Payne (2017) applied heterogeneous panel techniques to examine the impact of financial development on consumption of energy and neutral effect between financial development and energy consumption. Farhani and Solarin (2017) examined the relationship between financial development, foreign direct investment, energy demand and real GDP for US using quarter frequency data for the period 1973-2014. They applied combined cointegration and symmetric causality approaches and found that financial development, real GDP and foreign direct investment reduce energy demand in long-run but financial development and foreign direct investment encourage energy demand in short-run. They also reported the unidirectional causality relation running from foreign direct investment to energy demand. Liu et al. (2018) examined the impact of financial development on energy demand for Chinese economy by applying ARDL and VECM Granger causality approaches. They reported that long-run relationship exists between financial development, urbanization, GDP, energy demand and economic structure. Their empirical analysis indicates the presence of feedback effect between financial development and energy demand in long-run but financial development causes energy demand in short-run. Destek (2018) applied OLS technique to test the impact of financial development, real income and energy prices on energy consumption for a panel of 17 emerging nations and found that financial development reduces energy consumption.

Moreover, Chen et al. (2019) applied a two-way fixed-effect model to investigate the impact of financial development on energy intensity for a panel of non-OECD and OECD countries. Their empirical results indicated that financial development has a considerable but negative (positive) effect on energy intensity in non-OECD nations (OECD countries). They further reported the presence of a U-shaped relationship between financial development and energy intensity. Applying directed acyclic graphs and structural vector (SVAR) models, Pan et al. (2019) noted that trade openness, financial development and technological innovation add to energy intensity. Yue et al. (2019) applied panel smooth transition regression to examine the relationship between different financial development indicators and energy consumption for a panel of transition economies. They confirmed that financial development has a neutral effect on energy consumption and financial intermediates have a considerable but positive impact on energy consumption. For Ghanaian economy, Adom et al. (2020) investigated the relationship between financial development and energy intensity for the period of 1970-2016 by applying FMOLS and DOLS approaches. They reported that financial development decreases energy intensity. Recently, Mukhtarov et al. (2020) unfolded the empirical relationship between financial development, energy consumption, energy prices and economic growth for Kazakhstan. They applied the Vector Error Correction Model and found that economic growth and financial development have a positive effect on energy consumption but energy prices decline. Raghutla and Chittedi (2020) applied bounds testing approach and VECM Granger causality to investigate the relationship between energy consumption, financial development and economic growth for India covering the period of 1970-2018. Their empirical results confirmed the long-run relationship between the variables. They found the presence of bidirectional causality between financial development and energy consumption.

II.II. Financial Development-Renewable Energy Consumption Nexus

Due to the increased importance of environmental quality, researchers suggested using renewable energy sources for meeting rising energy demand. In such circumstances, various studies indicated financial development to be the main source of investment for exploring renewable energy sources. Empirically, numerous studies investigated the effect of financial development on renewable energy consumption using time-series and panel data sets but provide conflicting empirical findings. For instance, Wu and Broadstock (2015) applied the panel GMM technique to examine the impact of financial development, institutional quality on renewable energy consumption for a panel of 22 emerging market economies for the period of 1990-2010. Their empirical results indicated that financial development and institutional quality have a positive impact on renewable energy consumption. Using the ordinary least square model, Kim and Park (2016) examined the relationship between financial development and renewable energy technologies for a panel of 30 countries. Their empirical evidence highlighted that the renewable energy sector relies on financial development and financial development further helps in lowering carbon emissions due to deployment of renewable energy technologies. For Russian economy, Burakov and Freidin (2017) investigated the empirical linkages between economic growth, renewable energy consumption and financial development for the period of 1990-2014. They applied Johansen cointegration and VECM Granger causality approaches and confirmed the presence of a long-run relationship between economic growth, renewable energy consumption and financial development. Their causality analysis indicated the unidirectional causality running from renewable energy consumption to financial development but similar is not true from the opposite side. By applying the panel fixed effect model, Best (2017) noted that financial capital is pushing the transition to sustainable renewable energy sources and financial capital adds to renewable energy consumption. Yazdi and Beygi (2018) applied the Pooled Mean Group approach to investigate the impact of financial development, energy consumption, trade openness, renewable energy consumption, economic growth and urbanization on carbon emissions for a panel of 25 selected African economies. Their empirical findings indicated the neutral effect of financial development and renewable energy consumption.

Ji and Zhang (2019) examined the relationship between financial development and renewable energy growth for Chinese economy by applying VAR models and confirmed that financial development is positively linked with renewable energy growth. Further, their empirical results highlighted that a 1% increase in financial development contributes to renewable energy consumption by 42.42%. In Indian economy, Eren et al. (2019) examined the impact of financial development and economic growth on renewable energy consumption for the period of 1971-2015. They applied cointegration and VEC Granger causality approaches and found the existence of long-run relationship between renewable energy consumption and its determinants. They also find that a unidirectional causality from financial development to renewable energy consumption and economic growth. Using panel vector autoregressive approach, Charfeddine and Kahia (2019) examined the relationship between financial development, economic growth, carbon emissions and renewable energy consumption for 24 MENA countries. Their empirical results showed that financial development adds to renewable energy consumption. Recently, Anton and Nucu (2020) applied the panel fixed effect technique to investigate the relationship between financial development and renewable energy consumption for a panel of 28 European Union countries. They found that financial development has positive but significant effect on renewable energy consumption.

