Environmental pollution in Asian economies: Does the industrialisation matter?

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Abstract

Industrialisation is a significant part of any country’s economic development. This study discusses the relationship between industrialisation and carbon dioxide emissions for Asian economies. The industrialisation has a major impact on carbon emissions, but its relationship with the environment differs in various regions of Asia. The empirical results are obtained by models of panel regression, which divide a balanced panel dataset of 46 countries into five groups depending on their subregions over the period 1991–2017. The tests of panel cointegration estimation found a majority of the cointegrated variables and verified the long-run relationship between the variables. The long-run coefficients are estimated using a fully modified ordinary least-squares (FMOLS) method, and results conclude that industrialisation has a positive impact on the carbon dioxide emissions in the long run. These findings reveal that various industrialisation development strategies should be pursued in a bid to reduce emissions, depending on the levels of economic growth. Based on the findings, some policy suggestions are proposed for Asian economies.

1. Introduction

Low environmental maintenance has brought back the significance of environmental friendliness throughout the globe during the last few centuries. Nevertheless, the thirst for economic and financial development has led to severe environmental degradation. Rapid industrialisation and urbanisation have developed enormous environmental difficulties, particularly in terms of energy consumption and carbon emissions. The industrial revolution pushed urbanisation and industry settlement as the main routes to social and economic restructuring. These paths, however, encourage the fast increase of consumption of fossil fuel and yield important quantities of CO2 and other emissions of greenhouse gasses. The developing countries, caused by fast economic growth, have
experienced fast-paced urbanisation and industrialisation since the 1970s. These procedures also go hand in hand with the rapidly rising demand for fossil fuels and CO_2 emissions.

In 1997, an international treaty was implemented known as the Kyoto Protocol, in which states ratified the greenhouse gas emission reduction on the grounds of scientific analysis, in line with attempts taken to improve the worldwide environment. More specifically, the advanced nations have been called upon to make about 5.2% of their greenhouse gas emissions relative to 1990 levels. The United Nations Framework Convention on Climate Change (UNFCCC) also suggests a regional decrease, with European nations, for example, recommended to decrease their emissions by 8%, while the suggestion was made for Canada and Japan to decrease their emissions by 6%. From 2008 to 2012, the first commitment was made, and the Doha amendment was envisaged for 2013–2020 as an expansion of the Kyoto Protocol. European countries are committed to a reduction of 5%, while the underlying span of 15% of the overall CO_2 emission reduction is projected compared to the 1990 basic year. Although these are wonderful steps towards a better environment, some states are still not showing much interest in these measures.

As the intergovernmental panel on climate change report (Coninck et al., 2005) shows, emissions have increased by approximately 80 per cent, from 21 to 38 gigatonnes (Gt) between 1970 and 2004. New growing evidence suggests that significant emission accumulation from human activity’s use of non-renewable energy is the primary driver of worldwide warming, which could lead to a global climate disaster. Developed countries have made the most emission sessions in the past and presently produce elevated emissions per capita, but pursuing economic growth implies that developing nations will generate the majority of future emissions in the world. Economic growth, although in the past, does not contain an intrinsic necessity for emitting higher quantities of greenhouse gas (GHGs). In the meantime, industrialisation and urbanisation trends also differ across areas (Zhang and Lin, 2012); carbon emissions are thus affected at both the general and per capita levels by regional characteristics. Research that only from a domestic perspective examines the effects of industrialisation on CO_2 emissions ignores the effects of regional variations and leads towards a partial estimate. The paper deals with the effects on global and regional CO_2 emissions of industrialisation in Asia.

A stream of literature has found the relationship of CO_2 emission with other factors like non-renewable energy consumption and environmental quality (Majeed and Luni, 2019; Çetin and Ecevit, 2017; Omri, 2013). A variety of air quality indices, such as CO_2, CH_4, SO_2 emissions, are taken into consideration to quantify environmental degradation (Borhan and Ahmed, 2012; Yasmeen et al., 2019). The CO_2 emission levels are directly linked to an economy’s manufacturing level and take the statistically positive association of manufacturing levels with investment outflow (Adu et al., 2013; Abosedra et al., 2020).
2015; Hafeez et al., 2018; Shah et al., 2019). A shift in the global financial development growth rate of 52.41 per cent of global GDP in 2016 is noted by World Bank (2016). To start up the new projects to meet optimum investment and equipment demand, financial development should be tackled.

Throughout previous research, contradictory findings have been observed, due to changes in methodology and data, but (Boutabba, 2014; Farhani and Ozturk, 2015; Dogan and Seker, 2016; Ozatac et al., 2017) also indicate different influences on emissions in various stages of development. Therefore, with this background, the key purpose of this study is to explore the influence of industrialisation on the environmental quality of Asian economies. Despite numerous kinds of literature, the role of this study is noteworthy in the following ways. Firstly, according to our best knowledge, this is the pioneer study that empirically investigates the impact of industrialisation on environmental quality in the Asian region. Additionally, the study implied second-generation tests to examine the effect of incorporated determinants on environmental quality in Asia. Secondly, cointegration among the variable is determined through the Westerlund panel cointegration test. Thirdly, the study analysed the long-run relationship between the variables using the fully modified OLS technique. Furthermore, this study uses panel time series regression models of 46 Asian countries as the Asian region is not focused on the literature. The existing literature in the Asian region is augmented by these new methods and analytical results.

The rest of the paper is organised as follows: the literature review is presented in Section 2. The empirical model, data and methodology are described in Section 3. Section 4 describes the results and discussion, and Section 5 provides conclusions and policy outcomes.

2. Literature review

A stream of literature examines the connection between industrialisation and CO$_2$ emissions. Hossain (2011) used a panel of nine industrialised countries for the period 1971–2007 to find the impact of industrialisation and urbanisation on the CO$_2$ emissions. Similarly, Poumanyvong and Kaneko (2010) also investigated the effect of industrialisation and environmental degradation by using the STIRPAT model. Cherniwchan (2012) exposed that a 1% increase in industry share will lead to an increase of 11.8% in the emissions per capita by using sulphur emission data for 157 countries over the period 1970–2000. Nejat et al. (2015) examined the link between industrialisation and carbon emissions for the top ten most CO$_2$-emitting countries (China, India, the United States, Japan, Russia, South Korea, Germany, Canada, the UK and IR Iran). If proper policies are adopted regarding energy usage, then it will be more helpful in the mitigation of CO$_2$ emissions and also increasing the development level of the country. Asane-Otoo (2015)
also found a significant positive impact of industrialisation on CO\textsubscript{2} emissions in middle-income countries by introducing input–output modelling.

