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# THE IMPACT OF STRUCTURAL TRANSFORMATION ON ENVIRONMENTAL POLLUTION: EVIDENCE FROM ASIAN COUNTRIES

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**ABSTRACT**

This paper examines the impact of structural transformation on environmental pollution in selected Asian countries for the years 1990–2015. This transformation decomposes into technological progress, structural changes, demographic changes and trade openness. We analyse the extended stochastic impacts by employing the regression on population, affluence, and technology (STIRPAT) model. Findings suggest that the industrialization process will induce increased environmental pollution, while the teritarization process lowers environmental pollution. Further, the results support the existence of an inverted-U curve between affluence level and $\mathrm{CO_2}$emissions and urbanization and $\mathrm{CO_2}$ emissions, implying that at a higher scale of the economy, environmental pollution decreases. Nevertheless, as the scale of the economy becomes large, environmental pollution cannot be counter balanced by the positive impact of tertiarization effect. In addition, we found an interesting result by accounting for a range of demographic dynamics; the results show that an increase in aging population contributes to carbon emission increment. This study not only sheds light on existing literature, but it also provides policy makers with insightful information on how to promote growth and sustainability development policies .

**Keywords:** Structural transformation, environmental pollution, technological progress, structural changes, demographic changes and trade openness Asian countries,population.

## 1.0 Introduction

Looking back in 1990, the nitrogen oxides fell significantly in Europe and projected to continue to decrease in Europe up to 2050, however in Asian it is still continued to grow (OECD, 2012) and moreover, to date it accounted for more than 50% of the global anthropogenic $CO_2$ emissions global anthropogenic (Behera and Dash,2017).As we look into the previous and recent global trends scale,$CO_2$ emissions grew by 58% between 1990 and 2014, nevertheless there has been a slowdown in annual growth rates of global $CO_2$ emissions since 2012as reported in "Trends in Global $CO_2$ emissions for 2016 Report" by Olivier *et al*., (2016). According to this report, this trend associates significantly with the structural change with a shift away from carbon-intensive activities and high value-added manufacturing industry, particularly in China and several Asian countries.

Historically, structural change said to influence the economic development in two ways. First, the structural transformation from agricultural to industrial production, which also known as industrialization process as an economy grows induced higher scale of production and cause pollution to rise (see Cherniwchan, 2012; Antoci *et al*.,2014; Nejat *et al.,* 2015). Second, the structural transformation from agricultural or industrial production to services sector which also known as tertiarization process promote an increase in the share of less polluting sectors in economies and reduce the pollution level. This theory basically based on Three-Sector Analysis [23] which stated that, as income rises, the economy moves from primary sector (agriculture-based) to the secondary (industrial-based), and the pollution level will increase. Afterward, when a country becomes more prosperous, the economy moves to the tertiary sector (services-based), environmental pollution should be decreased (Millimet, 2000; Linden and Mahmood, 2007; Dinda, 2004; Alam, 2015). Eurostat (2014) reported that this situation happens as the level of awareness regarding the effect of environmental pollution increase. As such, people will demand more for services such as healthcare, education, security, and better places to stay. As stated in an earlier study by Panayotou (1993) and a recent study by Alam (2015), the Environmental Kuznet Curve (EKC)[24] hypothesis also discuss the relationship between economic growth phases (or known as the Three (3) - sector analysis) with environmental pollution, which mainly based on the early work of forest (1969), Kuznets (1976), and several recent studies of Dietrich (2009), Queiros and Teixeira (2014) and Nishi (2015).Although, past studies show that structural change is less significance to explain the EKC hypothesis (see Kander, 2005; Alam, 2015), as stated earlier, sign of permanent slowdown in the global C02 emissions registered in 2012-2015 re-opened the debates and Marsiglio (2016) proposed to revisit the implications of structural change specifically in a sectoral shift on the income-pollution nexus.

Nonetheless, an early study conducted by Hamilton (2000) argues that structural change in production alone cannot explain the pollution trends. According to Timmer (2012), the structural transformation process consists of four interrelated processes: first, a declining share of agriculture in GDP and employment as the advancement of industrialization process; second, the rise of a modern industrial and service economy; third, the rapid process of urbanization as people migrate from rural to urban areas and fourth a demographic transition from high rates of births and deaths. Moreover, it is projected that in 2050 a country that experiences fast growth of urbanization and aging population, mostly in Asian countries such as China and India likely to outstrip the benefits of any emission reductions (OCED, 2012).

Summarising, the green structural transformation, especially moving toward services-based economics and less carbon-intensive activities may become the crucial determinant in achieving the sustainable development. On the other hand, demographic transition, such as urbanization and age composition or the longevity of the population and trade intensity factor that reshaping the economic structure may also influence the environmental pollution.

