The asymmetric effect of public private partnership investment on transport CO2 emission in China: Evidence from quantile ARDL approach

Anwar, Ahsan and Sharif, Arshian and Fatima, Saba and Ahmad, Paiman and Sinha, Avik and Khan, Syed Abdul Rehman and Jermsittiparsert, Kittisak

Lahore Transport Company, Government of Punjab, Pakistan, National College of Business Administration and Economics, Lahore, Pakistan, University Utara Malaysia, Sintok, Kedah, Malaysia, ILMA University, Karachi, Pakistan, University of the Punjab, Lahore, Pakistan, University of Raparin, Sulaimania, Iraq, Tishk International University, Erbil, Iraq, Goa Institute of Management, India, Tsinghua University, Beijing, China, Duy Tan University, Da Nang, 550000, Vietnam, Henan University of Economics and Law, Henan, 450046, China, Xuzhou University of Technology, Xuzhou, China

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Abstract:
Transportation infrastructure is a pillar of economic development as well as a main contributor to climate change. Therefore, it is necessary to transform the transport sector investment into climate-resilient, low-carbon transportation choices in order to achieve sustainable transportation infrastructure. In case of China, this transformation might be necessary from the perspective of the "New-style Urbanization" strategy, and for fulfilling this strategy, policy realignment is required. To address this policy-level void in the literature, we explore the influence of public private partnerships investment in transport sector, renewable energy consumption, urbanization on transport-induced carbon emissions in China. For this purpose, we apply Quantile Autoregressive Distributed Lagged (QARDL) method during 1990Q1-2018Q4. Based on the results of the study, a multipronged sustainable development goal (SDG) framework has been suggested, under which SDG 11, SDG 13, and SDG 8 are addressed, while using SDG 17 as a vehicle.

Keywords: Public Private partnership investment in transport, Transport CO_2 emissions, Urbanization, Renewable energy consumption, Quantile ARDL

1. Introduction

In the epoch of industrialization, discerning sustainable development is progressively proving to be a prime issue faced by the nations. There are several reasons behind such a claim, and these reasons can be attributed to the drivers of industrialization. The Paris Climate change summit focused on these issues, while the recent Sustainable Development Goals (SDG) Report 2019 has stressed on these issues, for which the Asian countries are gradually turning out to be laggards in attaining the SDG objectives (UNESCAP, 2019). Policymakers in these nations are majorly interested in achieving economic growth, even at the cost of the socio-ecological balance. Therefore, prevailing industrialization policies in these nations exert negative externality on the social and ecological balances, and thereby cause harm to the basis of sustainable development itself. Among these nations, China has recorded the fastest economic growth, and because of its policy-level innovations, they are progressively acquiring eminence in the international politico-economic setting. As on 2018, the GDP growth rate of China is nearly 6.60 per cent, which is more than the double of the global average (World Bank, 2019). Now, this rise in economic growth comes with a rise in vocational opportunities, and owing to this incident, Chinese cities have started experiencing a migration of labor force from rural areas to urban areas. Once this urbanization has set in, the Chinese cities have started facing issues regarding the pressure on urban infrastructure. In order to address this issue, the “New-Style Urbanization” strategy has focused urban agglomeration, which is a progressive spatial arrangement of cities. Now, in order to reduce the transaction cost among the spatial nodes, the role of transportation system needs to be redefined. Therefore, the efficacy of urban development in China will face a nearly inelastic demand of the transportation activities, which might exert negative environmental externality.

Alongside this, rise in the industrial activities has also resulted in the cross-province and cross-border movement of factors of production and finished goods, and this has resulted in the rise in transportation activities. As the transportation sector in China is majorly dependent on the fossil fuel-based energy solutions, therefore, the rise in the transportation activities has resulted in a rise in the transport-induced CO_2 emissions. The intra-provincial movements of citizens for vocational opportunities also add to this ecological predicament. During the Second United Nations Global Sustainable Transport Conference in Beijing, China, during 5-7 May 2020, the unsustainable nature of transportation sector in China was discussed. While discussing this issue, due importance was provided to urban infrastructural planning, which might have a significant impact on strategic landscaping of transportation in China. Now, in case of China, the latest SDG assessment report by UNDP (2020) has reflected upon the misalignment of urban development and transportation policies, which might result in the nonattainment of SDG 11, i.e. sustainable cities and communities, SDG 13, i.e. climate action, and SDG 8, i.e. decent work and economic growth. Therefore, it is necessary to assess the nature of economic growth pattern prevailing in China, and how to harmonize the existing policies to ascertain the attainment of SDG objectives by 2030.

Now, “New-Style Urbanization” strategy being taken up Chinese policymakers might indicate a shift from the traditional hukou system to people-centric urbanization. This transformation is expected to restore the ecological balance in China through boosting green growth mechanism. However, this transformation necessitates promoting the renewable energy solutions, fostering innovation, protecting environmental quality, and assuring resilience in economic environment, and in this pursuit, flow of additional capital is necessary. This potential demand gap can be fulfilled through PPP investments. Hence, from the perspective of restoring the ecological balance in China, it is also necessary to ponder upon the role of public private partnership (PPP) investment. The UNESCAP (2016) has identified the significance of PPP investments in case of the Asia and the Pacific countries for ensuring the sustenance of environmental quality, and a reflection of this aspect can be visualized in the bilateral agreement between China and United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) for consolidating the PPP investments in Asia Pacific region. In view of this agreement, the role of China PPP Center needs to be revisited, as this center might act as a facilitator in boosting the PPP investments in this region. However, the growing urbanization in the Chinese urban centers might create a hindrance in attaining the objectives of SDG 11, and the role of China PPP Center might prove to be crucial in this regard. The Geneva Roundtable on Sustainable Development in 2018 has stressed on this issue, and policymakers have invited more than hundred private sector enterprises to join hands with government for fulfilling the 2030 commitment (UNDP, 2018). The stress areas identified in this discussion were transportation, urban planning and development, and green innovation. However, during United Nations Global Compact Leaders' Summit 2020, it has been showcased that the PPP investments in China are yet to produce the expected results, and therefore, a realignment of the economic policies is required, so that China can comply with the 2030 agenda (UNIDO, 2020).