In MENA countries, Al-Mulali and Ozturk (2015) found the combined effect of urbanisation and industrialisation on environmental degradation by using ecological footprint as an indicator of environmental quality. Urbanisation and industrialisation have a significant influence on carbon emissions. Some studies use the environmental Kuznets curve (EKC) framework to evaluate the relationship between urbanisation and CO\textsubscript{2} emissions. Since 2007, the top ten most CO\textsubscript{2}-emitting countries are being analysed, and among them, China is becoming the largest CO\textsubscript{2} emitters in the world. Lin et al. (2009) also investigated the relationship between industrialisation and GHG emissions in China. They found a positive impact of industrialisation and GHG emissions. For the era 1995–2009, Zhou et al. (2013) analysed China’s provincial panel data and found that industrialisation and urbanisation are the basic factors that increase carbon emissions. Tian et al (2014) stated that heavy manufacturing is the source of CO\textsubscript{2} emissions at the domestic level. Xu and Lin (2015) discovered an inverted non-linear U-shaped relationship in the three districts of China between industrialisation and carbon emissions.

Recently, the impacts of industrialisation on carbon emissions have been widely discussed over the decades in the entire sector or at the level of certain industries. Previous work in the context of industrialisation and CO\textsubscript{2} emissions mainly focused on the nexus at the general industrial level, while various manufacturing subsectors are neglected (Garcia and Sperling, 2010; Shahbaz and Lean, 2012; Shahbaz et al., 2014). A further consideration for this problem, for example, Akbostanci et al. (2009) discovered that changes in carbon emissions in Turkey were determined by the manufacturing industry. Parallel results have been found by Shrestha et al. (2009) in the electricity generation sectors of Asia–Pacific and North American countries; four Latin American countries (Ruiz-Mendoza and Sheinbaum-Pardo, 2010); European industry (Pardo et al., 2011); Mexican manufacturing industries (González and Martínez, 2012; Sheinbaum-Pardo et al., 2012); and EU27 iron and steel industry (Moya and Pardo, 2013). However, previous literature offered a non-linear connection between industrialisation and CO\textsubscript{2} emissions. Shahbaz et al. (2014), for instance, evaluated the effect of industrialisation on carbon emissions in Bangladesh using the ARDL model and discovered the presence of EKC between industrial growth and CO\textsubscript{2} emissions.

Research on this topic is receiving broad attention with rapid urbanisation and industrialisation growing pressure to preserve energy and decrease emissions in China. From a general sector view, Li and Xia (2013) and Zhou et al. (2013) found that one of the most significant variables influencing China’s CO\textsubscript{2} emissions was industrialisation. Heavy industrialisation, low energy efficiency and lack of environmental awareness are also attributable to these emissions. Furthermore, from a particular industrial sector view, more studies researched the connection between industrialisation and CO\textsubscript{2} emissions.
(Sun et al., 2011; Ke et al., 2012; Xu et al., 2012) and discovered a favourable connection. Share of heavy industry in the overall industry rises from 71.52% to 77.12% from 2004 to 2012 and less development in the energy-saving technology (Jiang and Lin, 2012); it is sure that heavy industry like iron, steel and cement sector will determine China’s CO₂ emissions. While Wen et al. (2014) and Ullah et al. (2020) stated that heavy industry increases carbon emission in the short term while a decrease in the long term due to the development of energy-saving technology. Thus, the empirical literature suggests positive as well as negative effects of industrialisation on carbon emission. In this regard, this study adds to the literature by exploring the result of industrialisation on carbon emission in Asian economies. The detailed summary of the existing studies is given in Table 1.

3. Methodology and data

Our current world is in numerous ways the product of industrialisation. There is a general argument that industrialisation is an integral part of the economic growth in developing and developed economies. It was the industrialisation that sustained productivity and economic growth, reduced poverty and improved the well-being of economic agents, exactly as occurred in Japan, South Korea, Taiwan, the United States and Europe in the 19th and 20th centuries. However, numerous studies in literature deal with the positive impact of industrialisation on environmental pollution (Shahbaz and Lean, 2012; Xu and Lin, 2015, and Liu et al., 2018). These studies also infer that industrialisation and reindustrialisation triggered carbon emissions. The purpose of this paper is to find out the relationship between industrialisation and CO₂. Therefore, a basic framework of industrialisation and CO₂ is based on the model of Liu et al. (2018) and Anwar et al. (2019).

\[
CO₂ = f(\text{IND}, \text{GDP}, \text{EC}, \text{UP})
\]  

(1)

where CO₂, IND, GDP, EC and UP stand for CO₂ emissions, industrialisation, GDP per capita, energy consumption and urban population, respectively. The above relationships between dependent and independent variables can be formulated in the form of a panel equation as follows.

\[
CO₂_{it} = \alpha_0 + \alpha_1 \text{IND}_{it} + \alpha_2 \text{GDP}_{it} + \alpha_3 \text{EC}_{it} + \alpha_4 \text{UP}_{it} + \epsilon_{it}
\]  

(2)

where \(i\) denotes the countries 1, 2, 3…46, \(t\) denotes the time dimension (1980–2017), and \(\epsilon_{it}\) is the error term, which has zero mean and constant variance. Panel data mostly have cross-sectional dependency that leads to biased information (Yasmeen et al., 2018; Shah et al., 2019). Therefore, before applying the unit-stationarity test, we employed the
| Author(s)                      | Country/region | Time span     | Techniques            | Independent variables                                      | Outcome on CO2 emission |
|-------------------------------|----------------|---------------|-----------------------|------------------------------------------------------------|-------------------------|
| Zhang and Lin (2012)          | 99 countries   | 1975–2005     | FE, RE                | Industrialisation                                          | Positive                |
| Parikh and Shukla (1995)      | China          | 1995–2010     | ARDL                  | Industrialisation, GDP                                     | Positive                |
| Al-Mulali and Sab (2012)      | 92 countries   | 1975–2005     | FMOLS                 | Industrialisation                                          | Positive                |
| Asane-Otoo (2015)             | 45 African countries | 1980–2009     | FMOLS                 | Industrialisation, urban population                        | Positive                |
| Shahbaz et al. (2014)         | Bangladesh     | 1975–2010     | ARDL                  | Industrialisation                                          | Mixed                   |
| Shafiei and Salim (2014)      | 29 OECD countries | 1980–2011     | GMM, FMOLS            | Urban population                                           | Mixed                   |
| Al-Mulali and Ozturk (2015)   | 14 MENA countries | 1996–2012     | FMOLS                 | Industrialisation                                          | Positive                |
| Lin et al. (2009)             | China          | 1978–2006     | OLS                   | Urban population, GDP from industry                        | Positive                |
| Wang et al. (2013)            | China          | 1980–2010     | OLS, ridge regression | Industrialisation, urban population                        | Positive                |
| Xu and Lin (2015)             | China          | 1990–2011     | ARDL                  | Industrialisation, urban population                        | Mixed                   |
| Zhou et al. (2013)            | China          | 1995–2009     | SYS-GMM estimates     | Industrialisation, tertiary industry/secondary industry    | Negative                |
| Li et al. (2012)              | China          | 1990–2010     | OLS, ridge regression | Industrialisation, urban population                        | Positive                |
| Martínez-Zarzoso et al. (2007)| EU             | 1975–1999     | FE, RE, GMM           | Industrialisation, urban population                        | Positive                |
| Author(s) | Country/region | Time span | Techniques | Independent variables | Outcome on CO2 emission |
|-----------|----------------|-----------|------------|-----------------------|-------------------------|
| Zhang and Lin (2012) | China | 1981–2011 | OLS, ARDL | Industrialisation | Mixed |
| Ahuti (2015) | Developing countries | 2015 | Qualitative | Industrial revolution, electronics industry | Negative |
| Kavzo lu (2008) | Turkey | 1987-2002 | PCA, postclassification comparison | Industrialisation, urbanisation | Mixed |
| Lin et al. (2017) | 53 countries | 1991-2013 | FE, RE | Industrialisation, urbanisation level, urban employment-level | Mixed |
| Mudakkar et al. (2013) | Pakistan | 1975-2011 | Granger causality | Industrialisation, economic growth | Positive |
| Shahbaz and Lean (2012) | Tunisia | 1971-2008 | VECM, ARDL | Industrialisation, financial development | Positive |
| Wang et al. (2014) | China | 1995-2007 | OLS | Industrialisation, energy consumption | Mixed |
| Shahbaz and Farhani (2015) | China and India | 1971–2011 | Granger causality test results | Industrial production | Negative |
| Ziramba (2009) | South Africa | 1980–2005 | Toda and Yamamoto test–Engle and Granger approach | Industrial output, employment, energy consumption | Positive |
| Ewing and Rong (2008) | United States | 2001–2005 | Generalised variance decomposition–VAR | Industrial production index, employment, energy consumption | Mixed |
| Dhami et al. (2013) | India | | Environmental input–output analysis | Industrialisation | Negative |
| Tian et al. (2014) | China | 2002-2007 | Input-output analysis | Heavy industries | Negative |
| Tian et al. (2014) | China | 2000-2011 | OLS | Industrialisation, energy consumption | Mixed |
Pesaran CD test (2004). This test is effective when the sample size has large N and fixed T and can be calculated as follows:

