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Moving a step closer towards environmental sustainability in Asian countries: focusing on real income, urbanization, transport infrastructure, and research and development

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ABSTRACT

Environmental pollution has become the matter of concern all over the world with the increase in urbanization, transport, industrialization and several other factors. The researcher has therefore designed this study to investigate the impact of urbanization, research and development R&D expenditure, infrastructure development and real income on the emission of carbon dioxide in Asian countries. The data collection process involved six Asian countries from 1997 and ending 2019. The panel data estimation and analysis tools and techniques were applied on the collected data and the results were obtained. The results of regression estimation suggest that as per MG estimator, all the variables have significant and positive impact on CO_2 emission but infrastructure development has insignificant impact. In case of FMOLS, again all the variables have significant and positive impact on CO_2 emission but infrastructure development has insignificant impact. However, in case of DOLS, all the variables have shown significant impact on CO_2 emission. In the last, DK estimator indicates that urbanization, real income and population density have significant and positive impact on CO_2 emission but R&D expenditure and infrastructure development has insignificant impact. In this way, the impacts of all independent and control variables on CO_2 emission were estimated.

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1. Introduction

The development in the Asian states is directly linked with the growth of the sustainable cities, like the economically dynamic cities are major aim to make future economic growth and continued reduction in the poverty(Ulucak & Khan, 2020; Wang et al., 2019). In the current environment-oriented business perspective, many steps have been made by the business community within the Asian states to achieve the sustainable development goals by establishing the environmental quality products and services. There is a projection that over the next 25 years, the urban population of the Asian countries will be grown by 70% more than 2.6 billion people(Mishra et al., 2019). This transformation of a large number of people from the agriculture economic sector to the industrialization results in many environmental issues within the states that create a major barrier in front of the states to attain the sustainable economic growth(Hakkarainen et al., 2016). Now the Asian Development Bank is making a new urban services based initiatives that will play an important rule to overcome the negative impact of transport infrastructure and other environmental affected industrial development(Ahvenniemi et al., 2017; Anwar et al., 2017; Sadorsky, 2018). In the Asian market perspective, the urbanization is mostly associated with the social, political, environmental and economic transformation, and such transformation majorly affecting the two most popular countries in the world, named as China and India that result in redefining the global environmental issues, the global economy and geopolitical landscape(Xie & Sun, 2020). In majority of the Asian countries, the enormous growth and the rapid growth of cities result in raising the living standards and reducing poverty, but unfortunately at the cost of environmental and social costs(Shen et al., 2016). In this region, the projected continuations of the industrialization, urbanization and other technological development will effectively strain the sustainability of the Asian cities that result in major improvement in city management and governance and the massive programs of infrastructure investment(Crippa et al., 2018; Hoesly et al., 2018). According to the different surveys, it's become clear that the majority of the air pollution factor is generated from the developing states that are mostly Asian. It means that many harmful gases like COs, NOs, and PM 2.5 concentrations are being emitted by the developing states of the Asian continent(Novello, 2019). According to the survey report, which majorly based on exploring those states that are majorly involved in the harmful gas emission and pollute the environment, and their related outcomes are shown in the following figures;

According to the above-mentioned figures, it becomes clear that China and India are those major Asian states whose urbanization based industrial activities badly affect the environment all over the globe. Like according to Figure 1, it becomes clear the carbon dioxide type harmful gases are majorly emitted 27% from Chinese industrial activities and 11% through the Indian industrial revolution (Saikawa, Trail, et al., 2017). While the remaining amount of such gases is emitted by the rest of the other countries. In Figures 2 and 3, the nitrogen dioxide and PM 2.5 are excessively emitted by china state and Indian state with the comparatively higher percentage as compared to the other countries, which shows that these infrastructures, oil refineries, transportation and other environmental polluting industry are not fulfilling the environmental quality standards in their operating activities that result in the depletion of the ozone

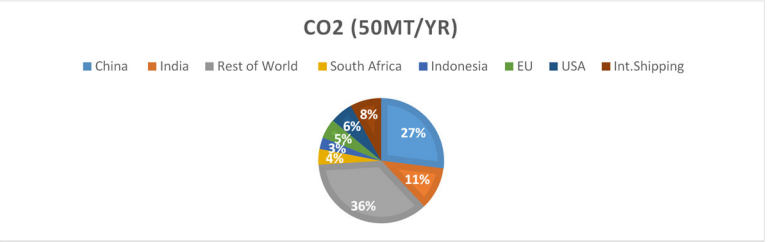

Figure 1. Estimated anthropogenic emissions of the CO_2 (air pollutants) by region.
Source: authors source.