While talking about the realignment of the existing policies in China for complying with the 2030 agenda, it is necessary to design a multipronged-SDG framework. In this pursuit, this study aims to analyze the impacts of urbanization, PPP investment, and renewable energy consumption on carbon dioxide (CO_2) emissions from transportation activities in China during 1990Q1-2018Q4. As the urban development activities in China are catalyzed by fossil fuel-driven transportation activities, which is also a major driver of economic growth in China, the economic and allied policies need to be redesigned, so that China can make a progression towards attaining the SDG objectives by 2030. Consideration of these parameters within a single policy agenda might assist in designing a comprehensive policy framework for addressing SDG 11 and SDG 13, and thereafter SDG 8, while using the objectives of SDG 17, i.e. partnerships for the goals, as the major enabler. To our knowledge, this SDG-oriented policy-level approach to address the issues of transport-induced carbon emissions has not been adopted in the literature, and there lies the policy level contribution of the study.

While laying out the policy-level contribution of the study, it also needs considering that different levels of policy instruments might have disparate influences on all the levels of the target policy parameters. Simultaneously, this association requires to be examined for both short-run and long-run setups, as the outcomes will be applied for policy making. In this pursuit, Quantile Autoregressive Distributed Lag (QARDL) approach of Cho et al. (2015) has been adopted. There are numerous benefits of this approach: (a) this approach permits scrutinizing the long-term association concurrently with short-run dynamics all over a span of quantiles of the restricted distribution of the target policy parameter (Mensi et al., 2019). Second, it permits for locational asymmetry among the model parameters suitable for the setting of the target policy parameter within its restricted distribution (Lahiani, 2018). Now, from the policymaking standpoint, this methodological adaptation counterparts the policy-level contribution of the study. It is expected that diverse levels of urbanization, PPP investments, renewable energy consumption, and economic growth might have diverse influences on the transport-induced CO_2

emissions. Therefore, QARDL approach can respond to the problem of policy formulation, and in doing so, can enrich the literature of environmental economics from the contextually-driven methodological perspective.

In section 2 of this study, the review of literature is presented. The data set and econometric methodology are analyzed in section 3. The discussion on empirical results are presented in section 4. Discussion on policy implications is carried out in section 5. And finally, in 6th section the study is concluded.

2. Literature Review

This study explores the association among public private partnership investment in transport sector and CO_2 emissions of transportation sector by incorporation of the part of urbanization, economic growth and renewable energy consumption for the country case of China. The existing literature hardly shows any study on the direct association among public-private partnership investment in transport and carbon emissions of this specific sector. Therefore, we discover some studies explored the influence of investment of private sector in transportation on CO_2 emissions. For instance, Lin and Omoju (2017) examined influence of investment of private sector, urbanization and economic growth on CO_2 emanation from transport sector for eight Asian economies. They found that urbanization and economic growth increases transport CO_2 emissions. Whereas, the private sector investment reduces carbon emissions in transport sector. Similarly, Cruz and Katz-Gerro (2016) believed that private investment in transport could improve the quality of environment through adoption of advance technology, improvement in fuel efficiency that reduces pollutant emissions. In his study by Xue et al. (2017) claimed that private investment in public transport sector is a tool to reduces pollutant emission and better than traditional model of investments.

Various studies examined relationship between economic growth, urbanization, renewable energy consumption, and CO_2 emanation of transportation for different regions, and the results are inconclusive. Such as, Saighania and Sommer (2016) have explored the relationship among utilization of energy and transport carbon emission. They suggested that sources of renewable energy could lessen CO_2 emanation from transport sector. In case of provisional panel data of China over the period from 2000-2012, Xu and Lin (2015) scrutinized effect of utilization of energy, per capita GDP and urbanization on transport CO_2 emanation. The result shows that GDP, energy utilization and urbanization are positively associated with transport carbon emanation. For Pakistan during 1990-2015, Danish et al. (2018) explore the relationship of urbanization, economic growth and transport energy utilization with transport carbon emanation. They found that transport energy usage has positive association with carbon emanation. On the other hand, the rate of urbanization and rate of economic growth have insignificant influence on CO_2 emanation. For Saudi Arabia during 1971-2011, Alshehrya and Belloumi (2017) tested the presence of EKC hypothesis. But findings denied the existence of inverted-U shaped association. Therefore, result shows that economic growth increase CO_2 emanation in Saudi Arabia. In case of Asian economies from 1980-2005, Timilsina and Shrestha, (2009) estimated that intensity of transport energy and rate of economic growth are the main source of carbon emissions. By using cointegration technique for OECD countries during 1960-2008, Saboori et al., (2014) indicated that long-term tow-way causation exist among transport carbon emanation and economic growth.

For China during 1980-2012, Xu and Lin (2015a) explored the influence of urbanization, and transport energy usage on carbon emanation from transport sector. Their study explored that carbon emanations are increased by the rate of urbanization. Whereas, the efficiency of energy plays a key role in mitigate carbon emanation. Shafiei and Salim, (2014) investigated the factors affecting the CO_2 emanations for the case of OECD economies for the period of 1980-2011, and discovered that CO_2 emissions are related with energy consumption from renewable resources inversely.

Qiao et al., (2019) scrutinized the relationship of renewable energy and the rate of economic growth with environmental degradation in Group of Twenty (G20) economies inside the structure of EKC hypothesis by utilizing the data from 1990-2014 by utilizing the panel cointegration and Fully Modified Ordinary Least square. Results of analysis suggest that energy consumption from renewable sources lessens the environmental degradation and EKC hypothesis holds in case of economic growth and CO_2 discharge. As investigated by Saber et al. (2011), renewable energy can lessen the environmental degradation on earth through next generation plug in vehicles (gridable vehicles) can reduce environmental degradation from transportation industry. In case of China during 2000-2012, Xu and Lin (2016) explored that urbanization and economic growth are increasing transport CO_2 emissions. They also explored the fact that improvement of energy efficiency has reverse effect on carbon emanation of transportation sector.

Shahbaz et al., (2015) probed the relationship between road transportation consumption of energy and CO_2 emanations for case of Tunisia for the time period of 1980-2012. The results suggested a direct long-run association among the concerned variables. Talbi (2017) scrutinized the relationship of economic growth, consumption of energy from fuel and rate of urbanization with CO_2 discharge for the case of Tunisia by utilizing the Vector Autoregressive model for the time period of 1980-2014. The study confirmed the validation of EKC hypothesis for transportation sector. Wang et al., (2011) examined the key causes of CO_2 discharge of transport sector of China and found that economic growth is the key correspondent by utilizing the Logarithmic Mean Divisia Index (LMDI) approach. For China during 1991-2009, Shen and Chi (2012) examined the driving indicators of carbon emanation of transport sector. The findings suggested that urbanization and population proved major causes of carbon discharge of transportation sector for China. Similarly, for China, Lin and Xie, (2014) scrutinized relationship of economic growth as well as urbanization for transport sector environmental deterioration for the time period of 1981-2010 and revealed that long-term association prevails between these variables. Moreover, GDP along with urbanization have positive impact in increasing the transport sector CO_2 emissions and future policy implications are needed to lessen environmental deterioration.