II.III. Foreign Direct Investment-Energy Consumption

Foreign direct investment affects energy consumption via scale effect, technique effect and composition effect (Shahbaz et al. 2018). Various studies investigated the relationship between foreign direct investment and energy consumption but empirical findings are still inconclusive. For example, Mielnik and Goldemberg (2002) investigated the nexus between foreign direct investment, consumption of energy and gross domestic product using data from 20 developing countries. They found that an increase in foreign direct investment decreases energy intensity. Later on, Hübler and Keller (2010) applied the OLS regression approach for examining the impact of foreign direct investment inflows on energy intensity for a panel of 60 developing countries. Their empirical analysis indicated that foreign direct investment reduces energy intensity which suggests in developing energy-saving technology. Applying LMDI approach, Ting et al. (2011) examined the relationship between foreign direct investment and energy consumption intensity using data for Jiangsu province, China. They found that scale effect of foreign direct investment decreases consumption of energy intensity[1]. Using Chinese data, Jiang et al. (2014) applied a spatial panel approach to examine the impact of foreign direct investment on energy intensity covering the period of 2003-2011. They noted that foreign direct investment has a negative effect on energy intensity. Their empirical analysis also showed a U-shaped relationship between income and energy intensity. For East African economies, Adom and Amuakwa-Mensah (2016) investigated the relationship between foreign direct investment and energy productivity by considering the role of industrialization, income and trade openness. They applied a baseline regression approach and found that foreign direct investment and industrialization reduces energy productivity but income and trade openness promote energy productivity. By applying ARDL cointegration approach, Salim et al. (2017) examined the dynamic relationship between energy consumption and foreign direct investment for Chinese economy for the period of 1982- 2012. They found the presence of a long-run equilibrium relationship between foreign direct investment and energy consumption. Their empirical analysis shows that a 1% increase in foreign direct investment decreases energy consumption by 0.21% by keeping other things the same.

Moreover, Xin-gang et al. (2019) examined the relationship between foreign direct investment and energy intensity for a panel of 30 provinces of China. Using spatial econometric models, they find that foreign direct investment can facilitate convergence of conditional energy intensity and foreign direct investment spillover effect also plays an important role for energy intensity convergence. They further evidence that foreign direct investment decreases energy intensity due to scale effects. Uzar and Eyuboglu (2019) investigated the nexus between foreign direct investment, trade openness, economic development and energy consumption for Turkish economy by applying Fourier ADL and ARDL approaches. Their empirical results show a long-run relationship among foreign direct investment, trade openness, economic development and energy consumption. They note that foreign direct investment has a significant negative long-

[1]They suggested that foreign direct investment can only reduce consumption of energy intensity and to support the energy-saving technology and reduction of emissions are only possible by increase in foreign direct investment.

term effect on energy consumption. Their empirical evidence also shows the presence of unidirectional causality running from foreign direct investment, trade openness and economic growth to energy consumption. By applying the Generalized Method of Moments (GMM) estimator, Adom et al. (2019) investigated the relationship between foreign direct investment and energy demand for a panel of 27 African countries. Their results show that foreign direct investment has a concave impact on energy demand. Bu et al. (2019) applied panel-corrected standard errors (PCSE) and OLS regression techniques for examining the relationship between foreign direct investment and energy intensity for a panel of 13 Provinces in China. Their empirical results confirmed that foreign direct investment has a negative impact on energy intensity and also reduces energy intensity.

II.IV. Foreign Direct Investment-Renewable Energy Consumption Nexus

Due to the rise in importance of renewable energy consumption, few studies also investigated the relationship between foreign direct investment and renewable energy consumption with conflicting empirical results. For example, Sbia et al. (2014) applied the ARDL bounds testing approach to examine the relationship between clean energy consumption, foreign direct investment, trade openness, economic growth and carbon emissions using data from the UAE. Their results indicate the long-run relationship between the variables. They find that carbon emissions and foreign direct investment reduce clean energy demand. By applying Blundell-Bond dynamic panel econometric approach, Doytch and Narayan (2016) examined the impact of foreign direct investment on renewable energy consumption for a panel of 74 countries. Their findings indicate that foreign direct investment reduces non-renewable energy consumption in the industrial sector by increasing renewable energy demand. Paramati et al. (2016) applied panel econometric techniques, i.e., cross-sectional dependence, panel unit root, panel cointegration, long-run elasticities and heterogeneous panel causality to investigate the effect of stock market development and foreign direct investment on clean energy consumption for a panel of 20 emerging market nations. Their empirical results reported that stock market development and foreign direct investment have a considerable but positive impact on clean energy consumption. They also found a unidirectional causality running from foreign direct investment to clean energy consumption. Applying the fixed effect model, Marton and Hagert

(2017) noted that foreign direct investment reduces renewable energy consumption in the short run but, in long run, foreign direct investment increases share of renewable energy consumption.

Recently, Kilicarslan (2019) examined the impact of foreign direct investment on production of renewable energy for a panel of six different nations, i.e., Brazil, Russia, India, China, South Africa and Turkey. They applied the panel ARDL and Pedroni panel cointegration approaches and found the long-run relationship between the variables. Their empirical results also reported that foreign direct investment has a negative effect on production of renewable energy consumption. Yahya and Rafiq (2019) applied the GMM method and found that brownfield and greenfield investment have a positive effect on renewable energy consumption. For BRICS countries, Yilanci et al. (2019) examined the effect of trade openness and foreign direct investment on clean energy consumption for the period of 1985-2017. Their results confirmed that trade openness has a significant negative impact on clean energy consumption in China, Russia and South Africa while foreign direct investment has a considerable positive impact on clean energy consumption in Russia. They also found a unidirectional causality running foreign direct investment to clean energy consumption in China.

II.V. Research gap

This brief review of literature shows that the studies have mostly identified various drivers of renewable energy generation and consumption. However, mitigation of the risk associated with financing renewable energy projects is a policy void in the academic literature. Though the studies have discussed the scale and technique effects, isolation of these effects in addressing the risk still remains unanswered. This study addresses this research gap by recommending an SDG-oriented policy framework by isolating the scale and technique effects exerted by financial development and foreign direct investment.

III. Model construction and data

This paper deals with the decomposition of scale and technique effects of financial development and foreign direct investment on renewable energy consumption. Financial development supports allocating resources to lessen the dependence on the traditional energy sector by increasing production of renewable energy. Sound financial system makes it simpler and cheaper for industries to have easy access to international capital and to deploy technology in renewable energy production. Financial development moves cutting-edge technology to host nations, hence they are expected to increase their energy efficiency and governments will not only boost their domestic financial services but also need to encourage investments in development of renewable energy by moving traditional energy production to renewable energy production. Due to environmental awareness, financial sector development may support the development of green and clean technologies.