As Asian Countries undergoing another major structural transformation (Green and Stern, 2016), this paper aim to clarify the following questions; first, does the sectoral share proxies by agrarian, industrial and service sector output induce or moderate the environmental pollution in Asian Countries? Second, does the urbanization moderate or induce the environmental pollution in Asian Countries? Third, does the demographic transition via population aging moderate or induce the structural effect on environmental pollution in Asian Countries? Fourth, does the improvement in energy efficiency will substantially

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[23] This was initially developed by Clark in his three editions book entitle "Conditions of Economic Progress" (1940, 1951, and 1957) and further compelling and completed by Fourastie (1949).

[24] The Environmental Kuznets Curve (EKC) was initially a doctrine by the American economist Kuznets that analysed the relationship between the level of income per capita and the degree of inequality in the 1950s .The EKC is an inverted U-shaped curved that depicts a concave relationship between per capita GDP and environmental degradation.

mitigate environmental pollution in Asian Countries? Fifth, apart from that, assessments will also be conducted to know whether EKC that depicts a concave relationship between structural transformation and environmental degradation.

The remainder of this study is organized as follows. In Section 2, we review related literature that discusses the impact of structural transformation on environmental pollution. Next, this study will explain methods used in estimating and analyze the effect of structural transformation factors on environmental pollution in Section 3. Then, results analysis will be discussed extensively in Section 4 and conclude in section 5.

## 2.0 A Brief Review of the Literature

The empirical study on environmental pollution and economics generally hypothesizes an inverted-U relationship between environmental degradation and economic development which is the existence of the so-called Environmental Kuznets Curve (EKC). Mazur *et al*., (2015) study the association between carbon dioxide emission and economic growth during the period 1992–2010 in the European Union countries. They employed the fixed and random effect models to test the validity Environmental of Kuznets Curve (EKC) and found that there are no U-shaped EKC for all 28 current EU member states. This supported also by Kasman and Duman (2015) for new EU member. On the other hand, some study also extended the EKC model into a cubic term. Başar and Temurlenk (2007) who analyse the association between $CO_2$and income in Turkey for the years 1950-2000 found inverted N shape relationship between $CO_2$Per capita and income, and $CO_2$ from solid fuel and income while Omay(2013) results found that there are N-shaped association between $CO_2$ emissions and economic growth in Turkey for the period 1980-2009.

Most studies in the field of EKC-three sector analyses nexus majority focused on industrialization process. Cherniwchan (2012) adopted the simple two-sector model of neoclassical growth in a small open economy using sulfur emissions data for 157 countries over the period 1970-2000 to investigate the relationship between growth in the context industrialization process and environmental pollution. His study shows that the process of industrialization has a positive significant effect on observed emission changes where it empirically indicated that a 1% increase in the industry's share of total output is associated with an 11.8% increase in the level of emissions per capita. Meanwhile, Akin (2014) and Li and Lin (2015) believed that the impact of industrialization varies with countries' income levels. Using the STIRPAT framework, their found out that only in the middle and low-income group, industrialization process have a significant impact toward the $CO_2$Emission, while industrialization has an insignificant impact toward the high-income group. Conversely, the recent study by Alam (2015) argue that in the south Asian cases, the structural change from the secondary to the tertiary sector does not lead to $CO_2$ emissions reduction rather increases with rising income.

Urbanization has been viewed by some researcher as one of the major contributors to global $CO_2$ emissions. Zhu and Peng (2012) explain three different channels on how the urbanization affects $CO_2$ emissions. First, an increase in the city's population will increase the residential consumption and energy demand thereby increasing$CO_2$emissions. Second, urbanization tends to increase demand for housing automatically increase the demand for housing material such as cement which known as the major sources of $CO_2$ emissions. Thirdly, the clearing of trees and grassland activities as more demand for housing will increase, which releases the carbon stored in the trees. The positive association between urbanization and $CO_2$Emissionsare also confirmed by a number of studies. Azam, M. and Khan, A. Q. (2016) evaluate empirically the impacts of urbanization on the environmental degradation proxy of carbon dioxide emissions for four countries from the South Asian Association for Regional Cooperation

(SAARC) region, namely India, Bangladesh, Sri Lanka, and Pakistan over the period of 1982 to 2013. This study employed the least squares method as an analytical technique for parameter estimation and found out that the relationship between urbanization growth and environment found is significantly negative, while, the impact of urbanization on the environment is significantly positive in the case of Sri Lanka and insignificantly positive for Pakistan during the period under the study. Poku (2016) aims to examine empirically the relationship between urbanization, population and $CO_2$ emissions in 45 Sub-Saharan African (SSA) countries from 1990-2010. This study adopts the newly established pooled mean group (PMG) estimator for dynamic heterogeneous panels follow Pesaran and Shin (1999). The result of this study confirmed that an increase in urbanization significantly increases $CO_2$ emissions both in the long and short run where a one percent increase in urbanization increases $CO_2$emissions by 0.2044 percent.

