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Abstract:

In terms of attaining the objectives of Sustainable Development Goals (SDGs), the Asian economies are considered as laggards, and one of the major problems faced by these economies is the issue of environmental degradation. For addressing this pertaining issue, a policy-level reorientation might be necessary. In this view, this study aims to explore the impact of urbanization, renewable energy consumption, financial development, agriculture, and economic growth on CO_2 emissions in 15 Asian economies over 1990-2014. The empirical evidence demonstrates that urbanization, financial development, and economic growth increase CO_2 emissions, renewable energy consumption reduces CO_2 emissions, and the impact of agriculture is insignificant. Impulse response function and variance decomposition techniques are used to test the causality among the variables. Based on the study outcomes, a comprehensive SDG-oriented policy framework has been recommended, so that these economies can make progression towards attaining the objectives of SDG 13 and SDG 7. This study contributed to the literature by recommending this SDG-oriented policy framework, which encapsulates economic growth and its drivers.

Keywords: Urbanization; Renewable Energy Consumption; Financial Development; CO_2 emission; SDG

1. Introduction

While treading along the economic growth trajectory, attainment of the developmental path creates the divide between the Nations, and this divide is reflected in terms of the developmental policies being adopted in those Nations. For the developed Nations, the policymakers might be more interested towards improving the living standard of the citizens by upholding the development quality of the nations, while on the other hand, policymakers of the developing nations will be more interested in accomplishing economic growth even notwithstanding the sustainable development. Therefore, for the latter case, a classic trade-off between growth and development can be seen. If the latest Sustainable Development Goals (SDG) progress report is analyzed, then it can be seen that the developing nations are demonstrating poor performance, compared to their developed counterpart in various fronts, and Climate Action is major among them (UNESCAP, 2021). This report reiterated the environmental concerns raised by the United Nations, during the assessment of the environmental SDGs (UNESCAP, 2020). The prevailing economic growth trajectory in these nations is not environmentally sustainable, as economic growth pattern of these nations is largely dependent on the fossil fuel-based solutions. Therefore, these nations are finding it difficult to recalibrate the existing policies for attaining the objective the climate action, which falls under SDG 13. While drawing the reference of SDG 13, the Asian economies need special mention, as these economics are considered as the laggards in terms of attaining the SDG objectives. In the 2019 baseline Poverty Eradication report, World Bank has attributed environmental degradation to be one of the major hindrances on the way to achieve economic development in Asia (Fallesen et al., 2019). Given this contextual setting, policy reorientation is essential in the Asian countries, so as to avoid the climatic vulnerability of the economic growth and ensure sustainable development. The concern of the International Monetary Fund in this regard can be felt in the work of Prakash (2018), who also has stressed on the policy realignment aspect for these economies. This prevailing policy-level void gives the primary rationale for conducting the present study.

During treading along this economic growth trajectory, these economies are experiencing a surge in the job opportunities, because of which the urban regions in these economies are undergoing an anthropogenic transition. This transition can be referred to as urbanization, which is caused by the demand of labor force created by the rapid industrial activities. This shift of the labor force towards the urban areas has catalyzed the energy demand to escalate, and this escalation has consequentially given rise to the rise in ambient air pollution. While describing the economic inequality prevailing in these nations, the issue of unsustainable urbanization has been discussed in the Human Development Report 2019, and the problem of rising CO_2 emissions has also been attributed to the rising urbanization (UNDP, 2019). Now, in order to cater to the rising demand of energy in the urban areas, and at the same time, to protect and improve the environmental quality, these nations are exploring the potential of the renewable energy solutions. The latest Energy Target Assessment report of International Energy Agency has stressed on the discovery and diffusion of renewable energy solutions for achieving energy security and improving environmental quality in the Asian countries (Kristiansen and Arboleya, 2021). Now, this report has also mentioned about investment in the renewable energy generation systems by creating adequate financialization channels. These new financialization channels might help in boosting the development and deployment of domestic renewable energy systems, while the existing channels are more prone towards boosting the industrialization and consequential environmental degradation. The report by Asian Development Bank on Green Energy Financing in Asian economies has focused on this particular issue for the South Asian economies (Peimani, 2018). In such a scenario, this gives a clear indication that the existing policy framework in the Asian economies might create a predicament in achieving the energy solutions to be clean and affordable, i.e., the objectives of SDG 7. Realignment of urban development policies, energy policies, and financialization channels might be able to show a way to attain the SDG objectives by 2030 for these economies. This particular SDG-oriented policy design purpose gives the second rationale of the present study.