Foreign direct investment also affects renewable energy consumption via scale effect, technique effect and substitution effect. The relationship between foreign direct investment and renewable energy consumption also depends on association between foreign direct investment and economic growth. On the other side, foreign direct investment jointly with financial development plays a significant role in the allocation of financial resources for producing energy from renewable sources. Foreign direct investment and financial development increase investments and access to credit supports, and also stimulate economic activity via level and efficiency effects. Last but least, foreign direct investment may improve the deployment of renewable energy technologies while increasing energy efficiency intended to diminish carbon emissions. Economic growth affects renewable energy demand due to increase in per capita income and environmental awareness among the people. The general form of renewable energy demand function is modeled as following:

$$R_{i,t} = f(F_{i,t}, I_{i,t}, Y_{i,t}, K_{i,t}, E_{i,t}, IQ_{i,t}) \quad (1)$$

where ln, $R_{i,t}$, $F_{i,t}$, $I_{i,t}$, $Y_{i,t}$, $K_{i,t}$, $E_{i,t}$, $IQ_{i,t}$ and $\mu_{i,t}$ are natural-log, renewable energy consumption, financial development (domestic credit to private sector), FDI (foreign direct investment), economic growth (real GDP per capita), capital-labor ratio, fossil fuel energy consumption, institutional quality, and residual term. In the empirical model, renewable energy consumption has been used as the proxy for renewable energy demand. It is assumed that renewable energy consumption is a consequence of renewable energy demand and production. Following the analysis of worldwide renewable energy production and consumption pattern by Ritchie (2021), it can be deduced that renewable energy produced within a country will most likely be translated into consumption. Hence, renewable energy consumption is used as the proxy for renewable energy production. All the variables have transformed into natural-log before moving for empirical analysis following Shahbaz et al. (2021). The log-linear transformation not only smoothens the data but also directly provides an elasticity effect of the variables. The log-linear specification of energy (renewable) demand function is modeled as following:

$$\ln R_{i,t} = \alpha_0 + \alpha_1 \ln F_{i,t} + \alpha_2 \ln I_{i,t} + \alpha_3 \ln Y_{i,t} + \alpha_4 \ln K_{i,t} + \alpha_5 \ln E_{i,t} + \alpha_6 \ln IQ_{i,t} + \mu_{i,t} \quad (2)$$

In Eq. (2), $\alpha_1 > 0$ if financial development increases renewable energy consumption otherwise $\alpha_1 < 0$. Foreign direct investment is positively linked with renewable energy consumption if $\alpha_2 > 0$ otherwise $\alpha_0 < 0$. Economic growth has positive effect on renewable energy consumption due to people awareness environmental quality and we expect $\alpha_3 > 0$ otherwise $\alpha_3 < 0$. $\alpha_4 > 0$if substitution effect, i.e., capital-labor ratio increases renewable energy consumption otherwise $\alpha_4 < 0$. We expect $\alpha_5 > 0$ if fossil fuel energy is complementary to renewable energy consumption otherwise $\alpha_5 < 0$ (see Adebayo et al., 2021; Baz et al., 2021). As institutional quality helps in improving the renewable energy generation and consequential consumption, we expect $\alpha_6 < 0$. Lastly, $\mu_{i,t}$ is assumed to be having normal distribution.

It is noted in existing that financial development has non-linear effect on renewable energy consumption, i.e., U-shaped relationship is caused by the *Financial Kuznets curve*. This relationship implies that financial development (via scale effect) initially declines demand for renewable energy due to rapid increase in economic activity. In such a scenario, investors employ fossil energy sources to meet the energy demand for larger production domestically. After reaching the threshold point, the financial sector is directed to allocate financial resources to investors who employ green and energy efficient technology (via technology effect) for enhancing production due to environmental awareness among the people and environmental regulations implemented by the government. Similarly, foreign direct investment is inversely accompanied with renewable energy consumption initially (scale effect) but after threshold level, foreign direct investment demands renewable energy for enhancing domestic production in host country via technology effect. In doing so, we have included squared terms of financial development and foreign direct investment in energy (renewable) demand function as following:

$$\ln R_{i,t} = \beta_0 + \beta_1 \ln F_{i,t} + \beta_2 \ln F_{i,t}^2 + \beta_3 \ln I_{i,t} + \beta_4 \ln I_{i,t}^2 + \beta_5 \ln Y_{i,t} + \beta_6 \ln K_{i,t} + \beta_7 \ln E_{i,t} + \beta_8 \ln IQ_{i,t} + \mu_{i,t} \quad (3)$$

We expect $\beta_1 < 0, \beta_2 > 0$ if U-shaped relationship exists between financial development and renewable energy consumption otherwise inverted-U shaped association is present, i.e., $\beta_1 > 0, \beta_2 < 0$. The relationship between foreign direct investment and renewable energy consumption is U-shaped if $\beta_3 < 0, \beta_4 > 0$ otherwise $\beta_3 > 0, \beta_4 < 0$ i.e., inverted-U shaped.

$$\ln R_{i,t} = \delta_0 + \delta_1 \ln F_{i,t} + \delta_2 \ln F_{i,t}^2 + \delta_3 \ln I_{i,t} + \delta_4 \ln I_{i,t}^2 + \delta_5 \ln Y_{i,t} + \delta_6 \ln Y_{i,t}^2 + \delta_7 \ln K_{i,t} + \delta_8 \ln E_{i,t} + \delta_9 \ln IQ_{i,t} + \mu_{i,t} \quad (4)$$

In equation-4, we have included squared term of economic growth to test whether the relationship between economic growth and renewable energy consumption is U-shaped or inverted U-shaped. We expect $\delta_5 < 0, \delta_6 > 0$ if association is U-shaped otherwise $\delta_5 > 0, \delta_6 < 0$.