\[ CD_p = \sqrt{\frac{2}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij} \hat{\rho}_{ij}^2} \to N(0,1) \] (3)

where \( \hat{\rho}_{ij} \) is the correlation coefficients and the null hypothesis is verified as \( \hat{\rho}_{ij} = 0 \) against \( \hat{\rho}_{ij} \neq 0 \). Pesaran (2007) proposes a new second-generation panel unit root test, which is better in its properties due to asymptotic assumptions and allowing for cross-sectional dependence. Pesaran's test proposes (ADF(p) regression by first differences of the individual and cross-sectional means of lagged levels time series which is indicated as cross-sectionally augmented Dickey–Fuller (CADF). The CADF cross-sectionally augmented regressions are specified as:

\[ \Delta y_{it} = \theta_i + \alpha_i y_{i,t-1} + \beta_i \bar{y}_{t-1} + \sum_{j=0}^{p} \gamma_{ij} \Delta y_{t-j} + \sum_{j=1}^{p} \delta_{ij} \Delta y_{i,t-j} + \varepsilon_{ij} \] (4)

where \( \theta_i \) is deterministic term, \( \bar{y} \) and \( \Delta \bar{y} \) are cross-sectional average at any period \( t \), and \( p \) denotes lag order. After applying CADF stat, the cross-sectional augmented IPS (CIPS) can be estimated as:

\[ CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \] (5)

where \( CADF = \) the t-statistic of the OLS estimates of \( \alpha_i \), indicated as (CADF). In the presence of dependence, Pedroni and Kao are not preferable. Therefore, we applied the Westerlund cointegration test (Westerlund, 2007) to establish the long-run bonding between considered variables. This test is based on two statistics that are group statistic (Gt) and panel statistic (Pt). Group statistic determines the presence of cointegration for at least one cross-sectional unit in the model, while panel statistic verifies the presence of cointegration in the panel as a whole. After finding the long-run evidence, we run the FMOLS. This test is effective to deal with the issue of endogeneity among the series and also mitigate the error terms (Shah et al., 2019). For the coefficient \( \alpha \), the panel FMOLS statistical computation is calculated as:

\[ \alpha = N^{-1} \sum_{i=1}^{N} \left( \frac{T}{\sum_{t=1}^{T} (y_{it} - \bar{y})^2} \right)^{-1} \left( \frac{T}{\sum_{t=1}^{T} (y_{it} - \bar{y})} \right) z_{it}^2 - T \eta \] (6)

Furthermore, we aspplied the causality test developed by Dumitrescu and Hurlin (2012) for a certain conclusion. Moreover, it considers heterogeneity dimensions.
For the period 1991–2017, a balanced panel dataset of 46 Asian countries (see Table 2) is selected. Based on the accessibility of information, the sample set and time are chosen. Asian region’s territories (subregion) were taken as an autonomous sample unit. The regional sample set includes the 46 countries of Asia, 5 Central Asia, 8 South Asia, 11 South-East Asia, 14 West Asia and 4 East Asia. The divisions of income consist of 13 high-income countries, 12 high-middle-income nations, 17 low-middle-income countries and 3 low-income countries. CO2 is evaluated using carbon dioxide emission in metric tonnes per capita, while GDP was quantified by GDP per capita (constant 2010 US$). The (EC) is measured by the energy intensity level of primary energy. Finally, UP and IND were evaluated by the urban population (% of the total population) and industrial value added (% of GDP), respectively. All indicators have been extracted from the database of the World Bank. The detailed description of the concerned variables and sources is given in Table 3.

4. Results and discussion

Before running the regression, we have applied some necessary econometric tools such as descriptive stat, correlation matrix, CD-stat, panel unit root and Wasteland cointegration tests. Stationary properties of the series have been determined via CIPS and CADF panel unit root tests developed by Pesaran (2007). To determine the cointegration among the concerned variables, we rely on the Westerlund cointegration tests. Then, fully modified OLS is employed to ascertain the long-run magnitude impact of the concerned variables.

5. Descriptive statistics

Table 4 shows the descriptive and correlation statistics of all the variables used in the study. Descriptive statistics show that CO2 emission has mean 7.0019, and the standard deviation is 10.2896. The standard deviation of the IND is 16.6949, while its mean value is 34.6816. GDP has the mean value of 11091.1, and standard deviation is 15721.7. While the mean value of the EC and UP is 7.07414 and 54.6387, and the standard deviation is 5.43858 and 25.362. Table 1 shows the correlation between the variables that are used in the model. To measure the strength and direction of a linear relationship between the two or more variables, correlation is used. Correlation ranges from −1 to +1. In this table, the correlation coefficient of industrialisation with CO2 emission is 0.3978, which shows positive relationship industrialisation and CO2 emission. Rest of all the variables also show a positive relationship with CO2 emission. All other correlations are given in Table 4.
6. Empirical outcomes

Basic panel data techniques like panel unit root and cointegration tests are not sufficient to find robust results in the existence of CD. Thus, to address this problem, current research used the CD test as a measure to find the cross-sectional dependencies. The CD test results described in Table 5 strongly deny the null hypothesis that countries are cross-sectionally independent. These results imply that countries are not fully independent in the context of industrial growth policies, urbanisations, energy consumption and environmental quality.