Correspondingly, Li et al. (2016) explored the link among rate of economic growth and transport sector CO_2 emanations for China for the time period of 1995-2012 and resulted out that the GDP mainly increases the transportation CO_2 discharge. Through utilizing the LMDI decomposition approach, Liang et al. (2017) analyzed that the core factor of enhancing the transport CO_2 emissions is GDP for the country case of China for the time span of 2001to 2014. In a similar fashion, by using the data of 2004-2016 for the economy of China, Liu and Feng (2020) probed the association among energy-related transport carbon emissions, urbanization and economic growth through decoupling analysis which stands on the LMDI. For the country case of Pakistan, the relationship between environmental degradation from transportation sector, urbanization, economic growth along with consumption of energy has been analyzed by Mohsin et al., (2019) by using the Johansen cointegration method and Granger causality test for period of 1975 to 2015 and the findings show the validation of EKC hypothesis among transport emanations and GDP. In their study, Xu and Lin, (2018) explored the major sources of transport carbon emissions by using the data of China from 2000-2012. For this purpose, they applied quantile regression. The empirical finding of their study indicated that urbanization and GDP has been a main indicator for transport carbon emanation across all the quantiles.

By far, we have reviewed the literature on the association between the chosen model parameters of the present study. Owing to the inherent structural differences among the chosen contexts and the methodological adaptations, study outcomes vary. Apart from lack of consensus regarding nature of association between the model parameters, these studies are not able to provide any conclusive evidence regarding the sustainable policy making in those contexts. While devising a robust policy for internalizing the negative externalities caused by the economic growth trajectory, the analysis should be carried out by segregating the entire dataset at various levels, and the policy parameters might have diverse impacts at dissimilar levels. Therefore, in methodological front, none of the studies have considered to analyze the association at quantile levels. Given the recent developments in sustainable development scenario in China, there remains a gap in terms of a comprehensive policy-level approach, which can address the sustainable development issues in a comprehensive manner, by considering the various quantiles of the policy variables. There lies the focus of the present study.

3. Data and Methodology

3.1. Model Specification

The "New-Style Urbanization" for urban agglomeration in China is necessary to accommodate the rural-urban migration, which is a result of urban-centric industrialization, and consequential rise in job opportunities in the urban centers. The prevailing economic growth pattern in China is exerting a pressure on the urban infrastructure, and therefore, advanced urban agglomeration is the need of the hour. Now, the "New-Style Urbanization" necessitates the complementarity from the transportation infrastructure, so that the spatial nodes of the urban network can reduce the transaction cost of communication. Now, while stressing on the transportation for the urban development, the ambient air pollution might be increased, as the transport sector in China is largely dependent on the fossil fuel-based solutions. Therefore, the transportation-induced carbon emissions might rise in the ambient atmosphere. In such a situation, the policymakers might need to focus on substituting the fossil fuel-based energy solutions with clean energy solutions, and in this pursuit, the demand for additional fund will rise for implementing the solutions. This might increase the demand for PPP investment in the transportation. Hence, the PPP investment in the transportation sector might have an impact on the transport-induced carbon emissions.

In this contextual backdrop, it is necessary to analyze the impact of these economic indicators on carbon emissions following a theoretical framework, which will allow the evolutionary impact over a specified temporal frame (Shahbaz and Sinha, 2019). Henceforward, this study has embarked on the Environmental Kuznets Curve (EKC) hypothesis framework. Under this analytical framework, transportation-induced carbon emission is used as the dependent variable (following Yang et al., 2013), while the independent variables are economic growth (following Destek and Sinha, 2020), urbanization (following Sinha et al., 2017), and renewable energy consumption (following Sinha et al., 2018).

The testable empirical model of this study as,

$$TE = a_0 + a_1 EG + a_2 EG^2 + a_3 PPPT + a_4 URB + a_5 RNC \quad (1)$$

In equation 1, all the variables are in logarithmic form. TE, PPPT, URB and RNC are the transport carbon dioxide emissions, investment of public private partnership in transport, urbanization and renewable energy consumption respectively. EG is the economic growth and EG^2 is the square of economic growth which is used to estimate the EKC hypothesis in China.

3.2. Data

In present research, we empirically examine the role of public private partnership investment in transport sector (independent variable) on CO_2 discharge from transportation (dependent variable) along with urbanization, consumption of energy from renewable resources and economic growth from 1990Q1-2018Q4 for China. CO_2 emanations from transportation are measured in metric tons per capita and public private partnership investment in transportation is measured in constant US$. We use urban population (% of total population) as proxy for urbanization, energy consumption from renewable resources (wind, solar, nuclear, per and hydro) measured in million tons per capita and GDP per capita (Constant US$ 2010) used as the proxies of economic growth. The data of renewable energy consumption and CO_2 emanations from transportation has been taken from British Petroleum Statistical Review (BP Statistical Review, 2019) and International Energy Agency (IEA, 2019) respectively. Data for remaining variables (PPPT, Urbanization and GDP per capita) have been obtained from World Development Indicators (World Bank, 2019).

Table: 1 Definition and Sources of Variables

Sr. No.	Variables (Abbreviations)	Specifications	Source of Data
1	Carbon dioxide emission from transport sector (TE)	CO_2 emission from transport sector (Metric ton of CO_2 emissions per capita)	IEA-2019
2	Public private partnership investment in transport (PPPT)	Public and private sector partnership investment in transport (Constant US$)	WDI-2019
3	Urbanization (URB)	Urban population (% of total population)	WDI-2019
4	Renewable energy consumption (RNC)	Renewable energy consumption (Wind, Solar, Nuclear, Hydro per capita)	BP-Statistics-2019
5	Economic growth (EG)	GDP per capita (Constant US$, 2010)	WDI-2019

Note: World development indicators (WDI), British Petroleum Statistics (BP-Statistics), International Energy Agency (IEA).