The data of RECAI countries covers the period of 2000-2019[2]. We comb World Development Indicators (World Bank, 2020a) to collect data for renewable energy consumption and fossil fuel energy consumption as a share of total energy consumption. The data on domestic credit to private sector as share of GDP (proxy for financial development), real GDP (Constant 2010 US$), foreign direct net inflows (BoP, current US$), gross fixed capital formation (Constant 2010 US$) i.e., proxy for capitalization and labor force i.e., working age population ranges to people aged 15 to 64 is collected from world development indicators (World Bank, 2020a). Total population is used for transforming all the variables into per capita units. Institutional quality is indicated by government effectiveness, and its data is collected from the Worldwide Governance Indicators (World Bank, 2020b).

[2] Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, India, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Korean Republic, Mexico, Morocco, Netherlands, Norway, Philippines, Poland, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, the United States, and Vietnam.

IV. Methodological Framework

For carrying out the empirical analysis, we have adopted the second-generation methodological approaches. The major reason behind this adoption is that the RECAI nations are associated with each other by means of transactional spillovers, and they share a structural resemblance in terms of the application of renewable energy solutions. Therefore, the interdependence among these nations can be assumed at a theoretical level, and this interdependence should be reflected in the methodological application. In order to encapsulate this interdependence among the nations, second-generation methodological approaches have been adopted. This methodological schema starts with testing for the possibilities of cross-sectional dependence, which sanctions the applicability of second-generation methodological approach. In this pursuit, Chudik and Pesaran (2015) weak cross-sectional dependence test has been employed. Upon acceptance of the alternate hypothesis of the presence of strong cross-sectional dependence among the model parameters, the applicability of second-generation methodological approach is sanctioned. Now, in order to initiate the empirical procedure, it is necessary to check the integration property of the variables, especially in the presence of cross-sectional dependence. In this pursuit, panel unit root tests developed by Herwartz and Siedenburg (2008) and Breitung and Das (2005) have been employed. Upon the rejection of the null hypothesis of the presence of unit root, it can be ensured that the model parameters fulfill the integration property. Once the integration property of the model parameters is checked, it is necessary to ensure that the model parameters will be associated in the long run, in presence of cross-sectional dependence. This property can be checked by means of the cointegration property of the model parameters, and in this pursuit, Westerlund and Edgerton (2008) cointegration test has been employed. This test is capable of capturing the cointegrating association among the variables in presence of cross-sectional dependence. Once the Lagrange Multiplier (LM) statistics of the test demonstrate the rejection of the null hypothesis of no cointegration, the long run coefficients can be estimated. In order to estimate the long run coefficients in presence of cross-sectional dependence, Cross-sectional Autoregressive Distributional Lag (CS-ARDL) model has been employed. To build up CS-ARDL method, first the ARDL method needs to be built:

$$\Delta y_{it} = \alpha_i + \acute{\eta} g\left(d_{i,t,\tau}\right) + \sum_{l=1}^{\rho} \beta_i \Delta y_{i,t-l} + \sum_{l=0}^{\rho} \delta_{i,l} \Delta d_{i,t-l} + \varepsilon_{it} \tag{5}$$

However, the ARDL method cannot account for cross-sectional dependence between the variables. But in our study, cross sectional dependency can arise due to several factors. Therefore, we employ the CS-ARDL method where cross-sectional averages of the variables can curb out this cross-sectional error dependence in the ARDL method. This method basically uses the averages of the regressors as an augmentation in the ARDL method. Therefore, we now extend the CS-ARDL model as follows:

$$\Delta y_{it} = \alpha_i + \acute{\eta} g\left(d_{i,t,\tau}\right) + \sum_{l=1}^{\rho} \beta_i \Delta y_{i,t-l} + \sum_{l=0}^{\rho} \delta_{i,l} \Delta d_{i,t-l} + \sum_{l=0}^{\rho} \theta'_{il,h} \overline{h}_{t-l} + \theta'_{i,g} \underline{g}_t(\tau) + v_{it} \quad (6)$$

where, $\underline{h}t = (\Delta \overline{y_t}, \Delta \overline{d_t})$ represents the cross-sectional averages of regressors (Allotey, 2018). This method is also preferred due to the fact that it can account for slope heterogeneity as well as endogeneity problems (Chudik and Pesaran, 2015). It has the capacity to handle the exogeneity restriction in an efficient way conditional on the large sample size (Chudik et al., 2016). Moreover, approaches like FMOLS and DOLS do not produce short run coefficients but CS-ARDL method generate short run and long run coefficients (Sharma et al. 2021).

V. Empirical Results and Discussion

It is imperative to understand that the testable empirical model uses squared terms of parameters, and this treatment might lead to the issues of multicollinearity. In order to evaluate the possibility of multicollinearity, Variance Inflation Factors (VIF) and Tolerance statistics of the individual model parameters are analyzed. The empirical results detailed in Table-1 reveal the presence of multicollinearity between the parameters. With a view to confront this issue, the matrix of model parameters has been transformed orthogonally. VIF and Tolerance statistics of the transformed model parameters reveal that the prevailing issue of multicollinearity has been removed after the transformation. Once this issue has been undertaken, statistical exploration can be initiated.

Table-1: Variance Inflation Factors (VIF) and Tolerance

Variables	Before transformation		After transformation	
	VIF	Tolerance	VIF	Tolerance
FD	329.79	0.0030	1.00	1.0000
FD^2	364.59	0.0027	1.00	1.0000
FDI	23.03	0.0434	1.00	1.0000

FDI^2	21.87	0.0457	1.00	1.0000
Y	954.07	0.0010	1.00	1.0000
Y^2	1062.70	0.0009	1.00	1.0000
KL	25.31	0.0395	1.00	1.0000
FE	3.38	0.2962	1.00	1.0000
IQ	7.19	0.1391	1.00	1.0000

To initiate the analysis, it is necessary to evaluate the order of integration of the variables, as it will determine the relevance of the long run cointegration among them. Nevertheless, in order to determine the generation of unit root tests for defining the order of integration, it is necessary to assess the cross-sectional dependence among the data. In this pursuit, Chudik and Pesaran (2015) weak cross-sectional dependence test has been employed, and test outcomes shown in Table-2 demonstrate the presence of strong cross-sectional dependence. Based on empirical results, this study employs second-generation unit root tests, which assume cross-sectional dependence. To commensurate the objective of determining the order of integration, Herwartz and Siedenburg (2008) and Breitung and Das (2005) unit root tests are employed. The results are reported-3 which depict the stationarity of the variables after first differencing, thereby divulging their order of integration to be unity i.e. I(1). Once the order of integration of the variables is discovered, it sanctions the applicability of the cointegration test, and this test needs to be of second generation. In this pursuit, Westerlund and Edgerton (2008) panel cointegration test has been employed, and results are recorded in Table-4. The empirical results demonstrate the presence of significant cointegration between the variables, in presence of cross-sectional dependence.