Therefore, CADF and CIPS are used to define the order of integration when dealing with cross-sectional issues of dependency. In Table 6, CADF and CIPS results propose that all underconsidered variables are integrated at the level or first difference, implying that panel regression estimators can be used to estimate short- and long-run estimates. The results of the Westerlund cointegration test are shown in Table 7. Panel and group statistics inferred that the cointegration exists in Asia, regional Asia.

The present study applied FMOLS to validate and estimate the reliable empirical results after verifying the long-run relationship between the variables concerned. FMOLS long-term findings are described in Table 8. The results from the FMOLS model show that industrialisation has a positive impact on carbon dioxide emissions in Asia. This implies that a high level of industrialisation can be a source of carbon emission. These results are also supported by Yao et al. (2019). These results imply that when the industrial sector progressively grows, then the demand for energy inputs such as oil increases, which emits the carbon gasses into the air. Moreover, it also creates massive wastage and pollutes the environment. This wastage also causes to pollute the

Table 2 List of a selected panel of Asian countries

| Afghanistan | China | Japan | Malaysia | Qatar | Turkey |
|-------------|-------|-------|----------|-------|--------|
| Armenia     | Cyprus| Jordan| Maldives | Russian| Turkmenistan |
| Azerbaijan  | Georgia| Kazakhstan | Mongolia | Saudi | UAE |
| Bahrain     | India | Korea, Rep. | Myanmar | Singapore | Uzbekistan |
| Bangladesh  | Indonesia | Kuwait | Nepal | Sri Lanka | Vietnam |
| Bhutan      | IR Iran, Islamic Rep. | Kyrgyz Republic | Oman | Tajikistan | Yemen, Rep. |
| Brunei Darussalam | Iraq | Lao PDR | Pakistan | Thailand |
| Cambodia    | Israel | Lebanon | The Philippines | Timor-Leste |

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water system. This result also suggests that polluted countries mostly rely on heavy industries. Reindustrialisation is the economic process completed by non-renewable energy, which is a larger source of carbon emissions in Asia. Energy intensity also has a positive impact on carbon emission in the Asian region. More precisely, the GDP has a negative impact on the overall Asian region, South-East Asia and Western Asia, while it has a positive in the case of South Asia, East Asia and Central Asia.

In Table 9, the DH causality infers a bidirection causality between industrialisation and CO₂ in Asia, Western Asia, South-East Asia, South Asia and East Asia, respectively, while one-way causality in Central Asia from industrialisation to CO₂. In Table 10, empirical results in the Asian regional analysis suggest that industrialisation has a positive impact on carbon emissions in 30 countries. While three countries (IR Iran, Table 3 Variable definition and sources

| Variable                  | Symbol | Measure                                           | Source                      |
|---------------------------|--------|---------------------------------------------------|-----------------------------|
| Carbon dioxide emissions  | CO2    | CO₂ emissions (metric tonnes per capita)          | World Bank (2019)           |
| Industry, value added     | IND    | Industrial value added (% of GDP)                 | World Bank (2019)           |
| Gross domestic product    | GDP    | GDP per capita (constant 2010 US$)                | World Bank (2019)           |
| Energy consumption        | EC     | Energy use (kg of oil equivalent per $ 1000 GDP)  | World Bank (2019)           |
| Urban population          | UP     | Share of urban residents in total population      | World Bank (2019)           |

Table 4 Descriptive statistics and correlation

| Asia | CO2  | IND  | GDP  | EC   | UP   |
|------|------|------|------|------|------|
| Mean | 7.0019 | 34.6816 | 11091.1 | 7.07414 | 54.638 |
| Std. Dev. | 10.289 | 16.6949 | 15721.7 | 5.43858 | 25.362 |

Correlation matrix

|       | CO2   | IND   | GDP   | EC    | UP    |
|-------|-------|-------|-------|-------|-------|
| CO2   | 1     | 0.3978 | 0.8077 | 0.0221 | 0.6471 |
| IND   | 0.3978 | 1     | 0.2447 | -0.003 | 0.2177 |
| GDP   | 0.8077 | 0.2447 | 1     | -0.1895 | 0.7244 |
| EC    | 0.0221 | -0.003 | -0.1895 | 1     | -0.0938 |
| UP    | 0.6471 | 0.2177 | 0.7244 | -0.0938 | 1     |
Mongolia and Myanmar) have a negative significant effect on carbon emissions. The possible reason is their environmental rules and regulations are strict and they are not emitting carbon. Another reason is industry sectors are less contributed to the economy; this implies that deindustrialisation has a negative impact on carbon emissions. This result also infers that these countries mostly rely on the soft industry which is not a source of pollution. Moreover, environmental degradation increases because GDP per capita increases in 36 countries, while environmental degradation is decreasing in 5 countries. Therefore, in 5 cases it has no environmental impact. Empirical results indicate that the urban population has a positive impact on environmental degradation in 28 countries, negative impact in 14 countries and neutral effect in 4 countries, respectively.

Based on these results, the long-term regional forecast indicates that industrialisation has an important role in the deterioration of the environment. Green finance is, therefore, an environmentally friendly solution. Strict monetary policy and carbon tax can help to reduce risks to the environment. Industrialisation raises environmental degradation in 30 countries, representing increasing emission economic activities. In order to ease environmental degradation through green financing incentives, sustainable environmental policies are required. The highly monotonous existence of these countries suggests they need to pay attention to business and the environment. Governments and policymakers will concentrate on green funding for climate and environmental research in the sense of Asian country and regional politics. Therefore, when making decisions on industrialisation and financial development, environmental factors are the main concern. Also, in the current study, energy aspects are included. That is also positive for 41 countries and neutral for 4 countries, though negative for one country (UAE).

This study investigated the Asian region and its subregions (South-East Asia, East Asia, South Asia, south-west Asia and Central Asia). This study finds positive and negative impacts in these regions. For the South-East Asian region, the urban population and GDP per capita show negative impacts in some countries (Brunei, Indonesia, Malaysia, Myanmar, Philippine, Singapore and Thailand). For the East Asian region, urban population and industrialisation show negative impacts in China, Japan and Mongolia. For the south-west Asian region, industrialisation and urban population show a negative impact in Iraq, Israel, Kuwait, Oman and Qatar. For the South Asian region, all the variables show positive impacts. For the Central Asian region, the urban population has a negative impact.