According to the IPCC (2007), population aging, fertility and mortality believed to change the structure of economic activity which widely accepted as the main determinant of pollution emission. Liddle and Lung (2010) focused on 17 developed countries for 1960 until 2005 found that there is a negative relationship between the population share of the age group between 35 and 64 years and carbon emissions. In contrast, in the panel data study of OECD countries spanning the period 1960 to 2005 by Menz and Welsch (2012), population aging has a positive effect on pollution emission as the share of senior citizens increases with an increase in carbon emissions. This result is consistent with a previous study Menz and Kuhling (2011) for 25 OECD countries from 1970 to 2000 which indicated that the association between sulfur dioxide emissions and the population is positive. A more recent study by Hassan and Salim (2015) using a panel data over 1980-2009 shows that an increase in the share of the aging population lowering $CO_2$ emission in the long run for 25 high-income Organization for Economic Cooperation and Development (OECD) countries.

To date, many studies on the relationship between trade openness and pollution confirm that trade openness reduces the pollution level. According to Managi *et al*., (2009), trade liberalization reduces BOD, SO2 and $CO_2$ emissions in OECD countries, but SO2 and $CO_2$ emissions increase in non-OCED countries. Tetsuya and Managi (2011) study the effect of trade openness on deforestation for 142 countries and found a similar result, where an increase in trade openness moderate deforestation for developed countries but not for developing countries. This finding is supported by other studies such as Abdulai and Ramcke (2009) and Wagner (2007). Gani (2012) study the association between good governance indicated by political stability, government effectiveness, regulatory quality, rule of law, and corruption and carbon dioxide emissions in a cross-section of developing countries for the time frame 1996 to 2009 and found that trade openness correlates with CO2 emissions, which support the EKC hypothesis. A more recent study by Kasi and Sami (2016) which study the impact of economics determinates including trade on carbon dioxide emission for 58 countries over the period of 1990 to 2012 also found out that trade activities moderate the pollution level. Ozturk *et al*., (2016) focus on OCED countries for the period of 1990 to 2012 to analyse the validity of Environment Kuznets Curve hypothesis. The study concludes that a rise in trade activities moderates global warming. In contrast, Herpel and Frankel (2009) found that there is no detrimental effect of trade on environmental pollution in developed nations.

## 3.0 Data and Methodology

To accomplish the objective of this paper, we adopted a panel data from 35 Asian countries for the period ranging from 1990 to 2015. The theoretical framework, data, and regression model are discussed in the next section.

### 3.1 Theoretical background and model construction

This paper analyze the decomposed factor that affects the environment based on IPAT model as introduce by Erlich and Holdren (1971) as expressed below:

$$I = P \times A \times T \tag{1}$$

where the environmental impact (I) depends on the level of population (P), affluence (A), and technology (T). The equation implies that growing population rates and the level of affluence leads to a larger demand for natural resources and energy. On the other hand, improvement in technology has contributed to the development of economic activities where the level of technology is said to have a significant effect on the degree of environmental impact.

The IPAT equation for decomposition purposes have its limitations in estimating population elasticity as it is primarily a mathematical equation that is not suitable for hypothesis testing and it assumes a rigid proportionality between the variables (Cole and Neumayer 2004). Therefore, this paper follows Wang *et al*., (2016) which extends the IPAT equation into STIRPAT model.

$$I_{it}=a_i P_{it}^{b} A_{it}^{c} T_{it}^{d} e_{it} \tag{2}$$

where, $I_{it}$ is environmental pollution, $P_t$ is population, $A_t$ is affluence, $P_t$ is technology and $e_{it}$ is the error term. All the series are transformed into logarithmic form. Due to the use of panel estimation, countries are denoted by the subscripts i (*=1,….,N*) and time period are denoted by the subscripts t (t=1,….,T); $a_i$ denote the country-specific effect and $e_{it}$ represents the random error term. The elasticities for the following variable can be represented by b, c and d. The models are interpreted based on the estimated coefficients $(b, c, d)$.

For this paper, the STIRPAT model is extended to include structural transformation effect on pollution as proposed by Timmer (2012) and structural change (Ang and Choi, 1997; Schipper *et al*., 2001; Alam, 2015), urbanization (Poumanyvong and Kaneko,2010; Martinez-Zarzoso and Maruotti ,201 ;Sadorsky, 2014), and aging population which is used as a proxy for demography changes (Menz and Welsch, 2012). Taking natural logarithms of equation (2) provides a convenient linear specification for panel estimation and is designated as **Model 1**.

$$\mathrm{InZ_{it}} = \beta_1 In\mathrm{I_{it}} + \beta_2 lnS_t{}^{r} + \beta_3 lnG_t + \beta_4 In\mathrm{U_{it}} + \beta_5 In\mathrm{pop65_{it}} + \alpha_\mathrm{i} + \varepsilon_\mathrm{it} \tag{3}$$