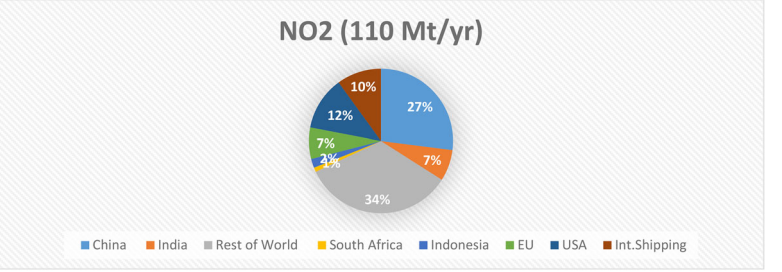

Figure 2. Estimated anthropogenic emissions of the NO_2 (air pollutants) by region.
Source: authors source.

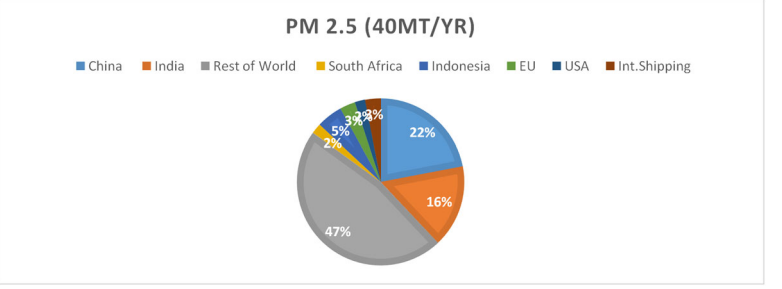

Figure 3. Estimated anthropogenic emissions of the PM2.5 (air pollutants) by region.
Source: authors source.

layer and make a human life in risk all over the globe(Saikawa, Trail, et al., 2017). The above figures show that 27% of harmful CO_2 and NO_2 and 22% of Pm 2.5 concentration is emitted from China because of their urbanization activities. Well, India is considered as the second harmful country in the environmental pollution all over the globe, with 11% emission of CO_2, 16% PM 2.5 concentration and 7% NO_2 based gas emission (Saikawa, Trail, et al., 2017).

The urgent concern in the international arena is how to stop the industrial revolution while maintaining the standard of living for people in both developed and developing countries worldwide. Only those states with effective administration that upholds sustainable development in all social, economic, and environmental dimensions are considered more developed (Faisal et al., 2020). The biggest environmental issues in Asian nations are caused by the fossil fuel usage and transportation infrastructure, which are both directly tied to global CO_2 emissions. Urbanization and

economic growth-based environmental conditions in the emerging nations of the Asian subcontinent result in significant energy consumption in the transportation sector and an increase in the number of private automobiles (Li et al., 2017; Oney et al., 2017). Such high CO_2 emissions can be reduced if the proportion of private automobiles is reduced. In addition to carbon dioxide, all these greenhouse gases—nitrous oxide, methane, sulphur hexafluoride, perfluorocarbon, and hydrofluorocarbon—also cause excessive localised global warming (Saikawa, Kim, et al., 2017; Saikawa, Trail, et al., 2017; Super et al., 2017; van der Gon et al., 2017).

In this research article, there is a brief description regarding which type of steps will be more productive to make the environment free from any pollution and other harmful gases in the Asian countries. The major aim of this research work is 1) to critically evaluate the relationship between urbanization and CO_2 emission, 2) to exaggerate the impact of GDP and infrastructure on the CO_2 emission within the state, 3) to analyze the relationship between R&D and CO_2 emission in the Asian countries perspective, 4) to suggest effective steps that must be followed by the developing countries to attain the environmental sustainability. This research fulfills all the gaps made by the previous scholars in their research articles on the related topics. This study based on a constructive approach to help the authorities and business communities to fulfill the sustainable development goals by making some effective steps in their operating activities.

After this, introduction based section 1, there are majorly five important sections of this research work based on exploring the reliability of this research article. Like in the section 2 of literature review, there is a brief description of the previous research work on the similar topic that will enhance the authenticity of this research article. After this, section 3, research methodology based on exploring the data collection procedure, the section 4 explored the results and the related analysis based data. At the end, the section 4 of discussion and conclusion based important part summarized all the related outcomes of this research work. In addition to this, the limitation and future implication is also discussed in this part.