7. Conclusion and policy implications

The paper empirically examined the effects of industrialisation on carbon emissions by using panel data covering 46 countries. The samples are divided into five categories
Table 5 CD test results

| Region       | CD-stat | Average absolute value of the off-diagonal elements | CO₂       | IND       | GDP       | EC        | UP        |
|--------------|---------|------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|
| Asia         | CD-stat |                                                      | 16.571*** | 12.235*** | 9.832***  | 10.866**  | 13.159*** |
|              |         |                                                     | 0.464     | 0.451     | 0.586     | 0.500     | 0.712     |
| Western Asia | CD-stat |                                                      | −11.953*** | 6.515***  | 2.248**   | −2.070**  | 5.416***  |
|              |         |                                                     | 0.473     | 0.444     | 0.375     | 0.384     | 0.523     |
| South-East   | Asia    |                                                      | −9.030*** | 0.394     | −6.751*** | −2.338*** | −7.457*** |
|              |         |                                                     | 0.738     | 0.444     | 0.535     | 0.459     | 0.932     |
| South Asia   | CD-stat |                                                      | −9.589*** | −8.393*** | −0.409    | −17.519*** | −12.127** |
|              |         |                                                     | 0.735     | 0.397     | 0.499     | 0.842     | 0.641     |
| East Asia    | CD-stat |                                                      | −10.069*** | 14.073*** | −11.636*** | −12.750*** | 5.583***  |
|              |         |                                                     | 0.386     | 0.767     | 0.392     | 0.707     | 0.591     |
| Central Asia | CD-stat |                                                      | −4.845*** | 2.941**   | 3.152**   | −2.280**  | −3.250**  |
|              |         |                                                     | 0.414     | 0.256     | 0.344     | 0.442     | 0.641     |

Note: Null hypothesis: no cross-sectional dependence, level of significance is \( ***P < 0.01, **P < 0.05, *P < 0.1 \).
|                | CIPS          |         |          | CIPS          |         |          |
|----------------|---------------|---------|----------|---------------|---------|----------|
|                | Level         | Diff    | Decision | Level         | Diff    | Decision |
| **Asia**       |               |         |          |               |         |          |
| CO₂            | 8.4492        | -14.6516*** | I (1)    | 3.4720        | -13.4420*** | I (1)    |
| IND            | 2.0979***     | -17.1515*** | I (0)    | -2.5883       | -16.2113*** | I (1)    |
| GDP            | 9.1967        | -13.7963*** | I (1)    | 5.1848        | -13.8065*** | I (1)    |
| EC             | 3.3744        | -16.2892*** | I (1)    | 1.4925        | -16.1627*** | I (1)    |
| UP             | 4.3788        | -26.4439*** | I (1)    | 2.5838        | -0.2400**  | I (1)    |
| **Western Asia** |             |         |          |               |         |          |
| CO₂            | -0.9348       | -9.7008*** | I (1)    | 0.2451        | -9.5627*** | I (1)    |
| IND            | -1.9603       | -8.7705*** | I (1)    | -0.3970       | -8.1065*** | I (1)    |
| GDP            | 0.7251        | -9.2727*** | I (1)    | -0.1433       | -8.8242*** | I (1)    |
| EC             | -1.3184       | -10.3146*** | I (1)    | -1.8610       | -13.0250*** | I (1)    |
| UP             | 2.3313        | -1.0023  | I (1)    | -0.0900       | -1.1730   |          |
| **South-East Asia** |           |         |          |               |         |          |
| CO₂            | 9.0546        | -6.6651*** | I (1)    | 4.7728        | -6.2252*** | I (1)    |
| IND            | 0.6066        | -8.2862*** | I (1)    | 1.4924        | -6.5400*** | I (1)    |
| GDP            | 5.5631        | -5.9223*** | I (1)    | 4.2208        | -6.9683*** | I (1)    |
| EC             | 2.7604        | -5.7757*** | I (1)    | 1.1160        | -3.6990*** | I (1)    |
| UP             | 0.6789        | 1.0311*  | I (1)    | 0.9980        | 1.5352*   | I (1)    |
| **South Asia** |             |         |          |               |         |          |
| CO₂            | 10.2079       | -5.6879*** | I (1)    | 3.5934        | -1.7858**  | I (1)    |
| IND            | -0.0882       | -7.6601*** | I (1)    | 0.1794        | -7.9876*** | I (1)    |
| GDP            | 7.6705        | -5.6014*** | I (1)    | 3.9061        | -5.1879*** | I (1)    |
| EC             | 2.0776        | -8.1145*** | I (1)    | 2.4868        | -7.5274*** | I (1)    |
| UP             | 7.4227        | 3.5634*  | I (1)    | 2.5661        | 0.0927*   | I (1)    |
| **East Asia**  |             |         |          |               |         |          |
| CO₂            | 2.2566        | -2.8357*** | I (1)    | -0.3733       | -2.6002*** | I (1)    |
| IND            | -0.3556       | -5.1376*** | I (1)    | 0.0182        | -4.9092*** | I (1)    |
| GDP            | 1.1267        | -4.0748*** | I (1)    | 1.3023        | -4.6546*** | I (1)    |
| EC             | 1.4190        | -4.0449*** | I (1)    | 1.9806        | -3.6673*** | I (1)    |
| UP             | 2.6852        | -0.1679*  | I (1)    | -0.6567       | -0.9871**  | I (1)    |
| **Central Asia** |           |         |          |               |         |          |
| CO₂            | -1.0578       | -4.5975*** | I (1)    | -0.1268       | -6.7245*** | I (1)    |
| IND            | -2.2053       | -5.8504*** | I (1)    | -5.1660       | -5.7996*** | I (0)    |
| GDP            | 5.0900        | -4.0390*** | I (1)    | 2.4610        | -4.0747*** | I (1)    |
| EC             | 1.5152        | -6.1024*** | I (1)    | -0.0566       | -5.1081*** | I (1)    |
| UP             | 1.8054        | 0.5064*** | I (1)    | 0.8888        | -1.1825*** | I (1)    |
based on the heterogeneity of the sample data. The results confirm that carbon emissions vary between different regions of Asia. Therefore, industrialisation and their impacts on the environment are positive in Asian countries. This finding indicates that industrialisation in various industrialisation processes has different effects on environmental degradation. As a country enters the postindustrialisation phase, knowledge-intensive industries develop rapidly and industrialisation reduces energy consumption. Also, industrialisation has a significantly positive impact on CO₂ emissions except for certain countries, and economic growth decreases, suggesting that industrialisation is an important source of carbon emissions. The links between urbanisation and carbon emissions are also positive in Asia.

Regarding policy, the effects of carbon dioxide emissions on varying levels of development and related industrialisation enable policymakers to formulate their

### Table 7 Results of Westerlund cointegration test

| Region        | Gt       | Ga       | Pt       | Pa       |
|---------------|----------|----------|----------|----------|
| Asia          | −5.249** | −2.079   | −18.825**| −13.022**|
| Western Asia  | −2.902   | −2.211   | −11.229**| −15.925**|
| South-East Asia | −4.567*  | −0.924   | −9.068** | −9.082   |
| South Asia    | −3.007*  | −2.649   | −4.794*  | −2.046   |
| East Asia     | −5.745** | −3.405*  | −5.863** | −3.121*  |
| Central Asia  | −5.504** | −4.136*  | −2.861   | −3.378*  |

Note: Null hypothesis: no cointegration; level of significance is ***P < 0.01, **P < 0.05, *P < 0.1.

