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DETERMINANTS OF RENEWABLE ENERGY IN ASIA: SOCIO-ECONOMIC AND ENVIRONMENTAL PERSPECTIVE

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Abstract

Energy related CO2 emission makes up two-third of global Green House Gas emission (GHG). It is mainly driven by developing countries especially those from Asia. Transition to Renewable Energy could reduce energy related emission. Identification of factors determining renewable energy is crucial for supporting its growth. We have tried to find out the factors determining renewable energy generation in developing countries of Asia. We used panel fixed effect model with Driscoll and Kraay standard errors using a sample of 26 countries for 19 years. The result shows that increased emission and energy consumption have not yet provide the incentive to invest in RE. Higher economic growth and increased dependency on imported energy find to encourage the renewable energy. Discouragement of renewable energy by the lobby of traditional energy sources is not found in our analysis.

Keywords: *Renewable energy, CO2 emission, energy consumption, energy import, traditional energy, economic growth*

JEL Codes: *Q42 O53*

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INTRODUCTION

Energy poverty is observed to be a major obstacle for developing countries to attain economic development and to eradicate the poverty [1]. Energy security is essential for socio-economic development but its enhancement through conventional source of fossil fuels exhaust the natural resources and contribute to the global Green House Gas (GHG) emission. Energy related emissions makes up around two-thirds of global GHG emissions [2]. Considerable efforts are in operation to phase out grey fuels, still coal accounts for almost 40% of electricity generation and more than 40% of energy-related CO2 emission [3]. At the same time energy demand has been increasing and is set to grow by more than 25% to 2040 [4]. Growing energy demand and increased emission results in the emergence of Renewable Energy (RE) as an alternative to traditional fossil fuels. Increased share of renewables in energy mix is a widely accepted tool for attaining energy security, sustainable development, and for combating the climate change[1]. RE has been growing significantly over the past decade. Renewable electricity capacity is forecast to increase by over 60% between 2020 and 2026, reaching more than 4800 GW [5].

Though global energy system is transforming towards less carbon intensive and sustainable energy system, emission from energy sector hasn't yet reduced to the level required for attaining the climate targets. Some estimates found CO2 emission from energy sector to be increasing or remaining at a constant pace [2, 6]. Emission must be reduced by 70% to bring temperature rise to well-below 2°C, a large-scale shift to electricity from renewables could deliver 60% of these required reductions, but for that RE must grow to two third of total primary energy supply by 2050 [7]. All this implies the need of further

[1] For e.g. in-order to attain emission reduction goals many countries, in their INDCs submitted in line with Paris agreement on climate change pledged to increase the share of renewables in their energy mix; goal 7 of 2030 agenda for sustainable development calls for substantial increase in the share of renewables in global energy mix; UN Secretary General's SE4ALL set one of its objective as to double the share of RE in global energy mix by 2030.

policies and actions for reducing the emission from energy sector and for making the sector environmentally sustainable.

Energy related CO2 emission is mainly driven by developing countries especially those from Asia. Globally energy-related CO2 emissions was flattened at around 33 Gt in 2019, driven by a sharp decline in CO2 emissions from the power sector of advanced economies, but the emissions outside of advanced economies grew to around 400 Mt with almost 80% of the increase coming from Asia [8]. Increased dependence on coal for energy use is the major cause for increased emission from such countries. In 2018 majority of the coal based power plants found in Asia were only 12 years old, decades younger than their average economic lifetime of around 40 years [9] this implies the possibility for the emission to continue in the future. Hence ongoing call for climate action and growing energy demand requires Asian countries to have a transition to RE sources. To promote the RE and to adopt appropriate energy policies it is essential to identify the factors influencing RE development. In this context this paper intends to identify the factors affecting RE generation in developing countries of Asia.

Most of the existing literature discussing the determinants of RE are focused on advanced economies [10, 11, 12, 13]. Some studies had considered developing countries for their analysis. Pfeiffer & Mulder [14] found out the factors affecting the diffusion of Non-Hydro Renewable Energy (NHRE) technology for electricity generation in 108 developing countries. On the other hand Brunnschweiler [15] analyzed the role of financial sector in RE development in a panel of 119 developing and transition economies. But studies with regional consideration like Asia is rare. Hence the present study is focused on developing countries of Asia.