2. Literature review

2.1. Urbanization and CO_2 emission

Researchers have shown that in low-income nations, urbanisation mostly results in lower energy consumption and increased carbon dioxide emissions; however, in middle-income countries, urbanisation causes a considerable rise in both energy consumption and CO_2 emissions. They found that the urbanisation process is reducing carbon dioxide emissions in the developing state after comparing these income states with high income nations (McGee & York, 2018; Wang et al., 2018). Most other business professors agreed that there is an inverted u-shaped relationship between urbanisation and carbon dioxide emissions, with the western area of China being the main source. They contend that increased urbanisation results in the excessive use of coal rather than natural gas, and that this gas transportation project significantly affected the country's energy structure (Shahbaz et al., 2016; Zhang et al., 2018).

In 2019, the researchers stated that the excessive use of CO_2 is usually occurs in the developing states where a large number of people are trying to change their living standard and its middle class majorly worked in the environment. Ali and other concluded that urbanization affects the carbon cycle when people decide to cut down the trees in order to accumulate the growing population (Ali et al., 2019; Chen et al., 2019). According to the scholars, when tress are cutted by the industrialization development then the lack of such large carbon sinks from the environmental result in the reduction of carbon dioxide absorption and the atmospheric temperature become enhanced (Cetin et al., 2018; He et al., 2017). In 2019, Salahuddin with related researchersconcluded that urbanization increased the industrialization and commercialization that will increase the use of fossil fuels and result in the contribution to climate change and global warming. They stated that such a transformation in the developing countries caused a major environmental change all over the world (Lv & Xu, 2019; Salahuddin et al., 2019). The previous research work has been proposed the following hypothesis;

H1: Urbanization has a significant impact on CO_2 emission in the Asian countries

2.2. GDP and CO_2 emission

In 2019, scholars stated that carbon dioxide within the environment caused a major change in the economic development. According to them, there is a positive correlation between the growing per capita GDP and the carbon dioxide emission (Zhang et al., 2019). According to them, there is no turning point to suggest that emission mostly started to decrease when reaching to its high position of GDP. In 2017, Bae, Mitic and others stated that gas transmission projects play a significant role in the change of the energy structure. According to the scholars, per capita GDP and per capita emission of CO_2 has a major impact on the economic growth based environmental degradation. They concluded that the economy mechanism is not enough to lower the emission and legal regulations are needed to avoid the environmental degradation (Bae et al., 2017; Mitić et al., 2017).

According to Gong and associated researchers, trade and business wars have occurred inside nations in the contemporary sophisticated technical period in order to defend their economic stable position in the market and protect their future. They said that most emerging countries are altering their living standards and clearing their land for development as a result of the race for electricity. Environmental and natural resources are negatively impacted by this race (Gong et al., 2019; Mansoor & Sultana, 2018). The second person added that too many industrial operations cause too much carbon dioxide to be released into the atmosphere, which raises temperatures globally and depletes the ozone layer. In developing countries, excessive urbanization-based economic development raises people's economic level but degrades the environment (Dogan et al., 2017; Kumar & Muhuri, 2019). The others came to the conclusion that the emission intensity of the economy may be used to determine how much a country's emissions of greenhouse gases per unit of economic activity have an impact on the environment globally (Osu et al., 2016; Wang et al., 2017). The following theory has been put out following a rigorous analysis of all prior studies;

H2: GDP has a significant impact on CO_2 emission in the Asian countries

2.3. Research and development and CO_2 emission

Sinha and others worked diligently in the year 2020 to investigate how technological advancements and other research and development initiatives within the state affect external environmental factors, leading to an increase in harmful gas emissions that have a negative impact on human health and the environment's temperature perspective (Sinha et al., 2020). According to experts, the majority of Asian states have a key difficulty in stabilising or reducing their greenhouse gas emissions in their carbon production system: how to sustain economic development. They claim that numerous research and development initiatives are undertaken by environmental scientists to ensure both the sustainable growth of an economy and an effective energy market (Mardani et al., 2019; Ravikumar et al., 2017).

Majority of the scholars show their positive sign regarding the R&D factor in the removal of excessive greenhouse gases from the developing state. According to them, if the green computing is operating within the state, then the environment will be less polluted and stated that if the efficient solar system based energy is used in the generation of electricity and other transportation systems, then the negative impact of such outside gases on the atmospheric environment can be resolved. (Kai et al., 2017; Salahuddin et al., 2018). The other related research scholars constructed a development of carbon dioxide molecular gate membranes for the IGCC process with the efficient capturing of the CO_2. According to them, such research-based development equipment will help to detect the existence of such gases and mitigatethem from the climate.