Table-2: Weak Cross-Sectional Dependence Analysis results

Variables	Test statistic	p-value	Variables	Test statistic	p-value
RE	2.886	0.004	KL	11.811	0.000
FD	3.659	0.000	FDI	10.299	0.000
FD^2	2.612	0.000	FDI^2	3.041	0.002
Y	19.233	0.000	FE	7.684	0.000
Y^2	3.904	0.000	IQ	39.240	0.000

Table-3: Second-Generation Unit Root Analysis results

Variables	Herwartz and Siedenburg (2008)		Breitung and Das (2005)	
	Level	First Diff.	Level	First Diff.
RE	1.0038	0.0799[a]	4.9443	-16.1955[a]
FD	1.0034	-0.3877[a]	6.1448	-12.2748[a]
FD^2	1.0053	-0.3037[a]	6.0940	-12.2827[a]
FDI	1.0068	-0.3158[a]	1.9824	-13.1035[a]
FDI^2	1.0003	-0.3976[a]	0.5846	-20.0989[a]
Y	1.0018	0.5926[a]	11.5484	-10.8235[a]
Y^2	1.0030	0.5603[a]	11.5098	-10.9464[a]

KL	1.0014	0.3253[a]	4.3246	-14.0420[a]
FE	0.9999	-0.0336[a]	3.3739	-16.1102[a]
IQ	-0.3718	-2.6882[a]	0.8113	-15.8302[a]
Note: a significant value at 1%				

Table-4: Westerlund and Edgerton (2008) Cointegration Analysis results

Test Parameters	Model (1)		Model (2)		Model (3)	
	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value
LM_τ	-7.623	0.000	-4.775	0.000	-1.257	0.003
LM_ϕ	-6.112	0.000	-3.005	0.008	-1.198	0.078

Note:
Model (1): model with a maximum number of 5 factors and no shift.
Model (2): model with a maximum number of 5 factors and level shift.
Model (3): model with a maximum number of 5 factors and regime shift

While conducting cointegration analysis, three models produce structural breaks, in presence of cointegrating association, and Table-5 shows such structural breaks. One set of structural breaks appeared during 2002-2005. This was the time, when the world experienced the global economic slowdown, which impacted industrial production across the countries (Fidrmuc and Korhonen 2004). Once the industrial processes were hit, allied economic and financial activities also experienced shocks. Therefore, energy demand and production, financial development, international trade, industrial investment, and job creation experienced the downturn shock (Wu et al. 2019). On the other hand, during 2004-2005, the sudden surge in oil prices helped the nations to boost their economies, and it had a direct impact on the manufacturing sector (Setser, 2004). Therefore, cointegrating association among the model parameters demonstrated structural breaks for the period of 2002-2005. The world experienced another economic slowdown in 2011, owing to slow recovery rate of economies and economic malaise, subsequent to credit crisis and recession in 2008 (Larsen et al. 2012). Once recovered, it hit the world again in 2014 in the form of deflation, followed by Chinese stock market crash in 2015, the consequence of which was extended to 2016 in the form of economic slowdown (Zhang and Du, 2017). These series of events had nearly similar consequences on industrial production processes, and hence, the impact of such events on model parameters appeared as structural breaks in long-run cointegrating association.

Table-5: Structural Breaks in Westerlund and Edgerton (2008) Cointegration Test

Provinces	*No Shift*	*Mean Shift*	*Regime Shift*
Argentina	2002	2003	2005
Australia	2002	2003	2003
Belgium	2002	2002	2002

Brazil	2002	2002	2004
Canada	2002	2004	2004
Chile	2002	2004	2004
China	2002	2005	2005
Denmark	2002	2005	2005
Egypt	2002	2005	2005
Finland	2002	2005	2004
France	2002	2005	2005
Germany	2002	2005	2005
Greece	2002	2011	2011
Hungary	2002	2011	2011
India	2002	2011	2011
Ireland	2002	2011	2011
Israel	2002	2012	2011
Italy	2002	2011	2011
Japan	2002	2012	2011
Jordan	2002	2011	2011
Kazakhstan	2002	2011	2011
Kenya	2002	2011	2011
Korea, Rep.	2002	2011	2011
Mexico	2002	2012	2011
Morocco	2002	2011	2011
Netherlands	2002	2011	2011
Norway	2002	2011	2011
Philippines	2002	2011	2011
Poland	2002	2011	2011
Portugal	2002	2002	2002
South Africa	2002	2011	2014
Spain	2002	2011	2011
Sweden	2002	2011	2011
Switzerland	2002	2016	2015
Thailand	2002	2016	2015
Turkey	2002	2016	2014
United Kingdom	2002	2015	2015
United States	2002	2002	2001
Vietnam	2002	2002	2002