The reminder of the paper is organized as follows; section 2 provides a review of the existing literature on different aspects of RE with a special focus on factors affecting RE generation. Section 3 explains the variables used as determinants of RE generation in this study. Section 4

discusses the data and methodology used for the analysis. Section 5 presents and discusses empirical findings. Section 6 provides the conclusion and policy recommendations.

Literature Review

Most of the existing studies on the determinants of RE considered developed countries for analysis. For example, Gan & Smith [10], by using the GLS model found that market deployment policies and GDP were the factors influencing renewable and bio-energy development in OECD countries. Marques et al., [11] used Quantile regression approach to found that CO2 emission, energy consumption, GDP, lobbying role of conventional energy producers, geographical area, and public policy were the factors affecting RE deployment in European Union (EU) countries. Marques & Fuinhas [12], by using dynamic panel model showed RE use as a persistent process in EU countries. RE use was found to be increasing with energy consumption and decreasing with CO2 emission. Contrary to the authors' expectation increased dependency on imported energy hadn't provide the incentive for attaining energy self-sufficiency through RE. Marques & Fuinhas [16] used PCSE to examine the impact of public policies on RE use by EU counties. Impact of other determinants like CO2 emission, energy consumption, and share of fossil fuels in electricity generation were also analyzed. Public policies of incentives/subsidies and policy processes were found to be the significant drivers of RE use. RE use was also encouraged by increased consumption but was discouraged by increased dependency. Lobbying effect was also supported by them.

Emodi et al., [17] tried to find out the factors influencing technological innovation in RE by 12 OECD countries. Using Fixed Effect model they found electricity generation from RE as a factor encouraging technological innovation but CO2 emission and R&D expenditure were insignificant. Countries with lesser population were found to be innovating more. They had also showed that price assurance through feed-in-tariff hadn't provided any incentive for additional innovation. A

different aspect of RE i.e. factors determining consumer's willingness to adopt RE for residential use was examined by Sardianou & Genoudi [18]. Their Probit model showed that elders and educated people were more attracted to RE use. Increased household income and electricity cost were the factors promoting RE use. But uncertainty about energy efficiency and higher installation and maintenance cost were found discouraging its use. Significant role of tax deduction in the promotion of RE was highlighted. Ratchet effect in RE consumption was also confirmed by them. Papież et al., [13] tried to identify the determinants of RE development in the EU countries. Their main aim was to find out how the distribution of energy sources in mid 1990s influenced RE sources in 2014. Countries with a large share of coal consumption in the energy mix and with high energy consumption were found not interested in RE development. Whereas those with low share of natural gas or high share of RE source were found attracted to RE. Countries with more diversified energy sources was also found interested in developing RE. Positive impact of GDP implies that the richest countries were more prone to invest in RE. Higher cost for consuming energy produced from fossil fuels was found promoting the RE.

Some studies can be found in developing countries as well, majority of them did the analysis with individual countries or developing countries as a group but with no regional distinction. Such studies include; Yang et al., [19] used panel threshold regression model to find out non-linear effect of government subsidy on RE investment. Analysis was made with 92 RE listed enterprises in China. Subsidy was found promoting investment and it was more effective in regions with higher energy consumption intensity, lower financing constraints, and lower economic development. It also had a very significant effect on investment by MSMEs. Keeley [20], by using Analytical Hierarchy Process (AHP) method found out the relative importance of various factors in attracting donors towards RE investment in Pacific small island developing states. National RE target and its prioritization, well-structured action plan, and legal and regulatory framework were most significant for enhancing RE

investment. Factors like ease of dealing with bureaucracy, financial stability of utility company, and social acceptance were partially significant. Whereas technological factors like data on RE sources and system, and technological capacity of utility company didn't have much significance.