**Model 2** includes the impact of trade openness as proposed by Ameer and Munir (2016):

$$\mathrm{InZ_{it}} = + \beta_1 In\mathrm{I_{it}} + \beta_2 lnS_{it}{}^{r} + \beta_3 lnG_{it} + \beta_4 In\mathrm{U_{it}} + \beta_5 lnpop65_{it} + \beta_6 lnTO_{it} + \alpha_\mathrm{i} + \varepsilon_\mathrm{it} \tag{4}$$

Equations 3 and 4 indicate that environmental impact ($Z_{it}$) proxy by $CO_2$ emission influence by technology which is proxied by energy intensity (I), affluence is proxied by GDP per capita(G), population effect proxied by urbanization intensity (U), and aging population (POP65). We include structural change effect that is proxied by the sectoral share of value added (S) and trade openness (TO).The combined effect of all the above factors on environmental pollution can be represented by a linear specification for panel estimation where countries are denoted by the subscript i (i = 1,…,N), and time is denoted by the subscript t (t = 1,…,T).Country-specific effects are included through $\alpha_i$ , and $\varepsilon_{it}$ represents the random error term. The variables in equation (1) and (2) are defined in Appendix 1.

The first term denotes the energy used per unit of output, or energy intensity, which represents the technology (T) effect. By lowering the energy intensity and carbon emission intensity, which indicates the enhancement in the efficiency of energy use, it is expected to moderate the economic growth effect in the environment. The second term denotes the structural changes as proxied by the sectoral share of value added. According to the EKC hypothesis, industrialization process will induce more environmental pollution, while teritarization process may lower environmental pollution. Thus, it is expected that agriculture and the industrial sector may increase the pollution, while services sector will lower the pollution level. The third term indicates the economic growth proxies whereby an increase in GDP per capita (G) represents the increase in the level of affluence (A) of the country at time t. Economic growth generates waste production, and rapid resource use induces increases in environmental pollution. Thus, it is expected that GDP per capita will have a positive effect on pollution. The fourth term shows how increased urbanization also helps to facilitate economies of scale for public infrastructure, where these economies of scale lead to lower environmental damages (Sadorsky, 2014). The fifth term refers to the share of the population aged above 65 years old, and it is expected to influence the environmental pollution negatively. The sixth term in model 2 refers to trade openness (TO) and it is expected to have a negative effect on environmental pollution.

**3.2 STIRPAT Model within the EKC Hypothesis**

The current study extends the STRIPAT model within the Environmental Kuznets Curve (EKC) hypothesis framework model based on the model proposed by Ameer and Munir (2016) and is designated as **Model 3.**

$$\mathrm{InZ_{it}} = \beta_1 In\mathrm{I_{it}} + \beta_2 lnS_{it}{}^{r} + \beta_3 lnG_{it} + \beta_4 lnG_{it}{}^{2} + \beta_5 lnG_{it}{}^{3} + \beta_6 In\mathrm{U_{it}} + \beta_7 lnTO_{it} + \beta_8 lnPOP65_{it} + \alpha_{\mathrm{i}} + \varepsilon_{\mathrm{it}} \quad (5)$$

$G_t{}^2$ and $G_t{}^3$ are respectively squared GDP per capita and cubic GDP per capita model of economic growth. This squared term and the cubic term allow expansion of GDP per capita accumulation effect on pollution, and provide the possibility of a non-linear relationship. According to EKC theory, it expected that squared GDP per capita will moderate the pollution effect and cubic GDP capita as a counter-balance is expected to have a positive effect.

This paper also extends the urbanization effect as proposed by Shahbaz *et al.*, (2017) to allow the expansion of urbanization accumulation effect, and it is designated as **Model 4** *in* equation (3)

$$\mathrm{InZ_{it}} = \beta_1 In\mathrm{I_{it}} + \beta_2 lnS_{it}{}^{r} + \beta_3 lnG_{it} + \beta_4 In\mathrm{U_{it}} + \beta_5 In\mathrm{U_{it}}^2 + \beta_6 In\mathrm{U_{it}}^3 + \beta_7 lnTO_{it} + \beta_8 lnPOP65_{it} + \alpha_{\mathrm{i}} + \varepsilon_{\mathrm{it}} \quad (6)$$

$U_t{}^2$ and $U_t{}^3$ are respectively the squared and cubic terms in a model of urbanization . The squared term and the cubic term allow the expansion of urbanization accumulation effect on pollution emission and it includes the consideration of the possibility of a non-linear relationship.