3.3. Descriptive Statistics

Table-2: Results of Descriptive Statistics						
Variables	**Mean**	**Minimum**	**Maximum**	**Std. Dev.**	**Jarque-Bera**	**Correlation**
TE	5.760	4.543	6.795	0.769	14.576***	-
PPPT	21.220	18.795	23.980	1.270	20.587***	-0.723***
EG	7.844	6.592	8.956	0.734	13.369***	0.469***
RNC	3.137	1.279	4.025	0.831	26.105***	-0.698***
URB	3.703	3.275	4.080	0.252	31.491***	0.604***
Note: ***, ** & * shows significance level at 1%, 5% and 10% respectively. Source: Author estimation						

In table number 2 given above, the descriptive statistics results and correlation of TE along with independent variables (PPPT, EG, RNC and URB) are presented. The results of the table 2 indicate that TE possesses a mean value of 5.760 which falls among 4.543 and 6.795. PPPT possesses a mean value of 21.220 which falls among 18.795 and 23.980. Other variables which include EG, RNC and URB have the mean values of 7.844 (which lies between 6.592 and 8.956), 3.137 (which lies between 1.279 and 4.025) and 3.703 (which lies between 3.275 and 4.080) respectively. Moreover, the Jarque-Bera test is applied to check the normality of variables which is mentioned in above table. The results of Jargue-Bera test demonstrate that all the variables are significant, which is a pre-requisite for quantile regression analysis (Godil et al., 2020; Mishra et al. 2019; Batool et al. 2019; Sharif et al. 2017; Raza et al. 2017). Furthermore, there is a negative correlation among TE, PPPT and RNC for the case of China.

3.4. Methodology

It is detected that usually unit root comes across in time series research which utilizes the macroeconomic variables in empirical studies. Due to the reason that the estimates of a regression are spurious if the analysis is between the non-stationary variables, so these analyses often utilize levels on which these variables become stationary. Therefore, the facts lose in long run in this scenario. As a result, cointegration tests are developed to cop up with this problem of analysis. Engle and Granger (1987) evolved the two-stage cointegration test which possess that if a series has unit roots on its levels as well as is stationary on its first difference, the erosion of information can be impeded if these variables are regressed at its levels. But there is also an issue with Angle and Granger cointegration technique that it is reasonable only if the number of cointegrated vectors is only one. If the cointegrated vectors are more than one, this technique is inadequate. On the other side, based on the VAR model, the cointegration technique initiated by Johansen (1988) gives the chance to decide whether or not the variables have more than one cointegrating vector. All the considered variables must be homogenized of order 1 that means I (1).

For the determination of long-term association between concerned variables, the very technique introduced by Pesaran et al. (2001) has not necessarily need the whole series of variables to be integrated of order 1. The condition of this method requires the non-integration of any variable of order 2 rather; they must be integrated of order 0 and order 1. Moreover, the methodology of cointegration is expanded to quantile regression by Xiao (2009). As reported by this method, for the purpose of endogeneity, it examines lags and leads of the regressors which are integrated. "The method of quantile cointegration permits for extra volatility of explained variables additionally to independent variable and gives appealing category for cointegration methods along with conditional heteroskedasticity" (Xiao, 2009). As a result, this technique gives a robust technique as well as enhances options of modeling for time series analysis in economics. Further, Cho et al (2015) developed this technique more.

3.4.1. Quantile Autoregressive Distributed Lagged (QARDL Method)

In current research, the novel QARDL method is utilized to check the non-linear relationship among transport emissions, PPP transport, and energy from renewable resources, urbanization and economic growth. The current technique was developed further by Cho et al., (2015). Specifically, current approach permits checking long-term association of quantile equilibrium effect of PPP investment in transportation, renewable energy, urbanization as well as economic growth on transportation CO_2 emissions for case of China. Furthermore, Wald test has been utilized for examining both short and long-term equilibriums by checking dependability parameters in every quantile.

At the starting point, the traditional linear ARDL model is described as under:

$$TE_t = \alpha + \sum_{i}^{o} \beta_1\, TE_{t-i} + \sum_{i}^{p} \beta_2\, PPPT_{t-i} + \sum_{i}^{q} \beta_3\, RNC_{t-i} + \sum_{i}^{m} \beta_4\, URB_{t-i} + \sum_{i}^{n} \beta_5\, EG_{t-i} + \sum_{i}^{r} \beta_6\, EG_{t-i}^2 + \epsilon_t \quad (2)$$

In above equation, ϵ_t represents the white noise error term described through the least field produced through $\{TE_t,\ PPPT_t,\ RNC_t,\ URB_t,\ EG_t,\ ,TE_{t-1},\ EG_{t-1} \dots \dots .\}$, and o, p, q, r, m and n represent the orders of lag sketched through Schewarz Info Criterion (SIC). Moreover, $TE_t, PPPT_t, RE_t, URB_t,\ GDP_t, GDP_t^2$ state to the natural logarithm series of transport CO_2 emissions, public-private partnership investment in transport, renewable energy, urbanization and economic growth discretely.

Following the above-mentioned procedure, in the framework of the quantile by revising the above stated equation, proposes the context given as under of the QARDL technique:

$$Q_{TE_t} = \alpha(\tau) + \sum_{i}^{o} \beta_1\,(\tau) TE_{t-i} + \sum_{i}^{p} \beta_2\,(\tau) PPPT_{t-i} + \sum_{i}^{q} \beta_3\,(\tau) RE_{t-i} + \sum_{i}^{m} \beta_4\,(\tau) URB_{t-i} + \sum_{i}^{n} \beta_5\,(\tau) EG_{t-i} + \sum_{i}^{r} \beta_6\,(\tau) EG^2{}_{t-i} + \epsilon_t(\tau) \quad (3)$$

In the above equation, $\epsilon_t(\tau) = TE_t - Q_{TE_t}(\frac{\tau}{\epsilon_{t-1}})$ [56] and 0< τ<1 is quantile. To carry out the data analysis, the study uses the following set of quantiles t lies to {0.05, 0.1, 0.2, 0.3, 0.4…. 0.9

and 0.95}. Furthermore, due to the reason that sequential correlation's probability into the white noise error term, the QARDL structure in the above equation (equation 3) is diversified as under:

$$Q_{\Delta TE_t} = \alpha(\tau) + \rho TE_{t-i} + \varphi_1 PPPT_{t-i} + \varphi_2 RNC_{t-i} + \varphi_3 URB_{t-i} + \varphi_4 EG_{t-i} + \varphi_5 EG_{t-i}^2 + \sum_{i}^{o} \beta_1(\tau) TE_{t-i} + \sum_{i}^{p} \beta_2(\tau) PPPT_{t-i} + \sum_{i}^{q} \beta_3(\tau) RE_{t-i} + \sum_{i}^{m} \beta_4(\tau) URB_{t-i} + \sum_{i}^{n} \beta_5(\tau) GDP_{t-i} + \sum_{i}^{r} \beta_6(\tau) GDP^2{}_{t-i} + \epsilon_t(\tau) \tag{4}$$