Such type of carbon dioxidecapturingtechnique is a promising process because it is energy efficientand simple to operate, in addition to this detection, such technique will also help to produce a new and high-performance separation membrane modules for the IGCC-CCS (Fernández et al., 2018; Lin et al., 2017). In addition to the previous researches, a critical analysis has been made by other researchers to explore how the research and development based strategic approach of any developed and developing state caused a major impact6 on its sustainable development phase within the eco-environmental perspective. According to the scholars, urbanization and real economic development caused a minor impact t6 on the greenhouse gas emission as compared to the research and development factors because of this industrialization based advanced situation. It becomes quite essential in front of the state to innovate new green technology to justify their environmental development phase. The other scholars stated that population, energy intensity and the carbon emission and the major driving forces to upgrade the R&D projects for the state's development (Haifeng et al., 2017; Zhang et al., 2020). Hence, the previous researchers' work on the similar topic successfully proposed a following hypothesis;

H3: Research and development has a significant impact on CO_2 emission in the Asian countries

2.4. Infrastructure and CO_2 emission

According to the previous researches, there are all-around 70% of the global greenhouse gas emission is mostly come from the infrastructural construction and other

operating activities like transport, building and power plants. According to the scholars, the urban transport project reduces the car usage in order to overcome the carbon emission factor within the state. They concluded that the deforestation and excessive transportation-related pollution result in the excessive carbon dioxide emission within the state (Chakamera & Alagidede, 2018; Whitman et al., 2019). In the Asian countries, many urban transport projects like Light Rail and Metros is the best way to reduce the number of private vehicle within the state that will help the developing countries to stabilize their environmental pollution factors. Tong with others concluded that railway infrastructure, urban transport projects, and the renewable energy projects are effective sources to mitigate the carbon emission-related environmental problem (McLaren et al., 2016; Tong et al., 2019).

In 2016, the majority of researchers evaluated the significance of infrastructure development projects within the developing nations of the Asian subcontinent critically and came to the conclusion that low carbon infrastructure effectively builds resilience in both developing and developed nations because it produces fewer carbon emissions than traditional infrastructure. They assert that the state's greenhouse gas emissions will be successfully reduced by the low carbon infrastructure (Jain & Tiwari, 2016; Oei & Mendelevitch, 2016; Tong et al., 2016). The other researchers investigated how investments in infrastructure affected industrial carbon dioxide emissions inside the state and came to the conclusion that if countries use green technology in the construction of their infrastructure, carbon dioxide emissions may be decreased. They said that considering the impact of infrastructure investments is important during the industrial revolution (Han et al., 2017; Smith et al., 2017; Tamura et al., 2018).

According to the scholars, in the current global warming situation, there is a need to entrepreneur twelve types of infrastructure investment at the industry level, like first one invest in the public transport and other health facilities factor, the second is to utilized the solar source of energy in electricity generation and the third one is to drive a new way to adopt green technology and computing system within the operating activities of a state. According to the researchers, governmental investment in the national road and the green infrastructure investment strategies will play an important role to reduce the emission of carbon dioxide gases within the growing state. they also suggested that in the environmental perspective, there is a need to reduce the airport infrastructure based investment that majorly pollutes the atmosphere with their dangerous gas emission (Karjunen et al., 2017; Kolosz et al., 2017; Pereira & Pereira, 2017; Zhang et al., 2018). After critically inspect the previous scholar's work on the related variables and their relationship, the following hypothesis has been suggested;

H4: Infrastructure has a significant impact on CO_2 emission in the Asian countries

3. Methodology

This section contains the information about the research design that the researcher has adopted to fulfill the purpose of the study i.e. to find out the impact of urbanization, research and development R&D expenditure, infrastructure development and real income on the emission of carbon dioxide in Asian countries. The details

regarding data collection method, model specification and various tools and approaches used in the current study have been elaborated in this section effectively.

3.1. Data and model

As discussed earlier, this study aims to find out the impact of four independent variables i.e. urbanization, R&D expenditure, infrastructure development and real income on CO_2 emission along with one control variable i.e. population density, the researcher has gathered data regarding all these variables from six Asian countries i.e. China, India, Pakistan, Turkey, Iran and Japan for the period of 23 years. This period starts from 1997 and ends 2019. This whole amount of data has been gathered from reliable and authentic resources or databases in order to ensure the quality of the collected data as well as the accuracy of the results obtained.