While these nations are trying to achieve economic growth by means of rapid industrialization, a major share of the income generation in these nations comes from the agricultural activities. These nations faced the issue of food crisis, and for reviving from that problem, policymakers of these nations have embarked on the innovative practices for ensuring sustainable agriculture. However, in order to enhance the productivity of the agricultural activities, deforestation started to increase in these nations, and displacement of natural habitat started to increase. While analyzing deforestation in the South East Asian countries, the European Parliamentary Research Service has stressed on the community farming activities, and it has also been mentioned that in pursuit of achieving agricultural productivity, these nations have in turn started degrading the environmental quality (Russell, 2020). Therefore, in order to attain the objectives of SDG 13, the policymakers of these nations need to look into the pattern of agricultural activities, so that the negative environmental externalities exerted by these activities can be internalized through the policy redesign. This agriculture-focused climatic policy design purpose gives the third rationale of the present study.

Given this persisting policy level problem in the Asian economies, it becomes imperative how to realign the existing policies in these nations for attaining the SDG objectives by 2030. Following the rationales discussed, it is evident that in order to tackle the climatic problem in these nations, policy realignment will be necessary at different levels and involving various stakeholders. Herein lies contribution of the present study. A multi-pronged SDG-oriented policy realignment has been recommended in this study for the Asian economies, so that they can adhere to the Agenda 2030. In order to achieve this research objective, 15 Asian economies have been chosen, and the study spans from 1990 to 2014. Considering the case of Asian economies can bring forth the aspect of generalizability of the policy framework recommended in this study, as this particular framework can be perceived as a benchmark approach for other emerging nations, which are also encountering the issue of environmental degradation. While the academic literature has focused on the association between these aspects over a long stint, no policy level convergence has been achieved through those studies, and the present study aims at achieving that policy convergence by recommending an SDG-oriented policy framework for realizing the aims of SDG 13 and SDG 7. By means of this framework, this study contributes to the literature at the policy level.

Robust design of this framework needs controlling of the potential operational issues present in the dataset. As these economies are associated with each other via economic and trade spillovers, it can be expected that cross-sectional dependence and panel heterogeneity might be present in the data. Therefore, the methodological adaptation should be able to take account of this issue. In this pursuit, Fully Modified Ordinary Least Square (FMOLS) technique has been adopted in this study. The FMOLS can overcome the problems of cross-sectional heterogeneity, endogeneity, and serial correlation (Xie et al., 2021). This can ensure the methodological complementarity in regard to the study objective. There lies the analytical contribution of the study.

2. Literature Review

More than a few empirical investigations inspected the connections among the carbon emission and different factors, for instance, urbanization, income, renewable energy utilization, financial development, and agriculture (Balcilar et al., 2018; Shafiei and Salim, 2014; Martínez-Zarzoso and Maruotti, 2011; Sinha, 2019). A few factors indicated positive roles of emission, while others indicated the negative side. The conflicting outcomes principally rely upon the use of various data sets, methodologies, countries, qualities, and timespans (Adewuyi and Awodumi, 2017; Sinha et al., 2019b). In Pakistan's case, over the period from 1990-2014, Waheed et al. (2018) indicated that renewable energy usage is negative, whereas agriculture activities are positively related with CE. Using a global panel of 102 economies, Le et al. (2020) found green energy reduces emission in high-income countries. They suggested that the negative association in developed countries is due to these economies' strong environmental policies. Similarly, by using the panel cointegration technique, Dogan and Seker (2016) analyzed that green energy mitigates carbon emanation in European Union during 1980-2012. Cheng et al. (2019) explored that, in the case of BRICS economies during 2000-2013, green energy reduces pollutant emission. For Africa during the period 1990-2014, Nathaniel and Iheonu (2019) explored unidirectional causality existing from green energy to CO_2 emission.

Parshall et al. (2010) explored that urbanization significantly influencing CE and environmental health in China and the USA. Hossain (2011) found similar outcomes in their studies on the United States of America and newly industrialized countries. Furthermore, Al-Mulali et al. (2012), Xie et al. (2020), and Yu et al. (2020) scrutinized that urbanization stimulates energy-consumption, which adversely affects the environment in lower-income economies. They also explored that faster urbanization increased more labor supply, which boosted overall energy consumption in China and affected carbon emissions. Moreover, Zhu et al. (2012) discovered the inverted U-curve association between CE and urbanization in twenty emerging economies.

Ali et al. (2017) explored the adverse influence of urbanization on CE. They utilized the data of Singapore during 1970-2015. They suggested that the leading cause behind such negative association is effective environmental policies in Singapore. Similar results were found for 19 emerging countries by Saidi and Mbarek (2017), they believed that urbanization is not responsible for environmental pollution. In a panel study of 69 nations, Sharma (2011) found an insignificant association between urbanization and environmental pollution.

Many studies have been found the progressive influence of economic-growth on CE such as Anwar et al. (2021 a, b), Alam et al. (2007), Al-Mulali et al. (2015), and Zafar et al. (2019). In the modern era of development, it has been observed that people are not paying attention to protect environmental health. In common practice, the consumption of fossils fuels is a big source of CO_2-emission, which is heavily augmented by economic-growth. However, research debates are still there among the researchers about the role of various economic indicators on environmental-degradation and health issues that can affect emerging countries' economic growth (Pao and Tsai, 2011; Baek, 2016; Bakhsh et al. 2017; Hanif, 2018; Koengkan, 2018). Evidence of a comprehensive review of this association can be found in the work of Shahbaz and Sinha (2019).