**3.2 Measurement and Data Sources**

This study estimates the environmental pollution by adopting the Carbon Dioxide ($CO_2$), from EDGAR (European Commission, Joint Research Centre,JRC). The first group of variables that explaining the pollution level includes the Affluence (A) effect represent by the per capita income, which is defined as Gross Domestic Product (GDP) per capita. According to World Bank (2016), GDP defines as total gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are in constant 2010 U.S. dollars. As this study also intends to explore whether the Environmental Kuznets Curve (EKC) hypothesis is supported, quadratic and cubic of form for per capita income is included. Apart from income, energy consumption also included denoted the Technology (T) effect. Energy consumption refers to the use of primary energy is refers to use of primary energy before transformation to other end-use fuels which include the use of coal, oil, gas and hydro-electrics (Poumanyvong and Kaneko, 2010). The third group of variables that explain the pollution level includes the structural transformation. The structural transformation decomposed into sectorial share, urbanization, and demographic transition as proposed by Timmer (2012) and also trade openness as proposed by Torras and Boyce (1998) and Antweiler *et al*. (2001). The sectoral share which decomposed based on the three sector hypothesis; agricultures, industrial and services sector value added. To measure the contribution of each sector measures based on the ratios of total value added to the gross domestic product. These variables reflect the level of agriculture-industrial-services development and believed the key indicators of sustainable development (Alam.2015). Next is the urbanization and population aged 65 and above denoted the Population (P) effect where according to World Bank (2017) urbanization measured using urban population as share in total population and the Population aged 65 and above (% of total population) defined as all residents regardless of legal status or citizenship who aged 65 and above except for refugees not permanently settled in the country of asylum as a percentage of the total population. Apart from that, trade activities measure based on trade openness which used in numerous empirical studies (see Antweiler *et al*., 2001; Copeland and Taylor, 2005 ; Jayanthkumaran and Liu ,2012). The trade openness volumes basically measures based on ratios of trade volumes which consist of export and import output divided by GDP.

The data comes from the online World Development Indicators (WDI) and Emission Database for Global Atmospheric Research (EDGAR).

### 3.3 Econometric Approach

The study employed static panel techniques to estimate the coefficients in each model. In the static model, this study interested in estimating the country-specific effects and time-specific effects of the model. If $y_{it}$ is the variable of interest, then static panel data models described as in equation (7).

$$y_{it} = \beta X_{it} + v_{it}, \qquad i = 1 \ldots N,\ t = 1 \ldots T \tag{7}$$

where $X_{it} = V_{it} + N_i$ and $v_{it} = \alpha_i + \varepsilon_{it}$ . The explanatory variable ($X_{it}$) consists of both time-invariant ($N_i$) and time-variant variable ($V_{it}$). Additionally, $\alpha_i$ represent the unobserved country-specific time-invariant effects, and $\varepsilon_{it}$ is the residual disturbance term which has zero mean, constant variance, and is uncorrelated across time and individuals. The symbol β is the *K X 1* vector of coefficients on the independent variables (X). However, in static panel techniques, two methods which are fixed-effects (FE) and random-effects (RE) can be distinguished depending on the nature of $\alpha_i$(Baltagi, 2008).

The fixed-effects model assumes that $\alpha_i$ is fixed as a country-specific constant term, and $\alpha_i$ is correlated with the independent variable (Baltagi, 2008). In this case, the within-group (WG) estimators, so-called the "fixed effects estimators" are used to estimate the model. If pooled Ordinary Least Squares (OLS) model is used in the estimation of the panel model, the unit fixed effect is ignored and excluded from the equation. According to Plumper *et al*., (2005) if $\alpha_i$ is correlated with both $y_{it}$ and $X_{it}$ the exclusion of the term $\alpha_i$ will lead to bias in the estimation of pooled OLS, especially if N is small. The random effects model is more appropriate when the unobserved country-specific $\alpha_i$ is uncorrelated with$\varepsilon_{it}$. therefore, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the independent variables.

The overall fit of the model is examined by adopting two tests: First, Breush and Pagan (1980) Lagrange Multiplier (LM) which will decide between a random-effects regression and a simple OLS regression. It tests the null hypothesis which assumes that variance across entities is zero. Second, the Hausman test (1978) allows the choice between fixed or random effects where the null hypothesis is that the preferred model is the random effects.

## 4.0 Estimation results

The estimation result for a linear specification of the panel estimation based on the STRIPAT model is presented in Table 1. The fit of the static panel data model is examined by performing two tests. First, the Breusch and Pagan (LM) test for both models (Prob>$chi^2$ = 0.00) concludes that there are country-specific effect in the model, thus Pooled OLS is inconsistent. Second, the result of the Hausman test for model (1) and model (2) respectively indicate that the fixed effect is inconsistent, thus the differences across entities have some influence with the regressors, and indicates the suitability of random effect estimation for models (1) and (2).