### Table 8 FMOLS estimates

|                | Asia | Western Asia | South-East Asia | South Asia | East Asia | Central Asia |
|----------------|------|--------------|-----------------|-----------|----------|--------------|
| IND            | 0.06*** | 0.07*       | 0.07***         | 0.03***   | 0.23***  | 0.01         |
|                | (8.60) | (1.74)      | (4.21)          | (2.08)    | (4.11)   | (1.23)       |
| GDP            | -0.51*** | -0.16***   | -9.97***        | 0.80***   | 1.66***  | 7.36***      |
|                | (4.51) | (3.19)      | (8.72)          | (7.16)    | (9.77)   | (6.33)       |
| EC             | 0.50*** | 1.15***     | 0.23***         | 0.22***   | 1.10***  | 0.33***      |
|                | (4.83) | (3.98)      | (5.20)          | (5.72)    | (3.30)   | (5.95)       |
| UP             | 0.12*** | 0.05***     | 0.20***         | 0.26***   | 0.49*    | 2.07***      |
|                | (7.73) | (7.09)      | (4.90)          | (8.25)    | (-1.76)  | (-10.03)     |

Note: Level of significance is ***P < 0.01, **P < 0.05, *P < 0.1.
Table 9  Panel heterogeneous causality results

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| **Asia**       |           |           |           |           |           |
| CO2            | 9.120***  | 19.097*** | 20.484*** | 3.290     |           |
| IND            | 12.938****| 22.555*** | 22.641*** | 2.098     |           |
| GDP            | 13.329*** | 12.382*** | 17.258*** | 3.211     |           |
| EC             | 15.648*** | 10.429*** | 26.477*** | 5.432**   |           |
| UP             | 1.422     | 3.211     | 3.542**   | 1.355     |           |

**Western Asia**

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| CO2            | 15.667*** | 4.064***  | 3.911***  | 8.700***  |           |
| IND            | 10.285*** | 7.758***  | 5.907***  | 5.693***  |           |
| GDP            | 4.995***  | 4.994***  | 10.059*** | 8.558***  |           |
| EC             | 6.396***  | 1.960**   | 6.890***  | 17.475*** |           |
| UP             | 7.030***  | 7.278***  | 15.611*** | 12.946*** |           |

**South-East Asia**

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| CO2            | 6.859***  | 14.020*** | 21.471*** | 3.212     |           |
| IND            | 10.066*** | 7.621***  | 17.980*** | 2.132     |           |
| GDP            | 5.511***  | 7.292***  | 10.856*** | 1.453     |           |
| EC             | 9.849***  | 8.2295*** | 17.643*** | 4.544*    |           |
| UP             | 1.975     | 3.276     | 1.342     | 4.211*    |           |

**South Asia**

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| CO2            | 2.796***  | 8.254**   | 10.254*** | 21.053*** |           |
| IND            | 6.486***  | 3.906***  | 6.100***  | 9.668***  |           |
| GDP            | 13.037*** | 1.176     | 6.076***  | 26.224*** |           |
| EC             | 3.724***  | 5.597***  | 8.678***  | 17.853*** |           |
| UP             | 3.618***  | 12.995*** | 9.626***  | 8.030***  |           |

**East Asia**

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| CO2            | 2.930***  | 9.069***  | 1.860**   | 16.937    |           |
| IND            | 2.711**   | 5.785***  | 16.634*** | 3.863***  |           |
| GDP            | 7.378***  | 3.026***  | 8.678***  | 6.008***  |           |
| EC             | 9.143***  | 3.161***  | 6.297***  | 18.675*** |           |
| UP             | 1.349***  | 2.790**   | 2.012**   | 7.412***  |           |

**Central Asia**

|                | CO2       | IND       | GDP       | EC        | UP        |
|----------------|-----------|-----------|-----------|-----------|-----------|
| CO2            | 4.904***  | 4.536***  | 8.918***  | 1.755*    |           |
| IND            | 0.367     | 4.136***  | 9.744***  | 6.863***  |           |
| GDP            | 0.326     | 2.808**   | 0.942     | 3.974***  |           |
| EC             | 4.500***  | 0.168     | 11.593*** | 6.337***  |           |
| UP             | 8.004***  | 9.588***  | 9.842***  | 3.634***  |           |

Note: Null hypothesis; no causality, level of significance is ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$, respectively.
| Country          | IND Coefficient | S.E | GDP Coefficient | S.E | EC Coefficient | S.E | UP Coefficient | S.E |
|------------------|-----------------|-----|-----------------|-----|----------------|-----|----------------|-----|
| Afghanistan      | 0.11            | 0.10| 0.02            | 0.08| 0.14***        | 0.01| 0.04**         | 0.01|
| Armenia          | 0.03***         | 0.01| 0.88***         | 0.18| 0.05***        | 0.01| 0.19**         | 0.08|
| Azerbaijan       | 0.01            | 0.01| 2.29***         | 0.32| 0.31***        | 0.02| 0.18**         | 0.08|
| Bahrain          | 0.11            | 0.09| 30.96***        | 9.08| 1.85*          | 0.99| 1.25           | 2.33|
| Bangladesh       | 0.01            | 0.01| 0.21            | 0.25| 0.07*          | 0.05| 0.03*          | 0.02|
| Bhutan           | 0.01            | 0.01| 0.04            | 0.29| 0.31***        | 0.03| 0.33***        | 0.04|
| Brunei Darussalam| 0.31***         | 0.10| -6.69***        | 1.58| 0.08           | 0.40|-0.54*          | 0.34|
| Cambodia         | 0.02            | 0.03| 0.12***         | 0.01| 0.02***        | 0.01| 0.08***        | 0.01|
| China            | 0.13***         | 0.01| 10.96***        | 0.41| 0.59***        | 0.01|-0.4***         | 0.03|
| Cyprus           | 0.09***         | 0.02| 5.38***         | 0.11| 0.86***        | 0.06| 0.4***         | 0.02|
| Georgia          | 0.07**          | 0.03| 1.67***         | 0.26| 0.1***         | 0.01| 0.17***        | 0.05|
| India            | 0.03***         | 0.01| 1.48***         | 0.16| 0.32***        | 0.02| 0.11***        | 0.02|
| Indonesia        | 0.06**          | 0.02| 2.49            | 2.36| 0.35           | 0.49|-0.03           | 0.05|
| IR Iran, Islamic Rep. | -0.03***   | 0.01| 3.29***         | 0.34| 0.41***        | 0.05| 0.18***        | 0.01|
| Iraq             | -0.01           | 0.01| 1.38**          | 0.47| 0.11*          | 0.05| 0.53**         | 0.18|
| Israel           | 0.46***         | 0.11| 14.78***        | 3.02| -0.09          | 0.25|-6.25***        | 0.93|
| Japan            | 0.07***         | 0.02| 5.86***         | 0.74| 0.64***        | 0.07|-0.05**         | 0.02|
| Jordan           | 0.03***         | 0.01| 2.82***         | 0.09| 0.66***        | 0.02| 0.02***        | 0.01|
| Kazakhstan       | 0.02            | 0.03| 20.16***        | 1.46| 0.81***        | 0.05|-9.8***         | 1.08|
| Korea, Rep.      | 0.14***         | 0.04| 5.81***         | 0.57| 1.03***        | 0.13| 0.13*          | 0.08|
| Kuwait           | 0.01            | 0.02| 25.63***        | 6.04| 1.36           | 1.55|-0.52           | 1.33|
| Kyrgyz Republic  | 0.01            | 0.03| 1.97***         | 0.03| 0.17***        | 0.01|-0.13***        | 0.01|
| Lao PDR          | 0.31**          | 0.03| -0.02           | 0.04| 0.02***        | 0.00| 0.02***        | 0.01|
| Lebanon          | 0.06***         | 0.01| 2.08***         | 0.15| 0.38***        | 0.02| 0.08***        | 0.02|
| Malaysia         | 0.04***         | 0.01| 8.09***         | 0.61| 0.43***        | 0.06|-0.07***        | 0.02|
| Maldives         | 0.23***         | 0.02| 0.82**          | 0.34| 0.31***        | 0.10| 0.22***        | 0.02|
| Mongolia         | -0.85***        | 0.06| -9.99***        | 2.54| 2.13***        | 0.17| 2.28***        | 0.18|
| Myanmar          | -0.04***        | 0.01| 0.31***         | 0.03| 0.12***        | 0.01| 0.55***        | 0.01|
| Nepal            | 0.02***         | 0.01| 1.46***         | 0.09| 0.08***        | 0.02|-0.03***        | 0.01|
| Oman             | 0.10***         | 0.01| 13.54***        | 0.64| 1.88***        | 0.06|-0.08***        | 0.02|
| Pakistan         | 0.01            | 0.03| 1.21***         | 0.26| 0.26***        | 0.05| 0.01           | 0.01|
| The Philippines  | 0.01***         | 0.00| 1.33***         | 0.02| 0.27***        | 0.01|-0.08***        | 0.01|
| Qatar            | 0.39***         | 0.06| -6.02***        | 1.75| 6.07***        | 0.56| 3.88***        | 0.45|
| Russian          | 0.05**          | 0.02| 5.42***         | 0.81| 1.41***        | 0.10|-3.65***        | 0.19|