Pfeiffer & Mulder [14] used two stage estimation methods to analyze the factors accelerating adoption and diffusion of NHRE for electricity generation in developing countries. Economic and regulatory instruments, higher per capita income and schooling levels, falling share of clean carbon energy resources, and stable democratic regimes were the factors promoting RE diffusion. Unlike some of the existing literature [10, 11, 12] this study found that growth in electricity consumption and institutional and strategic policy support programs delayed the diffusion of technology and the amount of electricity produced by NHRE. Brunnschweiler [15] by running panel model of GLS and GMM confirmed that development of financial sector especially of commercial banking sector had significant role for promoting RE in developing and transition economies. Energy sector policies, regulation measures, and increased income were also significant for its development. Their result had also showed RE as a persistent process. As in the case of developed countries presence of lobbying effect of traditional energy in developing countries was confirmed by Pfeiffer & Mulder and Brunnschweiler [14, 15]. Kutan et al., [21] analyzed the effect of FDI inflows and stock market development on RE consumption by India, Brazil, China, and South-Africa. Impact of RE and Non-RE consumption on CO2 emission and economic output was also examined. Group Mean Fully Modified OLS (FMOLS) model showed RE consumption increased with FDI inflows and stock market development but it was reduced with CO2 emission. Though RE and Non RE consumption were found contributing to economic output, Non-RE was coming with increased CO2 emission.

Rafiq et al., [22] used VECM model to identify the indicators of RE generation in India and China. They examined the dynamic relation

between carbon emission, economic growth, and RE generation. For India unidirectional short-run causality was examined from carbon emission to RE generation and output respectively, and also from RE generation to output. This suggests that renewable technologies were being used to reduce the detrimental impacts of growing emissions while it was also helping to boost the economic growth. Long run bidirectional causality between all the variables indicated the inherent interdependence of growth, energy production and pollution. For China they found unidirectional causality running from output and carbon emission to RE generation. For long run, there was unidirectional causality from output to RE generation, and bidirectional causality between carbon emission and RE generation. This suggest that China had already started to commit its sustainable development through the adoption of cleaner technologies linked to both output and carbon emission growth.

Salim & Rafiq [23] analyzed the determinants of RE consumption in six major RE investors in emerging economies (Brazil, China, India, Indonesia, Philippines and Turkey). They used country specific Auto-Regressive Distributed Lag (ARDL), and panel based FMOLS and Dynamic OLS models for analysis. Panel models showed positive impact of income and emission on RE, but oil price was insignificant. In ARDL model income and emission had positive impact on RE in Brazil, China, India, and Indonesia, whereas in Philippines and Turkey income alone had a positive impact. Authors specify that this difference may be due to the increased concern given to the environmental sustainability by countries with higher economic growth. ARDL model also showed limited role of oil price.

ARDL model was used by da Silva et al., [24] to examine the determinants of RE growth in Sub-Saharan African (SSA) countries. Growing fossil fuel price was found discouraging the adoption of RE. Negative impact of CO2 emission and the ratification of Kyoto protocol indicate that environmental concerns resulting from these were

insufficient to encourage the renewable sources in SSA. GDP was found having a positive impact implying that increased income would help the country to invest more in renewable sources. Negative impact found for population growth implies that as population grew countries would try to resort to cheaper source of fossil fuels to meet the growing energy demand. Increase in energy imports was found reducing the renewables adoption. This could be because the countries worried with energy security would resort to fossil fuels rather than renewables by taking cost into considerations.

As literature with regional distinction especially those dealing with RE generation in developing countries of Asia is very rare, it seems appropriate to concentrate on those countries. In addition to that Asia being a region with largest use of coal and there by the largest emitter of energy related CO2 emission, provision of knowledge about factors influencing RE may help to improve the pace of transition towards RE. Following section provide detailed description of variables under concern, their source, methods, and estimation procedure.

DETERMINANTS OF RE GROWTH

To indicate RE development, we used contribution of RE in total primary energy supply measured in ktoe as our dependent variable. Explanatory variables were chosen by reviewing the existing literature. Variables chosen for this analysis represents certain socio-economic and environmental characteristics.

CO2 Emission

A significant portion of GHG emission, a major reason for rising atmospheric temperature and ongoing climate change, comes from CO2. Though there is some other gases having more heat trapping ability than CO2, CO2 is the most abundant one released from human activity and it stick in the atmosphere for a long time. Therefore CO2 has gained much attention in the actions aimed at combating climate change. CO2

emission is a common variable used in most of the existing literature [10, 11, 12, 13, & 17]. Following those literature, we include CO2 emission by assuming that environmental concerns associated with rising level of emission will encourage the countries to adopt alternative measures like the expansion of RE for reducing the emission from energy sector.