Acheampong (2019) stated that the financial sector provides easy loan facilities to promote the industrial sector, which has become a cause of industrial pollution and environmental deterioration. Using the data of 24 transition nations during 1993-2004, Tamazian and Rao (2010) explored that the financial sector performs a vital role in protecting the environment by providing low-cost loans to green technology industries. By applying the ARDL technique on the Indian economy, Boutabba (2014) explored that FD has a hostile influence on the quality of the environment. A similar finding found for 23 European economies by Al-Mulali et al. (2015) investigated that environmental deterioration increases with the financial sector's development. Using Pakistan's data during 1971-2011, Shahzad et al. (2017) investigated that carbon emanation and financial development are positively connected. For France during 1955-2016, Shahbaz et al. (2018) claimed that FD reduces pollution.

Funk and Brown (2009) stated that the agriculture sector provides food to the masses. It also serves as a significant source in expanding the economy. Johnson et al. (2007) stated that farming activities release a substantial amount of GHG into the air, augmented by the land organization. Numerous studies have documented the causes of pollution of the agricultural sector and the approaches to alleviate its impression (Amuakwa-Mensah and Adom, 2017; Smith, 2012). Asumadu-Sarkodie and Owusu (2017) have documented that different crops such as rice, cereal, other biomass-burned crops are the principal sources of CO_2-emission. He also concluded that modern machinery in the agriculture sector is helpful to reduce CO_2-emission. The emission of greenhouse gas from the agricultural sector has been doubled during the past 50 years, from 1961 to 2011 (Food and Agriculture Organisation, 2014).

The literature, as mentioned earlier, provides mix and conflicting empirical outcomes. Numerous studies claimed that urbanization increases environmental pollution (Yu et al., 2020; Xie et al., 2020; Al-Mulali et al., 2012). A few studies documented that urbanization upsurge environmental quality (Saidi and Mbarek, 2017; Ali et al., 2017). While Sharma (2011) suggested, no link exists between urbanization and the environment. Similarly, several studies documented that financial development mitigates carbon emissions (Shahbaz et al., 2018; Tamazian and Rao, 2010), whereas several studies indicated that financial development increases environmental pollution (Acheampong, 2019; Shahzad et al., 2017). From the above discussion, a clearer understanding of the relationships among urbanization, financial growth, income, and CO_2 emissions is required that helps policy analysts and government officials envision policies for addressing the problem of climate change. Therefore, this study looks at the role of urbanization, financial development, and renewable energy on CO_2 emissions for selected South Asian economies.

3. Empirical framework

3.1. Theoretical underpinning

As the fossil fuel-based energy is a key stimulus to economic growth in the Asian economies, the prevailing energy consumption pattern exerts a negative environmental externality in these economies. Now, the rising economic growth in these economies has resulted in a rise in the job opportunities. Hence, in anticipation of a better living standard, urban centers of these economies have experienced a rise in the migration of population from the rural areas. This gradual rise in the urban population has exerted a pressure on the urban infrastructure. With the rise in urban population, though overall income level rises, living standard increases disproportionately, as difference between skilled and unskilled labors enhance the income inequality. Consequently, the slums and shadow cities start forming, and the people living in these areas largely lack the access to clean cooking fuels. Hence, the level of emission rises in the urban centers and the peripheral areas. However, the overall rise in income gives rise to the demand of durables and consumables, which in turn is translated into rise in the level of agricultural and manufacturing production. Now, in order to boost these two production activities, the respective governments in these nations need to mobilize the finances, so that these sectors can have more access to the factors of production. In order to boost the agricultural activities, demand for arable lands largely results in deforestation activities, which subsequently affects the internalization of negative environmental externalities. On the other hand, as the Asian economies are largely dependent on energy-intensive industries, rise in the production level causes rise in the level of emissions. With a view to address this issue of rising emission levels and to comply with the objectives of Agenda 2030, policymakers start emphasizing on the utilization of renewable energy solutions. Though the Asian countries are behind their developed counterpart, it can be expected that the development and diffusion of these renewable energy generation technologies across the nations might start coopting the adverse ecological externalities wielded by the prevailing economic growth trajectory. Therefore, encountering the environmental degradation issue in these nations needs the formulation of a policy framework encompassing these impacts.