As far as the measurement units of the variables are concerned, the dependent variable i.e. CO_2 emission has been shown in the study by CO_2 and is measured in units of the percentage of total fuel combustion in the transport sector of that particular country. The first independent variable i.e. urbanization has been measured in context of the percentage of people in urban areas, and has been represented by URB. The next independent variable i.e. R&D expenditure has been measured in context of US dollars spent, and has been represented by RD. Another independent variable is infrastructure development, the measurement unit of which is US dollars spent and it has been denoted by ID. The last independent variable is real income. This variable is measured through GDP per capita in US dollars and is denoted through GDP. The only control variable of the study is population density having the measurement units of people present in per square kilometer area in that particular company. It has been shown by PD. In accordance with these variables, the researcher has generated the following equation or model for regression;

$$CO2_{it} = \alpha + \beta_1 URB_{it} + \beta_2 GDP_{it} + \beta_3 RD_{it} + \beta_4 ID_{it} + \beta_5 PD_{it} + \varepsilon_{it}$$

In the aforementioned equation, carbon dioxide is shown by CO_2, urbanization by URB, real income by GDP, R&D expenditure by RD, infrastructure development by ID, population density by PD and finally error term is shown by 'ε_{it}'.

3.2. Estimation procedure

After the data collection process, the next significant part of the study is to analyze that data through the use of appropriate tools and methods in order to obtain the desired results. In the current study, the collected data has been analyzed through cross sectional dependence test, panel unit root test, panel cointegration test and finally panel long run regression estimation test. The brief description of all these tests along with their way of use and importance has been discussed in this particular section.

3.2.1. Cross-sectional dependence

If the data collected is panel data, there might be possibility that the researcher may face some issues regarding the analysis of that data. One of the most important issues

in this regard is the presence of cross dependence and heterogeneity in the collected data. In addition, it has also been observed that the panel type of data has the ability to enhance the complication regarding the characteristics of the variables that are linked with macroeconomics. This data has higher extent of freedom and higher extent of variance too of it is compared with the other type of data i.e. time series data. In order to resolve all these issues and problems regarding panel data, the researcher has applied some contemporary techniques through which the aforementioned issues can be ignored during data analysis. However, in order to detect the presence of these issues, the researcher has initially conducted cross dependence test in this study (Pesaran, 2004).

3.2.2. Panel unit root tests

It is quite evident that the first step of panel data analysis must be to find out the order of integration of the collected data and also to determine the stationarity of the data, the panel unit root tests are commonly used for this purpose. In addition, this test also determines the nature of the series of collected data, whether it is permanent or temporary. However, as already discussed that panel data contain issues of cross dependence and heterogeneity, therefore the old or traditional unit root tests are of no use in this case because the use of those tests will not provide accurate and authentic results. This is the reason why the researcher has used ImPesaran Shin CIPS and cross section Augmented Dickey Fuller CADF tests for unit root in the current study. The advantage of using these tests in the study is that they provide accurate results in spite of the cross dependence and other issues of the collected data (Pesaran, 2007). Although, these two tests are used in the same way or through the same procedure, but it has been found out that CIPS test takes the average values from CADF test. The researcher has used the following equation for the aforementioned tests;

$$\Delta y_{i,t} = a_i + \rho y_{i,t} - 1 + \sum_{J=1}^{pi} a_J \Delta y_{i,t-J} + \varepsilon_{i,t}$$

3.2.3. Panel cointegration tests

After the confirmation of order of integration of the collected data, the next step is to find out whether there are any cointegrated relationships present among the variables of not. In this regard, various tests have been used in the past. Among the first generation tests, Pedroni, Kao and Johansen cointegration tests are included (Pedroni, 1999). On the other hand, the cointegration test by Westerlund (2007) is considered as the second generation cointegration test. Based on the presence of cross dependence, it was not possible to use the first generation tests because they would not be able to provide accurate results. Therefore, the second generation test has been preferred by the researcher. There are two types of statistics in this test i.e. Gs, Ga (group statistics) and Ps, Pa (panel statistics). The difference between these two types of statistics is that the panel statistics involve the error correction term while the group statistics have nothing to do with error correction (Danish & Wang, 2019). This test is based on the null hypothesis which indicates that there are no

cointegrated relationships among the variables. This test has been used in accordance with the following equation;

$$\Delta y_{it} = \delta_i d_t + \ a_i(y_{it-1} - \ \beta_i X_{it-1}) + \ \sum_{j=1}^{p_i} a_{ij}\Delta_{i,t-j} + \ \sum_{-q_i}^{p_i} y_{ij}\Delta_{i,t-j} + \ e_{it}$$