Energy Consumption

Energy consumption as a determinant of RE development is a widely analyzed concept [11, 12, 13, 17, 24, & 15]. However its impact is uncertain. Marques & Fuinhas [16] specified that growing energy demand can be supplied through fossil fuel sources, or RE sources or through a mix of both. Thus following the insights obtained from the existing literature this study include per-capita energy consumption measured in KWh to examine whether growing energy demand is actually promoting or discouraging RE development in Asian countries.

Contribution of Fossil Fuels to Electricity Generation

A common argument made by most of the existing literature [11, 12, 14, 15, & 25] is that if energy producers from fossil based sources enjoys significant power over economy and politics they will influence energy policies and there by hinder transformation towards clean energy. We also control for it by keeping per-capita electricity generation from fossil fuels as one of the explanatory variable. Though most of those studies used share of natural gas, oil, and coal separately present study include their contribution to electricity generation in total.

Energy Import

Many of the existing literature tested the hypothesis that increased dependence on imported energy encourages the countries to attain energy self-sufficiency by promoting RE development [11, 12, 24, &25]. We have also tested same hypothesis by including net energy import as a determinant of RE growth. Hence we expect a positive relation between energy import and RE contribution to energy supply.

Income

Impact of income on RE is a common factor examined by most of the existing literature [12, 15, 17, 25]. Most of these literature suggested that high income countries are likely to invest more in RE development since they are able to afford the cost of developing such technologies. Existing studies used alternatives indicators of income like GDP, GDP per-capita and GDP growth rate. Following the insights gained from these studies we use per capita GDP to test the hypothesis that increased income will help to meet the substantial investment requirement of RE generation. Hence we expect a positive relation between GDP and contribution of RE to energy supply.

DATA AND METHODOLOGY

Data

This study analyzed a panel of 26 developing countries of Asia (Armenia, Azerbaijan, Bangladesh, Cambodia, China, Georgia, India, Indonesia, Islamic Republic of Iran, Iraq, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Tajikistan, Turkmenistan, Thailand, Uzbekistan, and Viet Nam) from 2000 to 2018. Choice of this sample set is dictated by the availability of data. Table1 explains the variables used for analysis and their data source.

Table 1: Summary of Data Set

Variable	Explanation	Source
re	Contribution of renewables to total primary energy supply (ktoe)	OECD data [26]
co2	CO2 emission (kt)	WDI [27]
energycons	Primary energy consumption per capita (KWh)	Our World in Data [28]
elecff	Per capita electricity generation from fossil fuels (KWh)	Our World in Data [29]
import	net energy import (kt)	Data & statistics IEA [30]
gdp	GDP per capita (constant 2015 US$)	WDI [31]

Source: compiled by authors

Methodology

As the present data consists of both cross section and time series dimension we chose panel model for analysis. Efficient estimators can be obtained from panel model since it can control for unobservable individual specific and time effect. In addition to this, it helps to solve the problem of multi-collinearity and possible biases from omitted or unobservable variables, and it can better study dynamics of change, hence such model improves over cross section and time series model [32, 33]. A basic panel model can be expressed as:

$$Yit = \alpha i + \mu t + \beta Xit + \varepsilon it \quad (1)$$

where i=1,2,….,N for countries and t=1,2,……,T for time period. Yit is the dependent variable (in this analysis it is the contribution of RE to total primary energy supply). Xit is the vector of independent variables, αi is the un-observable country specific effect and μt is the time effect. εit is the error term.

In the presence of panel specific effects (individual heterogeneity) OLS estimator will no longer be best, unbiased, and linear. Hence static panel model of either Fixed Effect (FE) or Random Effect (RE) is usually used for estimation. FE model assumes that individual heterogeneity is correlated with other regressors hence it estimates intercept specific to panel unit. Whereas in RE model there is no such correlation hence it estimates error variance specific to panel unit [34]. Therefore in FE model intercept αi of equation 1 will include un-observable effect whereas in RE model it will be a part of the error term εit. In both this model, the slope remains constant across individual and time period. FE or RE model is chosen over pooled OLS using the F test and Lagrange multiplier test respectively. Rejection of null hypothesis of no individual specific heterogeneity choose FE or RE over pooled OLS. Choice between FE and RE models has to be made using Hausman specification test, here the null hypothesis is the absence of correlation between individual effect and regressors. Rejection of null hypothesis

favours FE model over RE model. In the present study statistical tests chose static panel model over pooled OLS, and then FE over RE model.