Taking a cue from this brief discussion, an assumption can be made that the course of economic growth in the Asian countries is wielding an ecological pressure by creating ambient air pollution. Hene, it can be said that the economic growth and its potential drivers are accountable for surge in CO_2 emissions in the Asian economies. In continuation to this argument, functional form of this association can be hypothesized as:

$$CE_{i,t} = f(Ub_{i,t}, RECp_{i,t}, FD_{i,t}, EG_{i,t}, Ag_{i,t}) \quad (1)$$

Here, CO_2-emission is represented as CE, urbanization as Ub, renewable energy-consumption as RECp, financial development as FD, agriculture as Ag, and economic growth as EG. Following the functional form in Eq. 1, the empirically testable version of the model can be represented as per the following:

$$CE_{it} = \beta_0 + \beta_1 Ub_{it} + \beta_2 RECp_{it} + \beta_3 FD_{it} + \beta_4 EG_{it} + \beta_5 Ag_{it} + \varepsilon_{it} \quad (2)$$

3.2.Data

The present study explores the effects of urbanization, renewable energy consumption, financial development, agricultural productivity, and economic growth on CO_2 emissions in 15 Asian economies (China, Indonesia, Vietnam, Sri Lanka, Malaysia, Turkey, Mongolia, Indonesia, Thailand, Iran, India, Nepal, Philippine, Jordan, Pakistan). The data of CO2 emissions in kilo ton per capita, percentage of total urban population, renewable energy consumption as percentage of total energy-consumption, amount of domestic credit to private sector as a percentage of GDP (in constant 2010 USD), agriculture value-added/worker (in constant 2010 USD) and GDP per capita (in constant 2010 USD) for 1990-2014 are gathered from the World Development Indicators (World Bank, 2019). Trend of the variables are shown in Figure 1.

Just to give an overview of the chosen countries, population of these 15 countries is almost 2.7 billion, which is nearly 35% of the world population (World Bank, 2019). The GDP of these countries was 2.753 trillion dollars in 1990, which increased almost nine times and reached 18.733 trillion dollars in 2018 (World Bank, 2019). According to world development indicators, these 15 countries produce 42% of the world's total CO_2 emissions (World Bank, 2019).

Place for Figure 1

3.3.Methodology

3.3.1. Unit Root Tests

The unit-root test is reflected as an ordinary measure in the time-series analysis (Chang, 2010). Therefore, it is claimed that individual unit-root tests do not explain the determination of separate regression errors across each cross-section. Furthermore, Levin et al. (2002) give the concept of panel unit-root test that can move freely across the sections to produce pooled t-statistics and permits trend and intercept coefficients. Thus, Levin Lin Chu (LLC) unit root test elaborates superior estimation as contrast to ordinary panel-unit root tests by considering Null hypothesis (H_0); individual time-series has a unit root problem, and alternative hypothesis (H_1); individual-time series is stationary (Akhmat et al., 2014; Niu et al., 2011). Moreover, the lag operator (ohm- Ω) allows the variation across the cross-sections. Finally, above mentioned technique is followed in the given steps;

In step I, Augmented-Dickey-Fuller (ADF) test is applied for individual cross-sections on the given equation;

$$\Delta ¥_{i,t} = \alpha_{0i} + \Omega\, y_{i,t-1} + \sum_{\mathcal{L}=1}^{pi} Ɔi\mathcal{L}\, \Delta ¥_{i,t-\mathcal{L}} + \beta mid_{m,t} + \mathcal{E}_{it} \quad (1)$$

Where, $t = 1,\ldots,T$ and $i = 1,\ldots,N,$

In step II, we use two auxiliary regression equations:

1) $\Delta ¥_{i,t}$ on $\Delta \mathcal{Y}_{i,t-L}$ and $d_{m,t}$, and get $\breve{\varepsilon}_{it}$ (estimated residuals) and,

2) $\mathcal{Y}_{i,t-1}$ on $\Delta \mathcal{Y}_{i,t-L}$ and $d_{m,t}$, and acquire residual $\hat{\upsilon}_{i,t-1}$.

In step III, we obtain standardized-residuals, using the following;

$$\tilde{\varepsilon}_{i,t} = \breve{\varepsilon}_{i,t} / Ó_{\mu it} \quad (2)$$

$$\hat{\upsilon}_{i,t-1} = \hat{\upsilon}_{i,t} / Ó_{\mu it} \quad (3)$$

Where, $Ò_{\mu it}$:standard-error (SE) in separate ADF-tests

At the end, the pooled-OLS is run by using the following:

$$\tilde{\varepsilon}_{i,t} = \Omega\, \hat{\upsilon}_{i,t-1} + \mathcal{E}_{it} \quad (4)$$

The null hypothesis is Ω=1. Therefore, Levin et al. (2002) proffer that the LLC test needs to correct the value of t-statistics by using the sufficient conditions of $(N_T)^{1/2}/T \rightarrow 0$ and $(N_T)^{1/2}/T \rightarrow k$. Previous research studies emphasize that the LLC test is handy for large panels if statistics range from 5 to 250 for T and 10 to 250 for N. Smaller the value of T smaller will be the power of a unit-root test, as the panel is undersized. While the larger value of T confirms to estimate unit-root for each cross-section separately. However, LLC-test has some disadvantages. First, this test restricts the logic that its null-hypothesis (H0) nullifies the perception regarding the unit root problem of cross-sections. The second drawback of the LLC-test is that this test statistics undertakes the panel is cross-sectional autonomous. Consequently, to evade the LLC unit-root test's weaknesses, the Breitung-panel-unit (BPU) test is also employed (Breitung, 2002).