**Table 1: Estimation Results for the Regression between Carbon Dioxide ($CO_2$) Emission and Structural Transformation Determinants**

| **DEPENDENT VARIABLE : CARBON DIOXIDE ($CO_2$) EMISSIONS** | | |
|---|---|---|
| **INDEPENDENT VARIABLE** | MODEL 1 | MODEL 2 |
| **ln (GDP per capita), GDP** | 0.020*** (3.812) | 0.001*** (0.047) |
| **Agriculture Sector Share ($S^a$)** | 0.000*** (1.600) | 0.001*** (1.556) |
| **Industrial Sector Share ($S^i$)** | 0.284 (1.651) | 0.000*** (1.955) |
| **Services Sector Share ($S^s$)** | 0.001*** (-5.308) | 0.045** (-5.373) |
| **Urbanization (U)** | 0.364 (-5.049) | 0.692 (-2.156) |
| **Population 65 years(POP65)** | 0.066 (3.69) | 0.06** (4.731) |
| **Energy Intensity(I)** | 0.685 (-9.138) | 0.750 (7.151) |
| **Trade(TO)** | - | 0.000 (-10.96) |
| **Breush and Pagan's (LM) test (p-value)** | Prob>$chi^2$ = 0.00 | Prob>$chi^2$ = 0.00 |
| **Hausman test (p-value)** | Prob>$chi^2$ = 0.468 | Prob>$chi^2$ = 0.498 |
| **R-squared** | 0.061 (within) | 0.061 (within) |
| **F-stat** | 0.000 | 0.000 |

Robust standard errors are heteroskedastic and serial correlation consistent-Statistics are shown in parentheses*, **, *** indicate significance at the 10%, 5% and 1% levels, respectively.

Models (1) and (2) indicate that GDP, the agriculture sector share, and the industrial sector share exert statistically significant positive effects on $CO_2$ emission. Tertiarization process proxied by the service sector share exerts a statistically significant negative effect on $CO_2$ emissions. By include the impact trade openness as proposed by Ameer and Munir (2016) as in model 2, it has a significant and positive effect with $CO_2$ emission. Nevertheless, Urbanization, aging population, and energy consumption found to be not significant in influencing the $CO_2$. The model (1) and (2) explains 6.1 % of the cross-country variation.

Next, the regression results for environmental pollution and structural transformation determinants within the EKC Hypothesis are reported in the table 2. The result of Breusch and Pagan (LM) Test and Hausman test for model (3) indicated that country effect is correlated with the residual, thus the Pooled OLS and random effects estimates are inconsistent. Therefore fixed effect is preferred. Nevertheless, the result of Hausman test and Breusch and Pagan (LM) Test indicates the suitability of random effect estimation for model (4).

**Table 2: Estimation Results for the Regression between Carbon Dioxide ($CO_2$) Emission and Structural Transformation Determinants within the EKC Hypothesis**

| DEPENDENT VARIABLE IS THE CARBON DIOXIDE ($CO_2$) EMISSIONS | | |
|---|---|---|
| **INDEPENDENT VARIABLE** | **MODEL 3** | **MODEL 4** |
| **GDP Per Capita (G)** | 0.03***<br>(3.25) | 0.05***<br>(1.48) |
| **Square GDP Per Capita($G^2$)** | 0.008***<br>(-2.054) | - |
| **Cubic GDP Per Capita($G^3$)** | 0.001***<br>(4.29) | - |
| Agriculture Sector Share<br>($S^a$) | 0.000**<br>(2..082) | 0.000**<br>(1.95) |
| Industrial Sector Share<br>($S^i$) | 0.109<br>(2.482) | 0.108<br>(2.480) |
| Services Sector Share<br>($S^s$) | 0.001***<br>(-4.90) | 0.000<br>(-5.437) |
| Urbanization (U) | 0.972<br>(0.241) | 0.379<br>(6.34) |
| Square Urbanization ($U^2$) | - | 0.553<br>(-1.57) |
| Cubic Urbanization ($U^2$) | - | 0.561<br>(0.155) |
| Population 65 years(POP65) | 0.05<br>(0.2401) | 0.09<br>(4.355) |
| Energy Intensity(I) | 0.564<br>(0.1326) | 0.629<br>(11.313) |
| Trade(TO) | 0.000***<br>(-9.123) | 0.000***<br>(-9.45) |
| Breush and Pagan's<br>(LM) test (*p-value*) | Prob>$chi^2$ = 0.00 | Prob>$chi^2$ = 0.00 |

| | | |
|---|---|---|
| Hausman test (*p-value*) | Prob>$chi^2$ = 0.04 | Prob>$chi^2$ = 0.2480 |
| R-squared | 0.1084(within) | 0.089 (within) |
| F-stat | 0.000 | 0.000 |

Robust standard errors are heteroskedasticity serial correlation consistent consistent-statistics are shown in parentheses.*, **, *** indicate significance at 10%, 5% and 1% level, respectively.