A problem with panel data is that there is high chance for cross sectional and temporal dependence. As this can lead to biased statistical inference most of the recent studies try to adjust their standard errors for possible dependences in the residuals. Though most of them account for heteroscedasticity and autocorrelation, cross-sectional dependence is largely ignored. Regardless of these type of dependencies standard panel estimators would be consistent (but inefficient), but the resulting standard error estimates would be biased thereby leading to invalid statistical inference (see [35] for detailed discussion). Hence to make valid statistical inferences it is essential to test whether the problems like cross-sectional and temporal dependence and heteroscedaticity is presented in the data set. If such problems are found to exist, correlation (both temporal and spatial) and heteroscedasticity consistent standard errors has to be obtained.

Alternative methods available for covariance matrix estimation includes; Feasible Generalized Least Squares (FGLS), Panel Corrected Standard Errors (PCSE), and Driscoll and Kraay's (1998) standard errors. FGLS method is infeasible if the panel's time dimension (T) is smaller than its cross-sectional dimension (N) and it has unacceptably small standard error estimates. Though PCSE estimator performs well in small panels their finite sample properties are poor when N is large compared to T. Driscoll and Kraay (1998) method uses Newey-West type correction to the sequence of cross-sectional averages of the moment conditions, this provide consistent covariance matrix estimator independently of the cross-sectional dimension (N). Hence this method performs well over the other two even in the case of small panels[2]. In the present study we tested for spatial and temporal correlation using Breusch-Pagan LM test

[2] Details about the methods of covariance matrix estimation is obtained from Hoechle [35]

and Wooldrige LM test respectively. We have also tested for heteroscedaticity using Modified Wald test for group wise heteroscedasticity. Since all these problems exist in our data and our T dimension is smaller than N dimension we choose FE model with Driscoll and Kraay standard errors for our analysis. We use STATA 15 version for doing the analysis.

RESULT AND DISCUSSION

Descriptive Statistics

The descriptive statistics provided in Table 2 shows that countries chosen for this analysis on average contribute RE of 23348 ktoe to total energy supply. These countries on average emit CO2 of 440364 kilo tons, but the standard deviation of 1524059 indicates that huge difference in emission exists across the countries. These countries on average requires 13873 KWh of energy. Average amount of electricity (per-capita) generated from fossil fuels is 1292 KWh, but the minimum value of 0 indicates that there is country with negligible reliance on fossil fuels (e.g. Nepal). Average value of energy import is found to be 17.3 kilo tons, but its standard deviation indicates the existence of huge difference across the countries. It is also clear that these countries on average hold a per-capita income of US$3262.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
re	494	23348.115	54959.789	8.689	295426.86
co2	494	440363.84	1524059.2	1960	10502930
Energycons	494	13872.8	11939.49	614.53	62048.453
elecff	494	1292.048	1251.377	0	5260.125
import	494	17.298	999.009	-2390.894	7027.605
Gdp	494	3262.388	2453.821	309.966	11075.58

Source : computed by authors

We chose FE model with Driscoll and Kraay (1998) standard errors for analysis. This model is selected following various specification tests. Result of all the specification tests is provided in Table 3. To check

whether static panel models performs well over pooled OLS model we performed F test and Breusch-Pagan LM test. From Table 3 it is can be observed that estimated value of F test is statistically significant hence it reject the null hypothesis that individual specific intercepts are zero. In the similar way Breusch-Pagan LM test reject the null that individual specific variances are zero. Thus both tests preferred static panel model over pooled OLS. Then to choose between FE and RE models we used Hausman test, its value is appeared to be significant. Hence we chose FE over RE.