3.3.2. Panel Cointegration Tests

In this study, the panel cointegration tests are used to explore the long-run association among the given factors. In doing so, the null hypothesis (H_0) is used as "no cointegration" (i.e., Pedroni, 1999; Kao, 1999; Groen and Kleibergen, 2003), while, Maddala and Wu (1999) and Westerlund (2007) take into account "cointegration" as null hypothesis (H_0). The present study analysis utilizes three different panel cointegration methods presented by Pedroni (2004).

Pedroni (1999, 2004) suggests seven diversified statistics to test cointegration. These proposed-tests have been suggested to correct for biasness in endogenous regressors and regarded as into between and within-dimension-statistics. Between dimensions-statistics are known group mean panel cointegration, while within dimensions-statistics are taken as panel cointegration only. These cointegration tests depend upon two steps extension, residual based procedure, suggested by Engle-Granger (1987). First, a seven steps test statistics strategy follows assessment and provisions the residuals.

The proposed-model characterizes the following test equation:

$$X_{i,t} = a_{0i} + r_i t + b_{1i} Z_{1i,t} + ... + b_{mi} Z_{mi,t} + m_{it} \quad (5)$$

Where, *m = 1 to M, t = 1 to T,* and *i* = 1 *to N.*

T: total observations *and N* represent, *total* units of cross-section in panel respectively, and *M is* total number of regressors. α_{0i} :is fixed effects or parameter of specific intercept which fluctuates across separate cross-sectional units. The similar is correct for time effect and slope-coefficients (h_{it}) which is used in third step.

First difference of each cross-section is taken to evaluate the residuals of differenced of regression in second step:

$$Dx_{i,t} = q_{1i} DZ_{1i,t} + ... + q_{mi} DZ_{mi,t} + h_{it} \quad (6)$$

In third step, we obtain $Ꝁ^2_{11,i}$: the long-run variance from residuals (h_{it}).

In the fourth step, we get an appropriate auto-regressive model using residuals (m_{it}) of the actual cointegration equation.

Finally, the seven panel cointegration tests (as suggested by Pedroni, 2004) are estimated with suitable mean and variance terms.

1. ʋ-statistics (Panel):

$$Z_{v,\, N\, \&\, T} = T^2\sqrt{N^3} \left(\sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, \mu_{it-1}^{2}\right)^{-1}$$

2. rho(*p*)-statistics (Panel):

$$Z_{p,\, N,\, T} = T^2\sqrt{N^3} \left(\sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, \mu_{it-1}^{2}\right)^{-1} \sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2} \left(\mu_{it-1}^{1}\, \Delta\mu_{it} - \gamma_i\right)$$

3. t-statistics (Panel nonparametric):

$$Z_{p,\,N,T} = (\sigma^2 \sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, \mu_{it-1}^{2})^{-\frac{1}{2}} \sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, (\mu_{it-1}^{1}\ \Delta\mu_{it} - \gamma_i)$$

4. t-statistics ((Panel-parametric):

$$z^{*}_{t,\,N,T} = \varsigma_{N,T}^{2}\ (\sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, \mu_{it-1}^{2})^{-\frac{1}{2}} \sum_{i=1}^{N}\sum_{t=1}^{T} \delta_{11i}^{-2}\, (\mu_{it-1}^{*1} - \Delta\mu^{*}_{it})$$

5. rho (p)-statistics (Group):

$$Z_{p,\,N,\,T} = \frac{T}{N^{\frac{1}{2}}} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \mu_{it-1}^{2}\right)^{-1} (\mu_{it-1}^{1}\ \Delta\mu_{it} - \gamma_i)$$

6. t-statistics (Grouped nonparametric):

$$Z_{t,\,N,T} = \frac{1}{N^{\frac{1}{2}}} \sum_{i=1}^{N} \left(\sigma_i^2\ \sum_{t=1}^{T} \mu_{it-1}^{2}\right)^{-\frac{1}{2}} \sum_{t=1}^{T}\quad (\mu_{it-1}^{1}\ \Delta\mu_{it} - \gamma_i)$$

7. t-statistics (Grouped parametric):

$$Z_{p,\,N,\,T} = \frac{1}{N^{\frac{1}{2}}} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \theta^2\ \mu_{it-1}^{2}\right)^{-1/2} \sum_{t=1}^{N} (\mu_{it-1}^{1}\ \Delta\mu_{it})$$

Where: $\gamma_i = (\sigma_i^2 - \theta^2)/2$ and $\theta^{*2}{}_{N,T} = 1/N \sum_{i=1}^{N} \theta^{*2}$

After estimating the panel cointegration test-statistics, we determine the following modification for mean and variance terms $(Y_{N,T} - \mu\ N^{1/2})/\sqrt{V}\ \Rightarrow \mathrm{N}(0,1)$ to ensure the asymptotic distribution.