Furthermore, the equation given above can be re-evaluated (Cho et al., 2015) to give under stated Error Correction model measuring again for QARDL structure:

$$Q_{\Delta TE_t} = \alpha(\tau) + \rho(\tau)(TE_{t-i} - \omega_1(\tau) PPPT_{t-i} - \omega_2(\tau) RNC_{t-i} - \omega_3(\tau) URB_{t-i} - \omega_4(\tau) EG_{t-i} - \omega_5 EG_{t-i}^2) + \sum_{i=1}^{o-1} \beta_1(\tau) \Delta TE_{t-i} + \sum_{i=0}^{p-1} \beta_2(\tau) \Delta PPPT_{t-i} + \sum_{i=0}^{q-1} \beta_3(\tau) \Delta RNC_{t-i} + \sum_{t-i}^{m-1} \beta_4(\tau) \Delta URB_{t-i} + \sum_{t-i}^{n-1} \beta_5(\tau) \Delta EG_{t-i} + \sum_{t-1}^{r-1} \beta_6(\tau) \Delta EG_{t-i}^2 + \epsilon_t(\tau) \tag{5}$$

By employing the Δ method, collaborative short-term influence of foregoing transport emanations has been computed through$\beta_* = \sum_{i=1}^{o-1} \beta_1$, although the collaborative short-run influence of simultaneous as well as foregoing EG on present stage for transport emanations has been captured as$\beta_* = \sum_{i=1}^{r-1} \beta_6$. Lastly, the coefficient ρ which is speed of adjustment must be reverse and significant in equation (5) (Cho et al., 2015).

Ultimately, for measuring short-term and long-term unsymmetrical influence of PPP transportation, renewable energy, urbanization along with economic growth on transport CO_2 emanations, current study applies the Wald test for testing the specific null and alternative hypotheses for getting the short-term and long-term parameters. On account of Cho et al., (2015), some influencing details pop up from past equations. From the very beginning, the short and long-term coefficients are based on quantiles, this phenomenon shows that those coefficients in QARDL framework can be unalike on every single quantile depicting that those coefficients can effect on each interval. Moreover, by using Wald test (Cho et al., 2015), the boundaries of short and long-term coefficients with as well as among the quantiles could be scrutinized.

3.4.2. Granger-Causality in Quantiles Test

In past studies of economics, if or if not a variable is pioneer of any other variable or not investigated under the structure of analysis of causality which was initiated by Granger (1969). More usually, it is assumed by this particular test that the contemporary worth of explained variable has been verified independently as well as by the lagged values of explanatory variable. Following Granger, (1969), numerous fresh methods of causality were established with the help of diverse techniques. In this particular study, the Granger-causality test in quantile technique developed by Troster (2018) has been applied to check the causality of quantiles amonf transport emissions, public-private partnership in transport, renewable energy, urbanization and economic growth. Following Granger, (1969), a specific variable Y_i does not Granger-cause the 2nd variable X_i has not hypothesized to approximate X_i , in accordance with the foregoing X_i. The study assumes that an explain vector $(P_i = P_i^X, P_i^y)' \in R^e, s = o + r,$ where P_i^y the previous demonstration group of $P_i P_i^y = (P_{i-1}, \dots, P_{i-r})' \in R^r$. Furthermore, this study explains the null hypothesis of non-causailty of Granger from Y_i to X_i as under:

$$H_o^{y \to X}: F_X(P_i^X, P_i^Y) = F_X(P_i^x), \text{for all } x \in R, \quad (6)$$

In the above equation, $F_X(P_i^X, P_i^Y)$ represents the interim distribution motive of X_i giving (P_i^x, P_i^Y). Under the null hypothesis from equation number 6. Conforming with (Granger, 1969), the study applies the D_T check by put in order the QAR approach m(.) for all $\pi \in \Gamma \subset [0,1]$, depend on null hypothesis of casual non-Granger relationship as under:

$$QAR(1): m^1\left(P_i^X, \partial(\pi)\right) = \gamma_1(\pi) + \gamma_2(\pi) Y_{i-1} + \mu_t \delta_\sigma^{-1}(\pi), \quad (7)$$

In above equation, the coefficient $\partial(\pi) = \gamma_1(\pi), \gamma_2(\pi)$ *and* μ_t approximated through the highest probability in an identical point of quantiles, and $\delta_\sigma^{-1}(\pi)$ represents the reverse for a standard basic distribution function. For identifying manifestation of causality among variables, this research finds out QAR approach of the above equation number 6 along with lagged to alternative factor. In last, the main equation of QAR (1) method along with equation number 7 is as under:

$$Q_\pi^X(P_i^X, P_i^Y) = \gamma_1(\pi) + \gamma_2(\pi) X_{i-1} + \vartheta(\pi) Y_{i-1} + \mu_t \delta_\varepsilon^{-1}(\pi) \quad (8)$$

4. Results and Discussion

The present section of the study emphasized on the empirical results, interpretation and discussion. It is a pivotal pre-requisite to perform the quantile unit root tests before QARDL model to scrutinize the stationary properties of the variables. The reason behind using the quantile unit root test methods instead of standard unit root tests which include Augmented Dickey Fuller and Phillips and Perron etc. is that the data is not normally distributed. Consequently, quantile unit root methods provide more robust inference and to avoid the biased results (Koenker and Xiao, 2004). In the present study, at different quantiles, table number 3 indicates outcomes of quantile unit root test for concerned variables. The results highlight that economic growth from 0.5th to 0.20th quantile is stationary at level; similarly, renewable energy consumption and urbanization are stationary at level from 0.90th to 0.95th quantile. The remaining values of these variable and all other variables become stationary at their first differences. Hence, while TE and PPPT are integrated to first order, i.e. I(1), EG, RNC, and URB are integrated to zero order, i.e. I(0). Presence of the model parameters pertaining to dissimilar orders of integration ensures the applicability of the QARDL model.