Table 3: Specification Test

Tests	Co-efficient	
F test (FE v/s Pooled OLS)	851.77	(0.000)***
Breusch-Pagan LM test (RE v/s Pooled OLS)	2503.97	(0.000)***
Hausman Test (RE v/s FE)	76.331	(0.000)***
Breusch-Pagan LM test of independence	2089.337	(0.000)***
Wooldrige LM test for auto correlation	52.5	(0.000)***
Modified Wald test for group wise heteroscedasticity	3.5e+06	(0.000)***

Source: computed by authors
Notes: *** indicates statistical significance at 1% level. P values are in bracket

After running FE regression, we tested for cross sectional and serial correlation using Breusch-Pagan LM test of cross sectional independence and Wooldrige LM test for auto correlation respectively. In the result both appeared to be statistically significant there by showing the presence of both kind of correlation. We had also tested for heteroscedasticity using Modified Wald test, which also appeared to be significant. In addition to that since our T (19 years) is smaller than N (26) we used Driscoll and Kraay (1998) method for adjusting the standard errors of FE model. Result of the FE model with Driscoll and Kraay standard errors is shown in Table 4.

Table 4: FE model with Driscoll and Kraay Standard Errors

Independent variables	Co-efficient	
co2	-0.009***	(0.002)
energycons	-0.281***	(0.085)
elecff	1.107	(1.650)
import	16.536***	(1.548)
gdp	2.153***	(0.332)
constant	22594.520***	(640.683)

Source: analyzed by authors
Note: ***indicates statistical significance at 1% level. Standard errors are in bracket

In the estimated model all but electricity generation from fossil fuels appeared to be significant. Which means that the variables CO2 emission, energy consumption, energy import, and GDP have some influence on the contribution of RE to total energy supply. Impact of CO2 emission and energy consumption appeared to be negative. If CO2 emission increased by 1 kilo tons, RE share would decrease by .01 kilo tons. This implies that environmental concerns associated with increasing emission hasn't yet provide the incentive to the countries considered for this analysis to promote RE. This result is in consonant with many of the existing literature; Marques & Fuinhas [12, 16] and Marques et al., [11, 36] for EU countries, da Silva et al., [24] for SSA, Kutan et al., [21] for India, Brazil, China, and South-Africa, and Papież et al., [13] for EU also found that increased emission was not acting as a cause for promoting RE. Contrary to our result Aguirre & Ibikunle [25] for a panel consisting of countries from EU, OECD, and BRICS showed positive effect for CO2 emission.

Regarding the influence of energy consumption, a KWh increase in energy consumption is found reducing the share of RE by .28 kilo tons. This suggest that growing energy demand is encouraging the countries to stick on cheaper energy sources like fossil fuels rather than making a switch to RE. Aguirre & Ibikunle [25] also found the similar result for a panel consisting developed and developing countries. They had also

emphasized that these tendencies would be higher in the case of developing countries, that is their large population and energy intensive growth make them to emphasis on fossil fuels hence to show less inclination to increase renewables relative to energy requirements. Our result also agrees with Papież et al., [13] who for a panel of EU countries found countries with high energy consumption having no interest in RE development. But we disagrees with Marques & Fuinhas [12, 16] and Marques et al., [11, 36], their analysis for EU countries found increased energy consumption as a factor promoting RE use. Da Silva et al., [24] analysis for SSA also found a positive impact for energy use.

Energy import is found playing a significant role in promoting the RE. That is as per our result if energy import increases by 1 kilo tons, on an average RE supply would increase by 16.5 kilo tons. Hence we accept the hypothesis that increased dependency on imported energy would encourage the countries to attain energy security by investing in RE sources. This result is in consonant with Marques et al., [11, 36], who for EU countries found that higher the import dependency higher will be the incentive to produce energy through RE sources. But da Silva et al., [24] for SSA found a negative impact for energy imports, hence they pointed out that countries worried with energy security probably would resort to import of fossil fuels rather than exploring domestic renewables for cost considerations. But some studies found energy import to be insignificant for promoting RE [12, 25].

Estimated values of CO2 emission and energy import indicates that, in the countries considered for this analysis, it is the energy security and not the environmental concerns that act as the main cause for the growth of RE. But Aguirre & Ibikunle [25] showed that environmental concerns were more relevant than energy security for promoting RE. This difference in result may be due to the sample considered for analysis. Our sample consists a set of developing countries whereas the other study considered a panel consisting developed and a few developing countries. In developed countries it is more probable for the

environmental concern to be a root cause for promoting RE, but in developing countries that probability is more for energy security.