Here, $Y_{N,T}$ shows the consistent practice of test-statistics (i.e., N and T). μ *and* V Represents Brownian Motion Movement-Functions (BMMF). The null (H_0) hypothesis: no cointegration for all the test- statistics is H_0: $\rho_i = 1,\ \forall\ i=1$ *to* N

Alternative (H_1) hypothesis: the existence of cointegration between and within-dimensions for the panel is H_1: $\rho_i < 1,\ i=1$ *to* N

Likewise, for within-dimensions H_1: $\rho_i = \rho < 1,\ i=1$ *to* N

Under the alternative-hypothesis, $\rho_i = \rho$, assume a typical value and, all the value of panel test-statistics departs ∞. Therefore, the leftward tail is needed to reject H_0 under the normal curve.

3.3.3. Panel Cointegration Estimates

We apply a cointegration test to confirm the long-term association among the factors. As Generalized Method of Movement (GMM), fixed-effect (FE) and random-effect (RE) may estimate misleading and inconsistent confidence when applied in panel data. Therefore, we use the FMOLS suggested by Pedroni (2001) and DOLS offered by Kao (1999). FMOLS addresses the problem of serial correlation and endogeneity in the ordinary least square estimator. Further, Pedroni (2001) recommended a parametric dynamic OLS (DOLS) estimator that eradicated the serial correlation and endogeneity problems. The present study uses both approaches as these techniques might deliver a more precise indication of the likely elasticity of urbanization and financial development as an exogenous variable.

Hence, panel FMOLS estimator for the slope-coefficient (β) is represented as:

$$\hat{\beta} = N^{-1} \sum_{i=1}^{N} (\sum_{t=1}^{T} (y_{it} - \bar{y})^2)^{-1} (\sum_{t=1}^{T} (y_{it} - \bar{y}))\ Z_{it}^{*} - T\,\hat{\eta}_i\,.$$

Where:

$$Z_{it}^{*} = (z_{it} - \bar{Z}) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta y_{it}.$$

$$\hat{\eta}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} (\hat{\Gamma}_{22i} + \hat{\Omega}_{21i}^{0}).$$

$\hat{L}_i$ = Lower triangle decomposition of $(\hat{\Omega}_i)$

The related t-statistic gives:

$$t_{\hat{\beta}^*} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}^*,i}.$$ And

$$t_{\hat{\beta}^*,i} = (\hat{\beta}_i^* - \beta_0)[(\hat{\Omega}_{11i}^{-1} \sum_{t=1}^{T} (y_{it} - \bar{y})^2)].^{1/2}$$

3.3.4. Decomposition Analysis

Most of the causality tests, do not provide relative strength causal associations (Shahbaz, 2012). On the other hand, the forecast variance decomposition method (FEVDM) and impulse response function (IRF) give an Innovative Accounting Approach (IAA) for examining causal connections among the indicators. This method was favored over the causality tests as it provides the course and scale of causal connotations between model parameters at various temporal frames (Menyah and Wolde-Rufael, 2010; Tiwari and Shahbaz, 2014). Moreover, this test has ability to calculate both endogenous and exogenous changes.

4. Results and Discussion

As the beginning point of the analysis, two diagnostic tests are conducted. First, the possibility of multicollinearity in the data is checked. This is necessary to understand whether the long run coefficients will be spurious, or not. The results of multicollinearity check reported in Appendix 1 show that the variables are free from multicollinearity. Second, once it is affirmed that the data is free from multicollinearity issues, the methodological selection needs to be confirmed. In this quest, possibility of the cross-sectional dependence in the model parameters is checked. This checking is necessary to decide on whether the methodological approach should be first or second generation in nature. The cross-sectional dependence test results reported in Appendix 2 show that the variables are not cross-sectionally dependent. Hence, in the empirical pursuit, the first-generation methods can be applied.

To start with, LLC (2002) panel unit-root test is applied. The findings reported in Table 1 show that the variables are first order integrated. For assessing robustness of the LLC test outcomes, the Breitung (2002) unit-root test is employed. This test confirms the stationarity properties of the variables. Once it is affirmed that the variables are first order integrated, i.e., they are stationary after the first differentiation, testing for the cointegration among the variables is sanctioned.