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on behalf of Organization of the Petroleum Exporting Countries

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country’s best-suited policies for saving energy and reducing emissions. The government should focus on clean and green energy consumption in industries by adding environmental rules for the unclean industries. The government should pay more attention to small-town industrial development by creating rural jobs and motivating environmental quality. Asian economies policymakers need to redesign their environmental and industrial policies.

References

Abosedra, S., Shahbaz, M. and Sbia, R., 2015. The links between energy consumption, financial development, and economic growth in Lebanon: evidence from cointegration with unknown structural breaks. Journal of Energy 1–16.

Adu, G., Marbuah, G. and Mensah, J.T., 2013. Financial development and economic growth in Ghana: Does the measure of financial development matter? Review of Development Finance 3, 4, 192–203.

Ahuti, S., 2015. Industrial growth and environmental degradation. International Education and Research Journal 1, 5–7.

Akboştancı, E., Türüt-Aşık, S. and Tunç, G.I., 2009. The relationship between income and environment in Turkey: is there an environmental Kuznets curve? Energy Policy 37, 3, 861–867.
Al-Mulali, U. and Ozturk, I., 2015. The effect of energy consumption, urbanization, trade openness, industrial output, and the political stability on the environmental degradation in the MENA (the Middle East and North African) region. *Energy* 84, 382–389.

Al-Mulali, U. and Sab, C.N.B.C., 2012. The impact of energy consumption and CO2 emission on the economic growth and financial development in the Sub Saharan African Countries. *Energy* 39, 180–186.

Anwar, A., Ahmad, N. and Madni, G.R., 2019. Industrialization, freight transport and environmental quality: evidence from belt and road initiative economies. *Environmental Science and Pollution Research* 1–18.

Asane-Otoo, E., 2015. Carbon footprint and emission determinants in Africa. *Energy* 82, 426–435.

Borhan, H.B. and Ahmed, E.M., 2012. Simultaneous model of pollution and income in Malaysia. *International Journal of Economic Perspectives* 6, 1, 1–21.

Boutabba, M.A., 2014. The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. *Economic Modelling* 40, 33–41.

Çetin, M. and Ecevit, E., 2017. The impact of financial development on carbon emissions under the structural breaks: empirical evidence from the Turkish economy. *Journal of Economic and Management Perspectives* 11, 1, 64–78.

Cherniwchan, J., 2012. Economic growth, industrialization, and the environment. *Resource and Energy Economics* 34, 4, 442–467.

Coninck, H., Loos, M., Metz, B., Davidson, O. and Meyer, L., 2005. *IPCC special report on carbon dioxide capture and storage*. Intergovernmental Panel on Climate Change.

Dhami, J.K., Singh, H. and Gupta, M., 2013. Industrialization at the cost of environment degradation—A case of leather and iron and steel industry from Punjab economy (Full Text).

Dogan, E. and Seker, F., 2016. The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews* 60, 1074–1085.

Ewing, R. and Rong, F., 2008. The impact of urban form on US residential energy use. *Housing Policy Debate* 19, 1–30.

Hafeez, M., Chunhui, Y., Strohmaier, D., Ahmed, M. and Jie, L., 2018. Does finance affect environmental degradation: evidence from One Belt and One Road Initiative region? *Environmental Science and Pollution Research* 25, 10, 9579–9592.

Hossain, M.S., 2011. Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy* 39, 11, 6991–6999.
Jiang, Z. and Lin, B., 2012. China’s energy demand and its characteristics in the industrialization and urbanization process. *Energy Policy* 49, 608–615.

Kavzolu, T., 2008. Determination of environmental degradation due to urbanization and industrialization in Gebze, Turkey. *Environmental Engineering Science* 25, 429–438.

Ke, J., Zheng, N., Fridley, D., Price, L. and Zhou, N., 2012. Potential energy savings and CO₂ emissions reduction of China’s cement industry. *Energy Policy* 45, 739–751.

Li, Y. and Xia, Y., 2013. DES/CCHP: The best utilization mode of natural gas for China’s low carbon economy. *Energy Policy* 53, 477–483.

Li, H., Mu, H., Zhang, M. and Gui, S., 2012. Analysis of regional difference on impact factors of China’s energy–Related CO₂ emissions. *Energy* 39, 1, 319–326.

Lin, S., Wang, S., Marinova, D., Zhao, D. and Hong, J., 2017. Impacts of urbanization and real economic development on CO₂ emissions in non-high income countries: empirical research based on the extended STIRPAT model. *Journal of Cleaner Production* 166, 952–966.