Table 3: Results of Unit Root test										
Quantiles	**TE**		**PPPT**		**EG**		**RNC**		**URB**	
	α(τ)	**t-stats**	**α(τ)**	**t-stats**	**α(τ)**	**t-stats**	**α(τ)**	**t-stats**	**α(τ)**	**t-stats**
0.05	0.891	-2.536	0.839	-2.215	**0.747**	**-3.933**	0.94	-0.757	1.037	-0.835
0.10	0.925	-1.816	0.731	-1.173	**0.755**	**-3.588**	0.907	-0.961	1.000	-1.059
0.20	0.904	-2.182	0.869	-0.481	**0.814**	**-3.711**	0.898	-1.250	0.991	-1.378
0.30	0.884	-2.638	0.911	-0.026	0.887	-2.415	0.887	-1.216	0.979	-1.304
0.40	0.916	-2.066	0.984	1.413	0.901	-1.728	0.835	-1.674	0.921	-1.846
0.50	0.924	-1.946	1.007	1.321	0.975	-1.379	0.796	-1.969	0.877	-2.171
0.60	0.957	-1.571	1.054	2.812	0.871	-0.206	0.806	-1.74	0.889	-1.918
0.70	0.969	-1.516	1.009	1.953	0.888	-1.401	0.781	-1.856	0.861	-2.047
0.80	0.922	-1.899	1.091	2.033	0.951	0.632	0.752	-2.615	0.829	-2.884
0.90	0.899	-2.258	1.089	3.000	1.103	0.448	**0.719**	**-4.061**	**0.793**	**-3.273**
0.95	0.916	-2.142	1.136	5.705	0.958	1.017	**0.748**	**-4.206**	**0.744**	**-3.433**
Notes: The table shows point estimates and t-statistics at 5% significance level. Bold values represent that the variable is stationary at level series.										
Source: Author Estimations										

In table number 4, QARDL estimation results have been presented. The parameter ρ* becomes significant and possesses a negative sign in quantiles (from 0.60 to 0.95) which indicates the long-term equilibrium reversion in these quantiles between TE, PPPT, EG, EG^2, RNC and URB. Now the results give certain indication for the prospective policies to be designed for China. Let us begin with the results for EG. The coefficients of EG and EG^2 denote that the EKC hypothesis is valid for China, and the turnaround points at the higher quantiles are outside the sample range. This finding falls in line with the finding of Sharif et al. (2020c) for China and Sharif et al. (2020a) for Malaysia. However, this piece of evidence indicates that the economic growth pattern prevailing in China is environmentally unsustainable. This segment of results is complemented by the finding for URB. The coefficient of URB is positive as well as significant influence on TE from 0.60 to 0.95 quantile. This result is in line with the findings of Ali et al. (2019) for Pakistan, Salahuddin et al. (2019) for South Africa, Mahmood et al. (2020) Saudi Arabia, Liu and Bae (2018) for China. This piece of evidence shows that the urbanization pattern in China is environmentally unsustainable, as rising pressure on the urban infrastructure is reflected in terms of the rising carbon emissions. Now, while treading the economic growth path, the rise in the job opportunities in the urban centers has initiated the labor migration, and hence, the "New-Style Urbanization" strategy has started taking shape for handling rise in urbanization. As transportation is one of the major instruments of this strategic initiative, therefore, this sector might also need to look into the environmental sustainability aspect, by means of utilizing clean and renewable energy. The results divulge that RNC-TE nexus is negative and significant from quantile 0.30 to 0.95. This piece of evidence demonstrate that the higher penetration of the renewable energy solutions will exert positive environmental externality by reducing the level of transport-induced carbon emissions. This segment of the results is similar with the findings of Sharif et al. (2020c) for the case of Turkey and Aziz et al. (2020) for Pakistan. Now in order to implement and sustain the transportation infrastructure, the government will require additional funding support, and that might be channeled through the PPP investments. However, these investments also need to be environmentally sustainable, for the "New-Style Urbanization" strategy to be successful. The coefficient of PPPT is positive and insignificant from quantile 0.05 to 0.20. It becomes negative and insignificant from 0.30^{th} to 0.70^{th} quantile. As we move from 0.80 to 0.95^{th} quantile, the coefficient is negative as well as significant at 5% and 10% levels of significance individually.

Table 4: Results of Quantile Autoregressive Distributed Lag Model (QARDL)

Quantiles (τ)	Constant	ECM	Long-Run Coefficients estimates					Short-Run Coefficients estimates					
	$\alpha(\tau)$	ρ^*	$\beta_{EG}(\tau)$	$\beta_{EG^2}(\tau)$	$\beta_{PPPT}(\tau)$	$\beta_{RNC}(\tau)$	$\beta_{URB}(\tau)$	$\varphi_1(\tau)$	$\omega_0(\tau)$	$\lambda_0(\tau)$	$\delta_0(\tau)$	$\psi_0(\tau)$	$\theta_0(\tau)$
0.05	-0.049	0.026	0.085	-0.024	0.797	0.357	0.018	0.672***	0.221	-0.061	-0.171***	-0.048	0.186*
	(0.307)	(0.050)	(0.934)	(0.392)	(1.402)	(0.952)	(0.305)	(0.198)	(2.260)	(0.946)	(0.054)	(0.078)	(0.111)
0.10	-0.454**	-0.031	0.857	-0.419	0.324	0.973	0.027	0.520***	2.639**	-1.290**	-0.109**	-0.082	0.237**
	(0.191)	(0.023)	(0.608)	(0.392)	(0.387)	(0.904)	(0.246)	(0.173)	(1.347)	(0.591)	(0.048)	(0.053)	(0.102)
0.20	0.323	0.015	0.588	-0.375	0.529	0.601	0.039	0.528***	0.881	-0.562	-0.097**	-0.073	0.243**
	(0.273)	(0.017)	(1.171)	(0.450)	(1.065)	(0.952)	(0.201)	(0.169)	(1.525)	(0.680)	(0.043)	(0.048)	(0.096)
0.30	0.338	-0.017	0.322	-0.254	-0.011	-0.900***	0.067	0.676***	0.532	-0.423	-0.077*	-0.068**	0.250*
	(0.276)	(0.028)	(1.745)	(0.787)	(0.392)	(0.204)	(0.183)	(0.189)	(2.258)	(0.947)	(0.041)	(0.031)	(0.133)
0.40	0.320**	-0.021	0.271	-0.193	-0.116	-0.316***	0.094	0.672***	0.564	-0.404	-0.076*	-0.064*	0.174
	(0.125)	(0.024)	(1.008)	(0.481)	(0.334)	(0.085)	(0.149)	(0.205)	(1.588)	(0.616)	(0.039)	(0.033)	(0.122)
0.50	0.227	-0.021	0.014	-0.078	-0.073	-0.428***	0.136	0.690***	0.028	-0.162	-0.094*	-0.067**	0.176
	(0.148)	(0.017)	(0.792)	(0.381)	(0.338)	(0.088)	(0.109)	(0.209)	(1.637)	(0.654)	(0.055)	(0.033)	(0.121)
0.60	0.281*	-0.041**	0.009	-0.037	-0.12	-0.345***	0.184**	0.706***	0.036	-0.153	-0.103**	-0.066**	0.141
	(0.163)	(0.020)	(0.365)	(0.159)	(0.168)	(0.093)	0.091	(0.175)	(1.479)	(0.627)	(0.043)	(0.028)	(0.134)
0.70	0.281	-0.043**	0.008	-0.038	-0.036	-0.349***	0.201**	0.715***	0.036	-0.161	-0.101**	-0.062*	0.136
	(0.177)	(0.018)	(0.315)	(0.158)	(0.150)	(0.049)	0.082	(0.134)	(1.337)	(0.574)	(0.047)	(0.035)	(0.116)
0.80	0.196	-0.063***	0.314	-0.104	-0.162**	-0.318***	0.267***	0.617***	1.989	-0.659	-0.076	-0.046	0.149
	(0.276)	(0.022)	(0.336)	(0.121)	(0.074)	(0.085)	0.062	(0.103)	(2.346)	(0.989)	(0.070)	(0.041)	(0.129)
0.90	0.249	-0.119***	0.421**	-0.152**	-0.166**	-0.404***	0.282***	0.718***	5.019**	-1.818*	-0.04	-0.032	0.039
	(0.316)	(0.023)	(0.212)	(0.076)	(0.084)	(0.096)	0.066	(0.140)	(2.564)	(1.084)	(0.101)	(0.087)	(0.105)
0.95	-0.107	-0.122***	0.521**	-0.198**	-0.237*	-0.416***	0.294***	0.637***	6.339**	-2.405*	-0.008	-0.012	0.058
	(0.458)	(0.022)	(0.241)	(0.099)	(0.126)	(0.098)	0.059	(0.132)	(2.874)	(1.241)	(0.099)	(0.106)	(0.110)