Place for Table 1

Unit root test result permits the examination of the cointegrating association among variables. Table-2 illustrates the result of panel cointegration tests. The empirical outcomes confirm the long-run association among CE, agriculture, EG, financial development, renewable energy-consumption, and urbanization for these economies. The results of Kao residual and Johansen-Fisher cointegration tests confirm the robustness of Pedroni (1999) cointegration test outcomes.

Place for Table 2

Results of cointegration tests testify cointegration among the variables, and this set of outcomes sanctions the estimation of long-run coefficients. FMOLS methodology suggested by Pedroni (2001) is utilized to find the unbiased and consistent long-run coefficients.

Place for Table 3

Following the confirmation of the cointegration test results, the long run coefficients are estimated, and the results are reported in Table 3. For the purpose of analyzing the long run impact of the economic growth and its drivers on CO_2 emissions, the results of FMOLS will be discussed. This study outcomes indicate certain insights regarding the developmental trajectory of these nations. To start with, the prevailing economic growth pattern in these nations is environmentally unsustainable, and it is evident from the impact of economic growth on carbon emissions. The coefficient of economic growth is positive and significant. This particular segment of the outcomes indicate that the persisting economic growth pattern is responsible for the rise in carbon dioxide emission in these nations. This piece of the empirical evidence resonates with the results of Salahuddin et al. (2015), Sharif et al. (2019), Sinha et al. (2019a), and Zafar et al. (2021). Now, it can be assumed that economic growth cannot automatically exert negative environmental externality. Therefore, in order to understand the dynamics of this externality, the impacts of the economic growth drivers on carbon dioxide emissions need to be analyzed. These nations are recognized by their high growth prospect, and economic expansion requires financial mobilization. The financialization towards the expansion of production processes adds to the economic growth. As majority of this production processes are labor-intensive in nature, so it can be expected that these processes will be less energy efficient. Hence, by means of the expansion of production processes, financialization might exert negative environmental externality in these nations. This very argument can be validated against the expansionary influence of financial development on carbon dioxide emissions. This piece of the empirical evidence resonates with the results of Ali et al. (2015), Al-Mulali et al. (2015), and Boutabba (2014). With the economic expansion, job opportunities start rising. As the industrial development in these nations is majorly concentrated in the urban and semi-urban areas, so the job opportunities are also concentrated in these regions only. Rise in the job opportunities in turn increases the expectation of a better livelihood, as the overall level of income will also rise. This expectation will start attracting the people from the rural areas towards the urban centers, and these nations will start experiencing a rise in the urban population. Now, as the job opportunities will be divided by the level of skill set, the urban population will be eventually segregated in to skilled and unskilled labors. This segregation might consequently increase the economic and social divides, and as a result, the urban centers will experience the formation of slum areas and shadow cities. The people residing in these areas lack the access to clean cooking fuels, and this unsustainable energy usage pattern in turn increases the level of carbon dioxide emissions. This argument can be validated by the expansionary impact of urbanization on carbon dioxide emissions. This part of the empirical outcomes is comparable with the works of Pata (2018), Liddle (2014), Shahbaz et al. (2014), and Alam et al. (2007). Now, with the rise in the overall level of income, the demand of durables and consumables will rise. While the expansion of production activities might be commensurate to the demand of durables, expansion of agricultural activities will be required to fulfill the demand of consumables. In order to expand the agricultural activities, more arable lands will be required. For this purpose, deforestation will take place. through the channel of deforestation, expansion of agricultural activities will exert and environmental pressure. Validation of this argument is reflected in the expansionary impact of agricultural productivity on carbon dioxide emissions. Although insignificant, this impact can be a serious concern for the policymakers.

Study outcomes reveal that the course of economic growth in these nations is environmentally unsustainable, and a major reason behind this is their reliance on the nonrenewable energy. This particular issue can be compared with the seminal work on the "*Limits to Growth*", initiated by the economists of *Club of Rome* (Meadows et al., 1972). Taking a cue from this discussion, it can be assumed that the basis of developmental course might be harmed by prolonged reliance on nonrenewable energy. Hence, the policymakers need to embark on initiating energy transition. Development and deployment of renewable energy solutions is a major component of this initiative. Gradually rising dependence on the renewable energy solutions can not only support these nations to diminish the level of emissions, but also can support in solving the issue of energy security. A substantiation of this argument can be reflected in the contractionary impact of renewable energy consumption on carbon dioxide emissions. This piece of the empirical evidence resonates with the results of Sinha et al. (2017), Sinha and Shahbaz (2018), Sharif et al. (2020), Dogan and Ozturk (2017), Emir and Bekun (2019), Alola et al. (2019), Aziz et al. (2020), and Zafar et al. (2020). The gradual rise in the renewable energy consumption in these nations is an indication that the prevailing pro-growth policy myopia might go for a realignment in the pursuit of sustainable development.

As a check of the robustness of the study outcomes, the empirical model has been tested using DOLS and Fixed effect OLS. The empirical outcomes reported in Table 3 indicate that the impacts of the model parameters are nearly consistent for both the methods, along with their significance levels. This gives an indication that the long-run coefficients estimated by FMOLS method are robust.