Though the relation between income and RE growth is highly examined a consistent result is not existing in the literature about that relation. As per our analysis if GDP/capita increases by 1 US$, RE supply on an average would increase by 2.15 kilo tons. This result suggest that countries with increased income would promote RE since they are able to meet the higher cost (associated with huge initial investment) of RE. Papież et al., [13] also found the similar result and they suggest that the richest countries are more prone to invest in RE since they can afford expensive RE technologies and support subsidies for promoting and regulating RE. Our result also agrees with da Silva et al., [24] and Marques et al., [36]. But Marques et al., [11] showed that impact of income could be heterogeneous, i.e. on the one hand if the deployment of RE is less higher income would encourage the take-off of renewables by allowing countries to support the high costs of renewable investment, on the other hand higher income could imply additional energy consumption, mainly through the fossil sources which is largely available in the market, hence it discourages the RE deployment. Contrary to these results Aguirre & Ibikunle [25] and Marques & Fuinhas [12] showed that GDP didn't have any significant role in promoting RE use.

From the assessment of electricity generation from fossil fuels it was observed that the variable considered to analyze the lobbying effect of traditional energy producers is insignificant. This result suggest that fossil fuels based energy producers are not playing any role in the growth of RE in developing countries of Asia. But most of the existing literature proved that if traditional fossil based energy producers play a significant role in the market and politics they would discourage the development of RE [11, 12, 13, 16, 25, 36].

CONCLUSION

The authors have tried to find out the factors determining RE generation in developing countries of Asia. To account for the problems of spatial and temporal correlation, and heteroscedasticity we conduct our analysis using FE model with Driscoll and Kraay (1998) standard errors. Our result showed that CO2 emission, energy consumption, energy import, and GDP have some influence on RE generation. But electricity generation from fossil fuels appeared to be insignificant for promoting RE.

Contribution of RE to total energy supply is found to be decreasing with CO2 emission. This indicates that environmental concerns associated with increased emission has not provided the incentive required to make a switch to RE. It also means that ongoing call for climate change mitigation and adaptation doesn't create social consciousness about the need for reducing the emission. Hence further awareness is required in developing countries of Asia for reducing the emission and combating climate change. Contribution of RE is found to be increasing with energy import. Which implies that increased dependency on imported energy would encourage the countries to attain energy self-sufficiency by investing in their own RE sources. By considering the impact that CO2 emission and energy import have on RE, it can be inferred that it is the energy security and not the environmental concern, which is acting as a primary cause behind the promotion of RE in the developing countries of Asia.

Negative impact of energy consumption on RE implies that developing countries of Asia are still relying on fossil fuels and other cheaper sources for meeting their growing energy demand. Though these countries have been investing in RE, their reliance on fossil fuels is quite high. Hence further awareness and support is required for making RE as a pure substitute for grey fuels. It was also found that RE contribution is increasing with income this implies that countries with more income are able to meet the higher initial investment required for exploiting RE sources. They are also capable to promote RE growth by

providing subsidies and incentives. Consideration of this result along with negative impact found for energy consumption raises a concern. Usually growing income will results in increased energy consumption, hence the countries considered for this analysis should ensure that they are not relying on fossil fuels for meeting their growing energy demand. Therefore these countries should adopt appropriate energy policies for meeting their growing energy demand without contributing to the global emission. Though most of the existing studies showed the presence of lobbying effect of fossil fuel based energy producers, we found that those energy producers are not playing any role in the growth of RE. Hence the countries can have a switch to RE without the fear of getting disrupted by traditional energy producers. Further those producers can also be attracted towards RE by providing regulatory and financial support.

Finally, it can be inferred that though developing countries of Asia have been promoting RE and adopting significant efforts towards climate change mitigation further efforts like the provision of sufficient financial mechanism, regulatory and policy support, and infrastructural development are required for RE expansion. Since quick and complete transition to RE is not possible adequate policies is required to make the fossil fuel based energy production more efficient and to ensure its gradual shift to renewable sources. As developing countries energy demand and intensity in the countries concerned is quite high hence further effort is required to ensure energy security in a sustainable manner.

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