Note: The table reports the quantile estimation results. The standard errors are between brackets. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Source: Author Estimations

Table 5: Results of the Wald Test	
Variables	**F-statistics [p-values]**
ρ	9.294*** [0.000]
β_{EG}	4.482*** [0.000]
β_{EG^2}	0.471 [0.905]
β_{PPPT}	2.180** [0.020]
β_{RNC}	5.328*** [0.000]
β_{URB}	3.794*** [0.000]
φ_1	3.029*** [0.000]
ω_0	1.21 [0.286]
λ_0	1.36 [0.202]
δ_0	0.951 [0.489]
ψ_0	1.750* [0.074]
θ_0	3.039*** [0.000]

***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.
Source: Author Estimations

While stating the results, it is also necessary to assess the empirical model for its dynamic stability. In order to carry out this diagnostics, current study utilized Wald test for scrutinizing the constancy (linearity) of parameters approximated as given in Table 5. As these results shown, the null hypothesis of parameter constancy of speed of adjustment parameter is rejected at 1% significance level. Moreover, the null hypothesis of linearity across different tails of every quantile for long term parameters among variables which are under consideration is rejected except square of economic growth. As a consequence, the current research concludes that long term parameters TE, EG, PPPT, RNC and URB are dynamic in various quantiles for country case of China. Additionally, Wald test rejects the null of linearity for short term cumulative impact of previous levels of TE across quantiles under consideration. Lastly, the cumulative short-term influence of RNC as well as URB is asymmetric (non-linear) at 10% and 1% significance level individually across quantiles. Possibility of endogeneity problem has been checked by Durbin-Wu-Hausman test, and results reported in Appendix 1 demonstrate the absence of endogeneity problem in the model.

Table 6: Granger Causality in Quantile Test Results								
Quantiles	ΔEG_t ↓ ΔTE_t	ΔTE_t ↓ ΔEG_t	$\Delta PPPT_t$ ↓ ΔTE_t	ΔTE_t ↓ $\Delta PPPT_t$	ΔRNC_t ↓ ΔTE_t	ΔTE_t ↓ ΔRNC_t	ΔURB_t ↓ ΔTE_t	ΔTE_t ↓ ΔURB_t

[0.05-0.95]	32.634*** [0.000]	31.950*** [0.000]	22.537*** [0.000]	18.730*** [0.000]	32.583*** [0.000]	27.357*** [0.000]	28.631** [0.000]	28.598*** [0.000]
0.05	19.570*** [0.000]	30.809*** [0.000]	27.791*** [0.000]	22.294*** [0.000]	16.373*** [0.000]	17.385*** [0.000]	19.057*** [0.000]	11.154*** [0.000]
0.10	27.480*** [0.000]	17.478*** [0.000]	17.840*** [0.000]	17.724*** [0.000]	21.362*** [0.000]	17.972*** [0.000]	17.226*** [0.000]	19.407*** [0.000]
0.20	10.723*** [0.000]	12.278*** [0.000]	12.363*** [0.000]	15.413*** [0.000]	17.934*** [0.000]	20.363*** [0.000]	21.807*** [0.000]	22.041*** [0.000]
0.30	22.153*** [0.000]	19.989*** [0.000]	21.817*** [0.000]	21.317*** [0.000]	17.086*** [0.000]	23.347*** [0.000]	20.301*** [0.000]	20.364*** [0.000]
0.40	13.329*** [0.000]	18.376*** [0.000]	20.975*** [0.000]	20.152*** [0.000]	21.094*** [0.000]	22.074*** [0.000]	26.925*** [0.000]	28.702*** [0.000]
0.50	10.151*** [0.000]	12.155*** [0.000]	15.228*** [0.000]	20.078*** [0.000]	22.486*** [0.000]	23.719*** [0.000]	22.260*** [0.000]	24.235*** [0.000]
0.60	20.134*** [0.000]	22.545*** [0.000]	21.561*** [0.000]	19.801*** [0.000]	22.918*** [0.000]	19.649*** [0.000]	20.361*** [0.000]	20.463*** [0.000]
0.70	29.480*** [0.000]	25.930*** [0.000]	26.699*** [0.000]	27.846*** [0.000]	25.146*** [0.000]	26.466*** [0.000]	22.060*** [0.000]	23.618*** [0.000]
0.80	14.654*** [0.000]	12.905*** [0.000]	12.398*** [0.000]	12.922*** [0.000]	15.837*** [0.000]	12.111*** [0.000]	15.212*** [0.000]	13.915*** [0.000]
0.90	21.078*** [0.000]	20.464*** [0.000]	26.378*** [0.000]	23.426*** [0.000]	20.880*** [0.000]	22.550*** [0.000]	17.124*** [0.000]	14.657*** [0.000]
0.95	27.872*** [0.000]	30.796*** [0.000]	26.122*** [0.000]	22.418*** [0.000]	26.905*** [0.000]	21.083*** [0.000]	29.456*** [0.000]	30.174*** [0.000]
Note: The table reports the F-statistics value, while [] contains p-values. *** represents level of significance at 1%. Source: Author Estimation								

In the last, Table 6 reveals the empirical findings of the quantile causality test. Main findings describe that there exists a two-way causality running among TE and PPPT because all critical values are rejected at 1% significance level. Moreover, the EG and EG^2 also have a two-way causality with TE as indicated by the results of the quantile causality test. The other two variables (RNC and URB) have also mutual causality which is in line with our long-term results.