Initially, the scale of the economy increases, it exerts a significant and positive effect on emissions level, but after a certain point, it exerts a negative effect, implying that at higher levels of income environmental impact decreases. This finding confirms the existences of an inverted-U association between $CO_2$ and GDP per capita which represents the level of affluence. Nevertheless, as the scale of the economy becomes very large as measured by the cubic GDP per capita, it exhibits a significantly positive effect on $CO_2$. In addition, structural changes as measured by the sectoral share of value added support the EKC theory. The agriculture value-added and industrial value-added both exert significantly positive effects on CO2 emissions, while tertiarization process lowers the environmental pollution as the service sector exerts a significant negative effect on $CO_2$ emissions. The coefficients on the aging population (POP65) exhibit a positive effect on $CO_2$while the variable trade openness presents a positive and statistically significant effect on emissions for Asian countries.

Model 4 includes the expansion of urbanization effect as proposed by Shahbaz *et al*., (2017). The results indicate that the association between $CO_2$ emission and expansion of urbanization is not statistically significant. Structural changes in the sectoral share of value added, aging population and trade openness are similarly not statistically significant, as found in Model 3.

In comparing the current results of with findings in the previous literature, the existence of an inverted-U relationship between GDP per capita and environmental pollution in our findings are consistent with those found in numbers of studies (see Hassan *et al*., 2015; Shahbaz *et al*., 2009). The positive sign of the agriculture value added and industrial value added as a proxy for structural change support the findings by Lin *et al*., (2009), Salim and Shafiei, (2014) and Nejat *et al*., (2015), while the negative sign of services sector value added contradicts Alam (2015). Similar to the finding of Sadorsky (2014), the urbanization variable is positive but statistically insignificant. The expansion of urbanization accumulation proxy by the square of urbanization found to support the theory of ecological modernization and urban environmental transition theory since it determines an inverse relation between urbanization and environmental pollution. Moreover, this finding also sheds light on the arguments by Breheny (2001) and Rudlin and Falk (1999) where negative consequences will counterbalance the benefit from economic development and increased urban density (Breheny, 2001; Rudlin and Falk, 1999).These findings on population aging are consistent with Menz and Welsch (2012) Menz and Kuhling (2011) but contradict findings by with Hassan and Salim, (2015). Finally, the association between trade openness and environmental pollution, supporting the EKC hypothesis accordance with the recent study by Case and Sami (2016) and Ozturk*et al*., (2016).

## 5.0 Conclusion and Discussion

The objective of this paper is to evaluate the impact of structural transformation on environmental pollution. Our findings confirm the inverted-U shaped relationship between GDP per capita and $CO_2$ emission when a quadratic term of GDP per capita introduce. Marsiglio (2016) stated that there are three main reasons for the inverted-U shape relationship which has been extensively discussed by the theoretical literature: first, as the countries become richer, it promotes environmental friendly technological innovation which may lead production to generate less pollution. Second, as countries become richer and the income per capita increase, the awareness for environmental protection activities increases, thus the demand for environmental quality increases. Third, structural changes related with rising per capita income can change the composition of economic activity which may shift economic production system from high polluting industry to low polluting services. The findings that structural changes affect the environment are confirmed in this study; agriculture and industrial activity contributes to carbon dioxide emissions, thus demand for services such as healthcare, education, security, and better places which shifting to low polluting industry proxy by services sector that contributes to emissions reduction. However, as scales of the economy become very large, it exhibits a significantly positive effect on $CO_2$, following an N-shaped trajectory against GDP per capita. This study also concludes that rising trade activities provide moderating effects.

We suggest policy implications emerging from our study are as follows. First, in terms of production, the continuous increase in carbon-intensive activities and industrialization may drive increase carbon dioxide emissions of Asian countries, while tertiarization process lowers environmental pollution. Therefore, it countries are recommended to embrace more sustainable development policies to promote structural shifts away from carbon intensive activities to low carbon energy mix, and to design and improve pollution control technologies. Second, policymakers should immediately initiate proper planning for demographical changes in age structure, specifically on the aging population. Third, stringent environmental regulations and policies on trade that affect the environment are crucial.

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**APPENDIX 1: Definition of Variable in Equation (1)-(4)**

| | |
|---|---|
| $\mathrm{Z_t}$ | Environmental pollution proxies by Carbon Dioxide ($CO_2$ at time t |
| $\mathrm{EC_t}$ | The amount energy use refers to use of primary energy before transformation to other end-use fuels at time t |
| $\mathrm{GDP_t}$ | Total gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. |
| $\mathrm{Y_t}^{\mathrm{r}}$<br><br>TPOP65 | The values added of the r sector at time t, where r=agriculture, industrial, service sector<br><br>All residents regardless of legal status or citizenship who aged 65 and above |
| $\mathrm{UP_t}$ | Total people living in urban areas in time t |
| $\mathrm{P_t}$ | The total population at time t |
| $\mathrm{EX + IM}$ | Export and import output at time t |
| $I_t = \frac{\mathrm{EC_t}}{\mathrm{GDP_t}}$ | The energy intensity at time t |
| $S_t{}^r = \frac{\mathrm{GDP_t}}{\mathrm{P_t}}$ | The sectorial share of value added of the r sector at time t |
| $G_t = \frac{\mathrm{GDP_t}}{\mathrm{P_t}}$<br><br>$POP65_t = \frac{\mathrm{TPOP65_t}}{\mathrm{P_t}}$ | The GDP per capita at time t<br><br>The population aged 65 and above as a percentage of the total population at time t |
| $U_t = \frac{\mathrm{UP_t}}{\mathrm{P_t}}$ | The urbanization intensity at time t |
| $TO_t = \frac{\mathrm{EX+IM}}{\mathrm{GDP_t}}$ | Trade openness at time t |