Now, once the long run cointegrating association between the variables is established, long run coefficients for the model parameters can be analyzed. In order to assess the long run coefficients in presence of cross-sectional dependence, CS-ARDL approach is adopted, and results are reported in Table-6. We find that the impact of financial development on renewable energy consumption is analyzed which positively and significantly affects renewable energy consumption. Ideally, in the case of the RECAI nations, financial mobilization towards the discovery of renewable energy is expected to have a positive influence on renewable energy consumption. This empirical result falls in similar lines with Ji and Zhang (2019) for Chinese economy. However, the evolutionary impact of financial development can be seen in Model II and III, where the impact is found to follow a U-shaped relationship with renewable energy consumption. During the initial phase of the evolutionary impact, the scale effect exerted by financial development restricted the development of renewable energy projects, while the evolution of scale to technique effect by means of technological transformation started to nourish it, which was translated into rise in renewable energy consumption. This has been substantiated by the presence of the turnaround points of this financial development-renewable energy consumption association arising out of Model II and III. This segment of empirical results is complemented by the impact of FDI on renewable energy consumption. In order to retain the renewable energy attractiveness, it is necessary that FDI in such nations turns out to be environment-friendly, so that the initiatives towards increasing renewable energy consumption can proliferate. The coefficient of FDI in Model I commensurate this expectation, as it suggests that FDI might have a positive impact on renewable energy consumption. This empirical evidence is consistent with Doytch and Narayan (2016). Yet, the evolutionary impact of FDI can be seen in Model II and III, where the impact is realized to be a U-shaped form. This reveals that scale effect exerted by financial development restricted the development of renewable energy projects, policymakers consider the environmental protection to be of lower priority, and hence, it became possible for FDI to exert negative environmental externality via scale effect to turn such nations a pollution haven. With the evolution of scale to technique effect by means of technological transformation, financial mobilization aimed at upholding renewable energy projects, which was complemented by the transfer of green technology via the FDI route. Consequently, FDI started to upsurge renewable energy consumption by exerting positive environmental externality via technique effect. This shows that the relationship between FDI and renewable energy consumption is U-shaped. This segment of the study outcomes extends the findings of Cheng et al. (2021) and substantiates the claim of Shahzad et al. (2021).

Table-6: CS-ARDL Analysis results

	Model I	Model II	Model III
Long Run Analysis			
FD	0.7495[a]	- 9.2827[b]	-8.8190[b]
FD^2	-	0.4679[c]	0.4454[b]
FDI	13.1117[a]	-14.8859[b]	-10.6349[a]
FDI^2	-	1.2977[c]	0.8940[a]
Y	1.6331[b]	1.6705[b]	-3.5529[b]
Y^2	-	-	0.1585[a]
KL	0.9439[b]	0.3941[c]	0.2395[c]

FE	0.1475[c]	0.5837[c]	0.3507[b]
IQ	0.4349[a]	0.2850[a]	0.3295[b]
Short Run Analysis			
FD	0.2504[a]	-3.1972[a]	-4.2719[b]
FD^2	-	0.6037[b]	1.2432[b]
FDI	3.3601[b]	-5.4174[a]	-4.0556[c]
FDI^2	-	0.6473[c]	1.3834[b]
Y	6.0149[b]	4.3571[b]	-6.7844[b]
Y^2	-	-	1.6346[a]
KL	-0.1873[b]	-0.9897[c]	-0.2293[a]
FE	0.6547[c]	0.3765[c]	0.2185[c]
IQ	0.1277[c]	0.1518[c]	0.2941[a]
RE-FD Association	-	U-shaped	U-shaped
RE-FD Turnaround point	-	20,323.52	19,932.16
RE-FDI Association	-	U-shaped	U-shaped
RE-FDI Turnaround point	-	309.67	382.96
RE-Y Association	-	-	U-shaped
RE-Y Turnaround point	-	-	20,869.77
Note: a significant value at 1%, b significant value at 5%, c significant value at 10%			

In continuation with this discussion, it turns out to be clear that economic growth patterns in such nations have tried to internalize the negative environmental externalities caused by growth trajectory, and therefore, economic growth patterns in such nations should protect environmental quality. The expected impact of economic growth on renewable energy consumption should be positive, and coefficients of economic growth (Y) in Model I and II support this logic. This segment of empirical findings falls in similar lines with Zafar et al. (2019) in case of Asia-Pacific Economic Cooperation (APEC) countries. Moving forward, the evolutionary impact of economic growth on renewable energy consumption follows a U-shaped association. It reveals that during the initial phase of evolutionary impact, scale effects exerted by economic growth restricted the development of renewable energy projects, and this restriction was imposed by policymakers via financial development and channels of FDI. With the evolution of scale to technique effect by means of technological advancements, economic growth started to internalize the negative environmental externality caused by it, and technique effect exerted by economic growth gradually started translating into rise in renewable energy consumption. This segment of the study outcomes falls in line with the findings of Chen et al. (2021). This statement has been further substantiated by the presence of a turnaround point of economic growth-renewable energy consumption association arising out of Model III. When this segment of the results is analyzed alongside the impacts of capital-labor ratio (KL) i.e. composition effect and fossil fuel energy consumption (FE), then the impact of economic growth on renewable energy consumption turns out to be more prominent. Out of all the model parameters, short run and long run impacts of composition effect differ, and this change divulges the evolution of impact of composition effect towards environmental sustainability. During the short run, the economic growth pattern desired by policymakers compels industries to be labor-intensive for achieving cost-effectiveness at the cost of environmental quality. Once this period of short-run policy myopia is over, economic growth patterns demand industries to be capital-intensive via additional investments towards technological innovation. This long-run policy agenda in turn enhances renewable energy attractiveness of these nations. This segment of empirical findings falls in similar lines with Hille et al. (2019) in case of Korea. However, it is not possible to switch to renewable energy solutions overnight, as it might cause harm to the economic growth pattern itself (Sinha et al. 2020 a, b). Therefore, the negative environmental impact of fossil fuel energy consumption will prevail in such nations, and the negative environmental externality exerted by fossil fuel energy consumption will in turn increase the demand for renewable energy sources. This phenomenon is reflected in short run and long run impacts of fossil fuel energy consumption on renewable energy consumption, which denotes that the continuous consumption of fossil fuel energy will in turn result in increase for consumption of renewable energy. Moreover, to develop and deploy renewable energy solutions, better institutional quality is necessary. The effect of institutional quality (IQ) across all the three models substantiates this claim. This signifies the importance of institutions in promoting renewable energy solutions. This segment of the findings falls in the similar lines with the finding of Wu and Broadstock (2015). Lastly, diagnostic tests are carried out to check the stability of the model outcomes, and the results are reported in Table-7. These outcomes endorse that the models are free from (a) heteroskedasticity, (b) normality, (c) serial correlation, and (d) omitted variable bias.