5. Implications for sustainable policymaking

With the objective of implementing the SDGs, results obtained in this study might prove to be significant for China. As China is inflicted by high level of urbanization and the "New-Style Urbanization" strategy is still at a nascent stage, China can be characterized by high economic growth and high consumption of fossil fuel. Hence, a policy-revamp is required in these nations for encapsulating the broad aspects of sustainable development. Our findings can shed light on this aspect.

Let the discussion start with the economic growth pattern. As the economic growth pattern is found to be unsustainable in nature, therefore the interventions need to internalize environmental externalities caused by the economic growth pattern. As the prevailing economic growth pattern in China is largely dependent on the fossil fuel consumption, a phase wise transformation is required to diffuse the renewable energy solutions across the country. However, an overnight transformation might dampen the economic growth pattern, which is not desirable (Sinha et al., 2020c). Therefore, the policy makers need to focus on the industrial sector for implementing the renewable energy solutions. the industrial sector can be endowed with renewable energy solutions at a pro-rata rate, and the rate might follow discriminatory pricing mechanism based on the carbon footprint of the sector. Moreover, policymakers also need to gradually reduce the subsidies on the fossil fuels solutions, so that the usage of these solutions can be discouraged. In this way the industrial sector will be gradually accepting renewable energy solutions, without causing harm to the cash flow structure. The interest income received by the government through this stage can be utilized to provide the solutions to the urban households at a rate lower than that of the industrial sector. The households might also be given a certain interest rate holiday, so that the energy transition can be smooth.

Once the government catalyzes the growth in renewable energy sector, it will also have multiplier effect on the transportation sector. Gradual acceptance of renewable energy solutions in the transportation sector will help this sector to exert the positive environmental externalities through causing a reduction in the carbon emissions (Roy and Singh, 2017; Roy et al., 2018). This initiative might help the "New-Style Urbanization" strategy to fulfill its green growth objective, while sustaining the livelihood of the urban households. In this way, China might make a move in fulfilling the objectives of SDG 11. As the gradual diffusion of renewable energy solutions will be accepted across the industrial sectors in China, the ambient air quality will be gradually improved, as the level of transport induced carbon emissions will be reduced over time. It will help China to make a progression towards attaining the objectives of SDG 13.

While making this policy level moves, the policymakers also need to ponder upon sustaining these initiatives, and in this pursuit, emphasis should be given on encouraging the public-private partnerships. With the rise renewable energy-led industrial growth backed by transportation, China might experience rise in the job opportunities in the renewable energy sector. This rise in the job opportunities might also help to absorb the surplus labor who, had been employed in the traditional fossil fuel energy generation sector. In this way, the policymakers might be able to not only avoid the problem of unemployment, but also to provide a sustained livelihood to the citizens (Sinha et al., 2020 a, b). This policy level alignment might help China in making an advancement in the way of achieving the objectives of SDG 8. In this journey, the attainment of objective of SDG 17 might play an instrumental role.

6. Conclusion and Policy Implications

The current study explores the association among public private partnership investment in transport and transport carbon emanations by incorporating part of urbanization, renewable energy usage in case of China from 1991Q1-2018Q4. In doing so, we apply Quantile unit root test to inspect the stationarity of indicators, then the study applies Quantile ARDL test proposed by Cho et al. (2015) for analyzing the cointegration among the concerned variables. Findings of the study can be useful for providing a policy-level solution for China in pursuit of making a progression towards attaining the SDG objectives. The multipronged SDG framework suggested in the study for China is the novelty of this study, and there lies the policy-level contribution of the study.

Along with the policymakers, the industrial sector also needs to contribute towards the success of the policy framework. In order to ascertain the attainment of the mentioned SDGs, the industrial sector should gradually shift the energy solutions towards green and renewable energy sources. It might be possible that several firms might not be able to cope with the transformation during the mentioned phases. In such a scenario, the firms should look into improving the energy efficiency, so that energy intensity can be reduced, and consequential negative environmental externality can also be reduced. While carrying out this exercise, the firms need to remember that these transformations should not be carried out at the cost of the labor force, i.e. technological innovations in pursuit of the betterment of environmental quality should not be a replacement of the human labors, as this might defeat the purpose of sustainable development. Along with this, the firms should endorse the growth in the new job opportunities in the renewable energy sector. This might cater them two benefits: (a) the growth in the renewable energy generation sector might help them in getting a higher return on their investments, and (b) it will help the firms to have an opportunity for vertical integration, and thereby, scaling up the operations of the newly formed firms.

While stating the policy framework, certain assumptions and caveats also need to be mentioned, without which the policy framework might not produce the desired result. First, environmental regulations need to be made more stringent, so that the natural resources can be protected and use of fossil fuels can be discouraged. Second, the import substitution policies for fossil fuel should be enforced, so that not only the utilization of fossil fuel can be reduced, but also the trade balance of the nation can be improved. Third, the surplus labors from the traditional fossil fuel generation sector should be given necessary training with an objective of their suitability in the renewable energy sector. Fourth, the rent-seeing mechanism from the governmental agencies should be handled strictly, in order to protect the prospect of public-private partnerships.

While stating the policy-level contribution of study, it is needed to be remembered that the study has been carried out on China at a national level, and without going at the provincial level. As the provinces might vary in terms of geographic and demographic structure, therefore the policy-level interventions might also vary according to those aspects. There lies the limitation of the study. However, this limitation gives an opportunity to extend this baseline policy-level model by incorporating the spatial dimensions of the different provinces of China. Moreover, the future studies can also incorporate the social dimensions of the urban households, which might add novel insights to the policy level aspect.

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Appendix 1: Results of Durbin-Wu-Hausman test of endogeneity

	Test Statistic	p-value
EG	0.35400	0.55186
EG^2	1.30982	0.25243
PPPT	0.59108	0.95754
RNC	1.05975	0.77523
URB	0.70223	0.55243