The results of variance decomposition analysis with 24-year forecasting horizons are described in Table-4. At five years, all variables, including Ub, FD, EG, and RECp except agriculture, are responsible for almost 4% variance in CO_2 emissions, whereas almost 96% variance of CO_2 emissions is accounted for its innovations. In the long run, almost 91% variance in CO_2 emissions is due to its innovation. Almost 9% due to all other variables, such as 0.98% due to financial development, 6.38% due to urbanization, 0.47% due to EG. The findings again show that the Ub is a leading cause of CO_2 emission. On the other hand, EG and FD also directly and significantly influence CO_2 emissions, but the effect is weak.

Place for Table 4

Place for Figure 2

Moreover, Figure: 2 demonstrates the impulse response functions. As the standard deviation of CO_2 emissions indicates an affirmative upsurge in future CO_2 emission. The accumulated CO_2 future response to FD, Ub, and EG is significant and positive, whereas the CO_2 future response to RECp is negative and significant. On the contrary, the future response of CO_2 to agriculture is statistically insignificant. Therefore, these findings support the previous econometric estimations.

5. Conclusion and Policy Implications

5.1.Summary of results

The primary aim of this research study is to explore the impacts of urbanization, renewable energy consumption, financial development, economic growth, and agricultural productivity on CO_2 emissions in selected 15 Asian economies for the period 1990-2014. Based on the long-run coefficient estimation results, it can be concluded that urbanization, financial development, and economic growth are responsible for environmental degradation in the long-run. On the contrary, renewable energy consumption is reducing environmental degradation. Moreover, agriculture has a positive but statistically insignificant influence on CO_2 emissions.

5.2.Policy framework

Prolonged reliance on nonrenewable might deter the overnight replacement of these solutions, as it might create hinderance in the economic growth pattern. Therefore, these policy instruments need to be calibrated in a way so that the problem of environmental degradation can be handled, and these economies move forward towards realizing the Sustainable Development Goals. As the urban centers of these economies encountering rise in the population, rise in the energy demand from the centers is inevitable. In order to cater to the surplus energy demand arising from the households, the policymakers might take a phase wise implementation schedule. In the first schedule, the policymakers might consider subsidizing the renewable energy solutions for the households. As this move will have certain negative financial implications, a complimentary move needs to be taken by considering the industrial players. Along with the households, the industrial players will also be able to avail the renewable energy solutions for a predefined rate prescribed by policymakers, while the price charged from the industrial players will be higher compared to the one provided to the households. Now, the financial institutions might be given instructions to disburse credits to firms for availing these solutions against discriminatory interest rates, depending on the carbon footprint of those players. Carbon footprint of the industrial players can be assessed, and based on the level of carbon footprint, the rate of interest will vary, i.e., higher carbon footprint will attract higher rate of interest. In that way, the industrial players will gradually be discouraged to consume the fossil fuel solutions, as the policy mandates will be focused at promoting the cleaner energy solutions. Gradual rise in the renewable energy demand will be having scale effect on the renewable energy generation, which in turn will start reducing the price of the solutions. this policy will help these Nations to achieve not only cleaner energy solutions, but also a secured energy future. This might support them to move forward on the way to realize the objective of SDG 7.

While securing the energy future the policy makers also need to make the agricultural activities mode sustainable by reducing the level of deforestation. If certain areas of forest need to be removed for the agricultural activities, policymakers need to ensure that equivalent afforestation program is also taken up, so that the forest habitat is not displaced. The farmers the advantage of affordable renewable energy solutions, so that be agricultural activities start internalizing the negative environmental externalities. A similar kind of activity might be carried out in the urban development front, and solution can be in terms of implementing sustainable housing policies. One of the major aspects of these policies can be in terms of reducing the scope of space heating, which is a major contributor of carbon emissions in the urban areas. Moreover, the policymakers might also consider the scope of vertical gardening designs, which can internalize the carbon emissions without having the space constraint. Lastly, providing easy and affordable loans to the urban citizens for availing the renewable energy solutions might have sustained impact on the environmental front, as the potential demand of energy arising out of these areas will be the demand of green energy. These policy solutions as a whole will be able to help these nations in progressing towards achieving the objectives of SDG 13.

5.3.Policy caveats and assumptions

In order to sustain this policy framework, the policy makers will be required to carry out certain measures. First, the public property rights to be defined more rigorously, with the purpose of stopping the unwarranted exhaustion of natural resources, i.e., forest resources. Second, import substitution on the crude oil should be imposed, to facilitate the reduction of overall consumption of fossil fuel to the minimum. Third, the bureaucratic structure needs to restrict rent-seeking exercises, so that the diffusion of renewable energy solutions across the nations can be smooth. These measures can be considered as the policy caveats.

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