Lin, S., Zhao, D. and Marinova, D., 2009. Analysis of the environmental impact of China based on STIRPAT model. *Environmental Impact Assessment Review* 29, 6, 341–347.

Liu, J., Yuan, C., Hafeez, M. and Yuan, Q., 2018. The relationship between environment and logistics performance: evidence from Asian countries. *Journal of Cleaner Production* 204, 282–291.

Majeed, M.T. and Luni, T., 2019. Renewable energy, water, and environmental degradation: A global panel data approach. *Pakistan Journal of Commerce and Social Sciences* 13, 3, 749–778.

Martínez-Zarzoso, I., Bengochea-Morancho, A. and Morales-Lage, R., 2007. The impact of population on CO₂ emissions: evidence from European countries. *Environmental and Resource Economics* 38, 497–512.

Moya, J.A. and Pardo, N., 2013. The potential for improvements in energy efficiency and CO₂ emissions in the EU27 iron and steel industry under different payback periods. *Journal of Cleaner Production* 52, 71–83.

Mudakkar, S.R., Zaman, K., Khan, M.M. and Ahmad, M., 2013. Energy for economic growth, industrialization, environment and natural resources: living with just enough. *Renewable and Sustainable Energy Reviews* 25, 580–595.

Nejat, P., Jomehzadeh, F., Taheri, M.M., Gohari, M. and Majid, M.Z.A., 2015. A global review of energy consumption, CO₂ emissions and policy in the residential sector (with an overview of the top ten CO₂ emitting countries). *Renewable and Sustainable Energy Reviews* 43, 843–862.

Omri, A., 2013. CO₂ emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics* 40, 657–664.

Ozatac, N., Gokmenoglu, K.K. and Taspinar, N., 2017. Testing the EKC hypothesis by considering trade openness, urbanization, and financial development: the case of Turkey. *Environmental Science and Pollution Research* 24, 20, 16690–16701.

Pardo, N., Moya, J.A. and Mercier, A., 2011. Prospective on the energy efficiency and CO₂ emissions in the EU cement industry. *Energy* 36, 5, 3244–3254.
Environmental pollution in Asian economies

Parikh, J. and Shukla, V., 1995. Urbanization, energy use and greenhouse effects in economic development: results from a cross-national study of developing countries. *Global Environmental Change* 5, 87–103.

Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics* 22, 2, 265–312.

Poumanyvong, P. and Kaneko, S., 2010. Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis. *Ecological Economics* 70, 2, 434–444.

Ruiz-Mendoza, B.J. and Sheinbaum-Pardo, C., 2010. Electricity sector reforms in four Latin-American countries and their impact on carbon dioxide emissions and renewable energy. *Energy Policy* 38, 11, 6755–6766.

Shafiei, S. and Salim, R.A., 2014. Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: a comparative analysis. *Energy Policy* 66, 547–556.

Shah, W.U.H., Yasmeen, R. and Padda, I.U., 2019. An analysis between financial development, institutions, and the environment: a global view. *Environmental Science and Pollution Research* 26, 21, 21437–21449.

Shahbaz, M. and Lean, H.H., 2012. Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. *Energy Policy* 40, 473–479.

Shahbaz, M., Sbia, R., Hamdi, H. and Ozturk, I., 2014. Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. *Ecological Indicators* 45, 622–631.

Sheinbaum-Pardo, C., Mora-Pérez, S. and Robles-Morales, G., 2012. Decomposition of energy consumption and CO2 emissions in Mexican manufacturing industries: Trends between 1990 and 2008. *Energy for Sustainable Development* 16, 1, 57–67.

Shrestha, R.M., Anandarajah, G. and Liyanage, M.H., 2009. Factors affecting CO2 emission from the power sector of selected countries in Asia and the Pacific. *Energy Policy* 37, 6, 2375–2384.

Sun, W.Q., Cai, J.J., Mao, H.J. and Guan, D.J., 2011. Change in carbon dioxide (CO 2) emissions from energy use in China’s iron and steel industry. *Journal of Iron and Steel Research International* 18, 6, 31–36.

Tian, X., Chang, M., Shi, F. and Tanikawa, H., 2014. How does industrial structure change impact carbon dioxide emissions? A comparative analysis focusing on nine provincial regions in China. *Environmental Science & Policy* 37, 243–254.

Ullah, S., Ozturk, I., Usman, A., Majeed, M.T. and Akhtar, P., 2020. On the asymmetric effects of premature deindustrialization on CO2 emissions: evidence from Pakistan. *Environmental Science and Pollution Research* 27, 12, 13692–13702.

Wang, S., Fang, C., Guan, X., Pang, B. and Ma, H., 2014. Urbanisation, energy consumption, and carbon dioxide emissions in China: a panel data analysis of China’s provinices. *Applied Energy* 136, 738–749.

Wang, P., Wu, W., Zhu, B. and Wei, Y., 2013. Examining the impact factors of energy-related CO2 emissions using the STIRPAT model in Guangdong Province, China. *Applied Energy* 106, 65–71.

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Wen, Z., Meng, F. and Chen, M., 2014. Estimates of the potential for energy conservation and CO2 emissions mitigation based on Asian-Pacific Integrated Model (AIM): the case of the iron and steel industry in China. *Journal of Cleaner Production* 65, 120–130.

Westerlund, J., 2007. Testing for error correction in panel data. *Oxford Bulletin of Economics and Statistics* 69, 6, 709–748.

Xu, B. and Lin, B., 2015. How industrialization and urbanization process impacts on CO2 emissions in China: evidence from nonparametric additive regression models. *Energy Economics* 48, 188–202.

Xu, J.H., Fleiter, T., Eichhammer, W. and Fan, Y., 2012. Energy consumption and CO2 emissions in China’s cement industry: A perspective from LMDI decomposition analysis. *Energy Policy* 50, 821–832.

Yao, X., Yasmeen, R., Li, Y., Hafeez, M. and Padda, I.U., 2019. Free trade agreements and environment for sustainable development: a gravity model analysis. *Sustainability* 11, 3, 597–611.

Yasmeen, R., Li, Y., Hafeez, M. and Ahmad, H., 2018. The trade-environment nexus in light of governance: a global potential. *Environmental Science and Pollution Research* 25, 34, 34360–34379.

Yasmeen, R., Li, Y. and Hafeez, M., 2019. Tracing the trade–pollution nexus in global value chains: evidence from air pollution indicators. *Environmental Science and Pollution Research* 26, 5, 5221–5233.

Zhang, C. and Lin, Y., 2012. Panel estimation for urbanization, energy consumption, and CO2 emissions: A regional analysis in China. *Energy Policy* 49, 488–498.

Zhou, X., Zhang, J. and Li, J., 2013. Industrial structural transformation and carbon dioxide emissions in China. *Energy Policy* 57, 43–51.

Ziramba, E., 2009. Disaggregate energy consumption and industrial production in South Africa. *Energy Policy* 37, 2214–2220.