3.2.4. Panel long-run estimation

In order to estimate the impacts of independent and control variables on the dependent variable, the long run estimation test is generally used. The traditional tests such as random and fixed effects regression estimation as well as generalized estimation method of moments regression have not been used because of the same reason i.e. the issues of cross dependence and heterogeneity. So the use of aforementioned tests does not guarantee the accurate and reliable results of analysis. This is the reason why 'mean group' estimator MG has been used in the current study. This test suggests that the estimation of average population results in the different groups having distinct slopes and variances. Especially for long run estimation, MG estimation is essentially used because it provides consistent results if the time series is prolonged (Pesaran & Smith, 1995). The impact on one variable over the other in different countries that have been selected for the study can be estimated through this test. This estimation model can be represented by the following equation;

$$\Delta y_{i,t} = \ \sum_{j=1}^{p_i} aijyi, \ \ t-j + \sum_{j=0}^{q} \beta_{ij} X_{i,t-j} + \ \mu_i + \ \tau_t + \ e_{i,t}$$

In this equation, $Y_{it}$is the vector for dependent variable while$_{Xit}$is the vector for independent variables. 'i' shows the number of countries while 't' shows the number of years for which the data has been collected. In the last, '$e_{i,t}$' is the error term. In addition to MG estimation, the researcher also has used DK regression estimation, FMOLS, DOLS for further estimation of the impacts. All these approaches that have been used work well even in the presence of cross dependence and heterogeneity.

4. Results and analysis

4.1. Descriptive statistics

The descriptive statistics have been presented in the Table 1 which provides the useful information about the collected data. The table shows the minimum and maximum values of the data collected for all the variables. Based on the values, the mean values for each variable is calculated. In addition, the variance or deviation from the mean value also called as standard deviation has been given in the table. All the descriptive measures provide significant information about the collected data.

4.1.1. Cross-sectional dependence test

In order to find out the possibility of cross dependence, the researcher has conducted a test, the results of which have been reported in Table 2. It can be seen that the null

Table 1. Descriptive statistics.

Variables	Mean	SD	Min	Max
CO_2	0.672	0.875	0.392	4.301
URB	2.468	4.278	−0.411	16.04
GDP	1.923	1.238	0.811	5.833
PD	0.754	0.765	0.391	2.136
RD	5.69	2.754	1.006	8.951
ID	0.791	0.61	0.463	1.323

Source: authors source.

Table 2. Cross-sectional dependence test.

Test	Statistics	Significance
Breusch-Pagan LM	2381.3672**	0.0000
Pesaran-scaled LM	121.3768**	0.000
Pesaran CD	102.389**	0.0000

Source: authors source.

Table 3. Unit root test.

Constructs	CIPS		CADF	
	Level	1st diff.	Level	1st diff.
CO_2	−2.893	−4.984**	−2.178	−6.284***
URB	−2.277	−4.480**	−1.097	−10.389***
GDP	−2.173*	−6.597***	−0.379*	−9.174***
PD	−0.138	−4.483***	−9.983**	−19.289***
RD	−0.016	−5.278**	−7.386*	−14.288***
ID	−2.836*	−6.298***	−3.389*	−7.203***

Source: authors source.

hypothesis of all the tests conducted in this regard have been rejected as the significance value is highly in favor of this rejection. As the null hypothesis indicated that there is no cross dependence in the collected data and now if the null hypothesis is rejected, it can be stated that the data contains cross dependence.

4.2. Unit root test

The results of CIPS and CADF unit root tests have been presented in Table 3 of the study both for level series and first difference. It can be estimated that in case of CIPS, the level series has all the variables accepting the null hypothesis except real income and infrastructure development. However, all the variables have rejected the null hypothesis once the first difference is applied on them. The same is the case for CADF where all the variables in level section do not reject the null hypothesis but all of them reject it in first difference series. In a nutshell, it can be stated that in case of both CIPS and CADF, all the variables have rejected the null hypothesis of non stationarity of the data in first difference series and thus it can se concluded that the data is stationary in first series.

4.3. Penal cointegration – Westerlund test

The results of panel cointegration test for both, the group statistics and panel statistics has been presented in the Table 4 of the study. It can be deduced from the table that Gt, Pt and Pa statistics have rejected the null hypothesis of no cointegration.