Table-7: Model Diagnostic test results

Diagnostic tests	Model I	Model II	Model III
Heteroskedasticity	0.21	0.49	2.13
(Breusch and Pagan, 1979)	(0.6434)	(0.4837)	(0.1440)
Normality	1.824	1.908	1.493
(Jarque and Bera, 1987)	(0.4509)	(0.3375)	(0.2821)
Serial Correlation	2.05	2.25	2.08
(Wooldridge, 2002)	(0.1603)	(0.1417)	(0.1576)
Omitted Variable Bias	0.95	0.71	0.51
(Ramsey, 1969)	(0.2265)	(0.3247)	(0.6141)
Note: p-values are within parentheses			

In continuation with the analysis of short-run and long-run coefficients, a subsample analysis has also been carried out to analyze the stability of the model outcomes. Moreover, based on the level of renewable energy development, a comparative analysis has also been carried out. For this, based on the 2020 RECAI ranking (EY, 2021), top-10 and bottom-10 RECAI countries are chosen. The model outcomes reported in Table-8 show the consistency of the coefficients, as the RE-FD, RE-FDI, and RE-Y associations show U-shaped form for both the cases. However, the turnaround points of the associations divulge some insights regarding renewable energy development scenarios in these countries. The turnaround points of the RE-FD, RE-FDI, and RE-Y associations for the top-10 RECAI countries are lower than those of the bottom-10 RECAI countries. Moreover, the turnaround points of these three associations for the top-10 RECAI countries are also lower than the turnaround points obtained for the aggregate data. This segment of the outcomes shows that the scale effect in the top-10 RECAI countries is dominated by the technique effect earlier than the bottom-10 RECAI countries. Though the turnaround points achieved in all the cases are within the sample range, comparison between the turnaround points show that the top-10 RECAI countries have better financialization and FDI channels for renewable energy development than the bottom-10 RECAI countries.

Table-8: Subsample Analysis results

Variables	Top-10 RECAI countries			Bottom-10 RECAI countries		
	Model I	Model II	Model III	Model I	Model II	Model III
Long Run Analysis						
FD	0.7827^{a}	-6.2093^{b}	-9.1752^{b}	0.8282^{a}	-5.0467^{c}	-14.1707^{a}
FD^2	-	0.3292^{a}	0.4826^{a}	-	0.2453^{b}	0.6758^{a}
FDI	1.9192^{b}	-14.2264^{b}	-13.0536^{b}	0.3285^{b}	-12.7972^{c}	-13.2874^{b}
FDI^2	-	1.3435^{c}	1.2223^{b}	-	1.0133^{c}	1.0677^{c}
Y	0.8639^{b}	1.3635^{a}	-1.9562^{b}	0.3399^{c}	1.7056^{c}	-2.6895^{b}
Y^2	-	-	0.1051^{a}	-	-	0.1305^{a}
KL	0.5808^{a}	0.2711^{b}	0.2096^{c}	0.1041	0.3333^{b}	0.3422^{b}
FE	0.2623^{c}	0.4254^{b}	0.3984^{c}	1.2972^{b}	0.7698^{a}	0.6573^{b}
IQ	0.4944^{b}	0.5517^{b}	0.6246^{b}	0.1985^{c}	0.1897^{c}	0.2840^{a}
Short Run Analysis						
FD	0.5516^{c}	7.2093^{b}	-7.0914^{b}	0.1717^{b}	-6.0466^{b}	-2.3437^{b}
FD^2	-	-0.1137^{b}	0.9619^{c}	-	0.3775^{a}	0.4602^{a}
FDI	1.3841^{b}	-16.8475^{a}	-11.7297^{b}	0.6715^{b}	-12.4811^{b}	-10.9959^{b}
FDI^2	-	3.8598^{b}	1.4793^{b}	-	0.1198^{c}	0.1986^{b}
Y	0.8219^{b}	1.3734^{c}	-1.7138^{a}	0.1278^{b}	0.2006^{b}	-1.2259^{b}
Y^2	-	-	0.7603^{a}	-	-	0.7374^{b}
KL	-0.6297^{c}	-0.8319^{b}	-0.9333^{b}	-0.3406^{c}	-0.1846^{a}	-0.5517
FE	0.1695	0.4522^{b}	0.4233^{c}	0.2656	0.8415^{b}	0.7221^{b}
IQ	0.9228^{a}	0.1885^{c}	0.6184^{c}	0.4958^{a}	0.1495^{c}	0.6047^{b}

RE-FD Association	-	U-shaped	U-shaped	-	U-shaped	U-shaped
RE-FD Turnaround point		12,467.66	13,440.25		29,342.48	35,752.98
RE-FDI Association	-	U-shaped	U-shaped	-	U-shaped	U-shaped
RE-FDI Turnaround point		199.24	208.46		552.59	503.93
RE-Y Association	-	-	U-shaped	-	-	U-shaped
RE-Y Turnaround point			11,007.97			29,869.64
Note: a significant value at 1%, b significant value at 5%, c significant value at 10%.						

However, without another set of analysis, it might be difficult to comment on the robustness of the models. In this pursuit, all three models have been tested using Cross-Sectional Augmented Distributed Lag (CS-DL) approach developed by Chudik et al. (2016) and Common Correlated Effects (CCE) approach developed by Pesaran (2006). These two tests are capable of considering cross-sectional heterogeneity. The robustness check is carried out majorly to assess (a) the sign of long-run coefficients, and (b) whether the turnaround points of the associations are within the sample range, as identified by results reported in Table-6. The outcomes of robustness check are reported in Table-9. This empirical evidence suggests that long-run estimates are robust.