**APPENDIX 2: CO2 emission trends for 35 Asian countries**

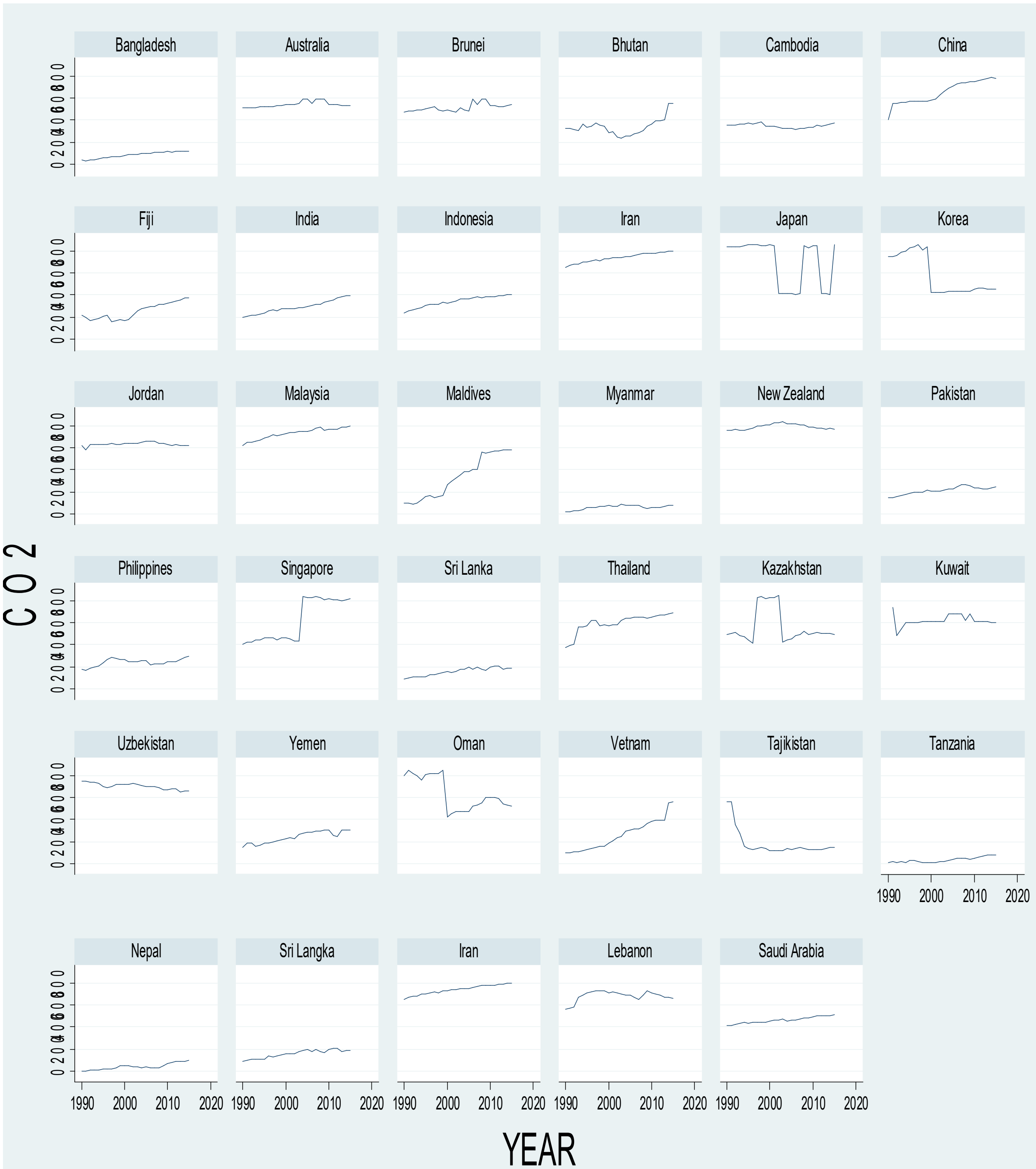


Figure 1: Time series of CO2 emissions used from EDGAR (European Commission) and derived from their analysis in this paper. This figure is for the 35 Asian countries for year 1990 until 2015.