Table 4. Penal cointegration – Westerlund test.

Statistics	G_t	G_a	P_t	P_a
Value	−3.284*	−5.827	−10.389**	−6.298**
Z value	−3.187	3.019	−5.389	0.936
P Value	0.000	1.000	0.000	0.0788
Robust Value	0.006	0.218	0.001	0.001

Source: authors source.

Table 5. Regression estimation.

	MG Estimator		FMOLS		DOLS		DK SE	
	Coef.	Sig	Coef.	Sig	Coef.	Sig	Coef.	Sig
URB	0.223**	0.022	0.385***	0.000	0.263**	0.003	0.342***	0.000
GDP	0.384***	0.00	0.327***	0.000	0.270**	0.005	0.243**	0.004
PD	0.226**	0.031	0.237**	0.006	0.467***	0.000	0.193**	0.049
RD	0.183**	0.023	0.223*	0.027	0.364***	0.000	0.274	0.047
ID	0.073	0.284	0.063	0.0125	0.153*	0.048	0.046	0.957

Source: authors source.

However, Ga statistics has not rejected it. As most of the statistic values have rejected the null hypothesis, it can be concluded that there are cointegrated relationships among the variables of the study.

4.4. Regression estimation

In the last, the regression estimation for MG, FMOLS, DOLS and DK estimation results have been reported in the Table 5. Let them discuss one by one. As per MG estimator, all the variables have significant and positive impact on CO_2 emission but infrastructure development has insignificant impact. The CO_2 emission is supposed to enhance by 22.3% and 38.4% with one percent increase in urbanization and real income respectively. In the similar way, CO_2 emission is supposed to increase by 22.6% and 18.3% with one percent increase in population density and R&D expenditure respectively. In case of FMOLS, again all the variables have significant and positive impact on CO_2 emission but infrastructure development has insignificant impact. The CO_2 emission is will be enhanced by 38.5% and 32.7% with one percent increase in urbanization and real income respectively. In the similar way, CO_2 emission will be increased by 23.7% and 22.3% with one percent increase in population density and R&D expenditure respectively. However, in case of DOLS, all the variables have shown significant impact on CO_2 emission. The CO_2 emission is supposed to increase by 26.3% and 27% with one percent increase in urbanization and real income respectively. In the similar way, CO_2 emission will enhance by 46.7%, 18.3% and 36.4% with one percent increase in population density, R&D expenditure and infrastructure development respectively. In the last, DK estimator indicates that urbanization, real income and population density have significant and positive impact on CO_2 emission but R&D expenditure and infrastructure development has insignificant impact. In other words, CO_2 emission will increase by 34.2%, 24.3% and 19.3% with one percent increase in urbanization, real income and population density respectively.

5. Discussion and conclusion

5.1. Discussion

The underlying purpose of this study was to developing a research that can predict how the sampled Asian countries can take a step toward developing environmental sustainability for the purpose of which the researcher has used the emission of carbon dioxide as endogenous variable and real income, urbanization, transport infrastructure and research & development are taken as exogenous variables while population has been used as a control variable. For measuring the emission of CO_2, percentage of total fuelcombustion is considered, while the real income has been calculated in terms of the GDP per capita, Urbanization is measured in terms of number of people that have moved from rural to urban areas and R&D in terms of expenditure on R&D from the total GDP. The transport infrastructure is measured as the amount of goods that are transported within a particular network by using domestic transport, and this is called freight transport.The results of the regression analysis has shown that all the variables have significant impacts on either reducing or increasing emission of CO_2 except of freight transport. The impact of real income and urbanization is positively significant i.e. they have shown to increase the emission of CO_2 in the environment whereas the impact of research and development is negatively significant i.e. it has shown to have a decreasing impact on the emission of CO_2. Similar results have been observed in prior research. R&D related results are supported by the research by Kahouli (2018) who found that in the Mediterranean countries, during the time period of 1990–2016, the investment on R&D had negative effects on the emission of CO_2. Fernández et al. (2018) also found R&D expenditures to have decreasing impact on emission of CO_2 EU and the US. There are conflicting reports for impact of real income on pollution as some studies find the impact insignificant (Saint Akadiri et al., 2019) while others find it to be increasing and significant (Dogan & Ozturk, 2017; Lu et al., 2017). Urbanization has been linked with pollution in multiple researches previously (Mikayilov et al., 2017; You, 2016; Yuan, 2019). Zhang et al. (2020) also found that transport infrastructure does not have significant role in CO_2 emission increase or decrease. Therefore, the results of this research are verifiable and reliable according to the past research.