Table-9: Robustness Check results

Variables	CS-DL			CCE		
	Model I	Model II	Model III	Model I	Model II	Model III
FD	0.2504[a]	-4.2049[b]	-56.4502[c]	0.1572[c]	-62.7507[c]	-93.7281[b]
FD^2	-	0.2176[a]	2.8616[a]	-	3.1712[c]	4.7405[a]
FDI	4.5178[b]	-5.9752[b]	-4.2739[c]	0.4618[b]	-8.4187[b]	-6.1746[c]
FDI^2	-	0.5191[c]	0.3741[b]	-	0.7162[a]	0.5114[c]
Y	2.9715[b]	5.5833[b]	-4.3485[b]	0.2732[a]	3.3270[a]	-7.6905[a]
Y^2	-	-	0.2180[a]	-	-	0.3865[c]
KL	0.1965[a]	0.2747[b]	0.3321[a]	0.6942[c]	0.3536[b]	0.4872[b]
FE	0.5488[c]	0.4836[b]	0.3831[b]	0.7847[a]	0.2843[c]	0.7343[c]
IQ	0.2201[b]	0.2738[b]	0.5565[b]	0.2084[b]	0.1778[b]	0.2107[c]
RE-FD Association	-	U-shaped	U-shaped	-	U-shaped	U-shaped
RE-FDI Association	-	U-shaped	U-shaped	-	U-shaped	U-shaped
RE-Y Association	-	-	U-shaped	-	-	U-shaped
Note: a significant value at 1%, b significant value at 5%, c significant value at 10%.						

VI. Conclusion and Policy Implications

This paper examined the effect of financial development and foreign direct investment on renewable energy consumption using a decomposing phenomenon based on the Renewable Energy Country Attractiveness Index (RECAI) for the period of 2000-2019 in 39 countries. Employing a second-generation methodological approach, empirical results indicated that financial development and foreign direct investment have a positive effect on renewable energy consumption. Economic growth adds to renewable energy consumption. Fossil fuel consumption has a positive and significant effect on renewable energy consumption. On the contrary, composition effect, i.e., capital-labor ratio declines renewable energy consumption. The nonlinear relationship between financial development and renewable energy consumption is U-shaped. The U-shaped association exists between foreign direct investment and renewable energy consumption. The relationship between economic growth and renewable energy consumption is also U-shaped.

VI.I. Core Policy Framework

The empirical findings have critical insights, which might be significant from the policymaking perspective, and to be specific, the policy framework might help these nations in attaining the objectives of certain Sustainable Development Goals (SDGs). The economic growth trajectory in such nations is fairly conducive for promoting the renewable energy generation initiatives. However, the prevalence of fossil fuel-based energy generation needs to be replaced gradually, so that the diffusion of renewable energy solutions can be diffused across the nations. In order to sustain the economic growth pattern, a financial mobilization channel needs to be utilized, so that renewable energy generation within nations can be encouraged and fossil fuel-based energy consumption can be discouraged. In order to diffuse renewable energy solutions, firms will require credits from financial institutions, and this credit channeling mechanism can be utilized for fulfilling the purpose. Policymakers need to focus more on differential credit mechanisms, so that firms with lower carbon footprint can be provided with the credit against lower interest rate, and conversely, firms with higher carbon footprint can be charged higher interest rate. This will gradually discourage firms to use fossil fuel-based solutions in their production processes, and they will be compelled to use renewable energy solutions. This might gradually increase the demand of renewable energy solutions in these nations, and this initiative might have a way for such nations to attain the objectives of SDG 7, i.e., affordable and clean energy. In pursuit of enabling the nations to progress towards being driven by green energy solutions, the policymakers will be necessarily internalizing the negative environmental externality exerted by means of economic growth patterns. Therefore, while attaining the objectives of SDG 7, such nations will also start treading along the path of attaining the objectives of SDG 13, i.e., climate action.

VI.II. Tangential Policy Framework

Along with the discussion of core policy framework, a tangential policy framework is required to support the core policy framework. This framework is designed by logically extrapolating the study outcomes. While the demand for renewable energy solutions will rise, the consequential demand for technological development is also expected to rise. In such a situation, it might not be possible for nations to develop the solutions within a nation, and hence, those solutions might need to be imported from other nations, via the FDI route. In this way, till the technological capacity of nations reaches its full potential, the FDI channel might be utilized for renewable energy generation by technology transfer. While carrying out these solutions, firms need to employ capital intensive technology-oriented solutions, rather than labor augmenting solutions. This will help them in fulfilling the demand of renewable energy solutions. However, this particular initiative might have an impact on the employment scenario of such nations, as labor will be gradually replaced by the process of technological development. In such a situation, policymakers need to intervene for maintaining the social order, and this can be ensured by providing proper training to surplus labor, so that they can be employed in new renewable energy generation firms. This will not only help these nations to tackle the problem of unemployment, but also will help these nations to sustain economic growth patterns. This initiative will help such nations to make a progression towards attaining the objectives of SDG 8, i.e., decent work and economic growth.

VI.III. Policy Caveats and Assumptions

Along with recommending the policy framework, it is also necessary to discuss the policy caveats and assumptions, without which the recommended framework might not produce desired results. The caveats and assumptions can be described as: (1) the policymakers should make laws and regulations for environmental protection more stringent, so that further depletion of natural resources can be curtailed, (2) rent-seeking mechanism in bureaucratic process should be minimized, so that technological diffusion can be smooth, and (3) financial institutions need to continue the differential credit mechanism, while the monitoring of debtor firms should be stringent and non-discretionary.

VI.IV. Limitations and Future Projections

Though the recommended policy framework can help such nations in attaining the SDG objectives, it should also be remembered that policy framework needs to be considered as a baseline approach. Consideration of the sector-level analysis and innovative aspects could have brought forth additional insights to the policy framework. There lies the limitation such as it should be reiterated that policy framework is a baseline approach to design further policies that can be more suitable for the other developed and developing nations, which aim to boost renewable energy generation. From this perspective, this aspect of generalizability is the specialty of framework. Further research in this aspect can be carried out by considering the spatial dimensions and quantile level analysis of renewable energy generation and multilateral trade dimensions.

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