6. Conclusion

The objective of this study is to determine the effect of real income, urbanization, R&D and transport infrastructure on the emission of carbon dioxide by keeping the population as a control variable for a panel of 6 Asian countries i.e. China, Turkey, Pakistan, India, Japan and Iraq, using data from 1997 to 2019. The researcher has made use of advanced long-run MG estimation approach for panel data analysis, and FMOLS, DOLS,and DK standard error regression methods to make sure that the model is robust. The results depict that the real income significantly causes an increase in the emission of CO_2 in the sampled countries. R&D has a reducing impact on the emission of CO_2. Similarly, the trends of increased urbanization in these countries has also been identified as a factor that contributes to the increase of

pollution, especially emission of CO_2. The transport infrastructure, however shows no significant role in increasing or decreasing emission of CO_2. The findings of this research have been outlined below:

- The impact of real income (GDP) and urbanization was found to be increasing and significant for the CO_2 emissions. This can be explained in light of the fact that the increase of real income and the population increase in the cities is accompanied by increased economic and social activities to cater for the increasing GDP and henceforth, contributing in the increase of energy demands. The increases energy demand puts a toll on the environment as the increase in usage of fossil fuels leads to increase of pollution in the air and especially in the increase of CO_2 emissions. Moreover, increased income is also responsible for increase in the emissions of CO_2 from transport. In the sampled Asian countries, it can be summarized that as the real income increases, more goods are purchased and more people are moving towards the cities, i.e. increased urbanization, for the purpose of gaining access to the facilities of education and health, leading to an increase in demands of transportation.
- The research has shown that the impact of transport infrastructure in terms of freight transport is insignificant on CO_2 emissions, so it can be summarized that the environmental conditions of the Asian countries is not deteriorated by transport. However, in the future, as the urban population is increased and the economic activities increase, the demand and need for transport increases, there might be significant concerns for the society in term of pollution by transport.
- R&D has a negative and significant coefficient implying that R&D lowers the emission of CO_2 in the Asian countries. Therefore, it can be said that the immediate action that needs to be taken towards environmental sustainability achievement in Asia is to invest the resources in R&D in every industrial sector, especially the transport sector. Moreover, motivating the public towards usage innovative green resources of energy is also a viable step in this direction.

7. Implications

There are several theoretical implications of this study. First of all, it provides a theoretical and literary basis of discussion regarding the factors contributing to pollution in the Asian countries and how can sustainability be achieved. This knowledge can be used by future researchers, academics and practitioners to enlighten themselves. Moreover, this study contributes to practical application by allowing the readers gain insight about econometric modeling and testing, which they can use and adapt the models of their own studies. The policy makers can deduce form this study that increasing population in the Asian countries can lead to worsening the environmental qualities. Therefore, the study implies that the policymakers should design policies that can lead to creation of awareness regarding efficient energy usage in the urban areas. Moreover, the industry practitioners should consider designing and launching vehicles that use efficient sources of energy and do not contribute to pollution. This will lead to making the transport sector friendly towards the environment.

Additionally, the governments in these countries should work towards discouraging the fossil fuel consumption in industrial sectors by imposing taxes and fines so that these sectors should shift towards efficient and renewable energy sources. The government and policymakers should consider the viability of usage of wind and solar energy in their respective countries, as these countries are usually warm and sunny, and should bring about revolutionary policies that encourage solar panel installation at mass levels in the urban as well as rural areas. The results have clearly shown the importance of R&D for the achievement of a sustainable environment, therefore, these countries should work towards increasing the expenditure in R&D and the policies should be to invest time and resources into installation and creation of renewable energy and green innovation.

8. Limitations and future research recommendations

There are a few limitations of this research that can help define future research scope in this area of study. The current research has only focused on one dimension of pollution i.e. CO_2 emission. The future researchers should look into other air pollutants and what factors determine them. Moreover, this research has been conducted using the longitudinal approach for the time frame of 1997–2019. The future researchers can improve the accuracy in the results by confirming them through cross-sectional researches considering the same theoretical model and by expanding the data time frame to get more accurate results in econometric models. Moreover, the data has been collected from six Asian countries, all of whom are in developing stages. There is need for the future researchers to test the validity of these results in developed countries as well so research can be conducted taking some European developed nations or any other regions that are more developed in economic and technological terms.

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