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# The Service Sector and Carbon Emission Nexus: Revisiting Environmental Kuznets Curve

*(Sektor Perkhidmatan dan Pelepasan Karbon: Tinjauan Semula Keluk Kuznet Alam Sekitar)*

**Jain Yassin**
Universiti Teknologi Mara

**Sarma Aralas**
University Malaysia Sabah

ABSTRACT

*This study aims to examine the expansion effects of the service sector on the carbon emission in a dynamic non-linear model. Using data of 34 Asian countries ranging from 1990 to 2016, this study adopts non-linear model of the Environmental Kuznets Curve and the GMM estimator. The finding provides evidence of an N-shape association between the service sector and carbon emission which indicates that the growth of the service sector fails to reduce the carbon emission perpetually. The elasticity of urbanisation and trade openness are found to be positive which indicates that an increase in urbanisation and trade openness significantly intensifies carbon emission. Meanwhile, an increase in the ageing population tends to mitigate* carbon emission in Asian countries. *This current study facilitates the understanding of the impact of the services sector on carbon emission as well providing a solid ground in designing a policy that incorporates the environmental standard in line with increased economic growth.*

*Keywords: Service Sector; Carbon Emission; Environmental Kuznets Curve; GMM; Asian Countries*

ABSTRAK

*Kajian ini bertujuan untuk mengkaji kesan pengembangan sektor perkhidmatan terhadap pelepasan karbon dalam model tak linear dinamik. Menggunakan data dari 34 negara Asia terpilih daripada tahun 1990 hingga 2016, kajian ini menggunakan model tak linear keluk Alam sekitar Kuznets dan penganggar GMM. Kajian ini mendapati terdapat bukti hubungan berbentuk N di antara perkhidmatan dan pelepasan karbon yang menunjukkan bahawa pengembangan sektor perkhidmatan gagal mengurangkan pelepasan karbon secara kekal. Keanjalan urbanisasi dan keterbukaan perdagangan didapati positif dan menunjukkan bahawa peningkatan pembandaran dan keterbukaan perdagangan secara signifikan meningkatkan pelepasan karbon. Sementara itu, peningkatan penuaan penduduk akan mengurangkan pelepasan karbon di negara-negara Asia. Berdasarkan hasil kajian ini, dapatan ini membantu peningkatan pemahaman mengenai kesan sektor perkhidmatan terhadap pelepasan karbon serta memberikan landasan yang kukuh untuk merancang dasar yang merangkumi piawaian persekitaran di samping meningkatkan pertumbuhan ekonomi.*

*Kata kunci: sektor perkhidmatan; pelepasan karbon; keluk Alam sekitar Kuznets; GMM; negara-negara Asia*

## INTRODUCTION

The growth of greenhouse gases (GHG) leads to global warming and a range of climate-related disruption of the ecosystem, environmental, and social. The greenhouse has been largely driven by Carbon dioxide ($CO_2$), Methane ($CH_2$), Nitrous oxide ($N_2O$), and the High Global Warming Potential (GWP) gases such as the Hydrofluorocarbon, perfluorocarbon, sulfur hexafluoride, and nitrogen trifluoride. Nevertheless, Carbon dioxide ($CO_2$) emissions comprise the largest share of greenhouse gases which contribute 73 per cent share in global GHG emissions (Olivier & Peters 2018).

According to Intergovernmental Panel on Climate Change (2014), one of the primary methods to mitigate carbon emissions is by switching from high carbon-intensive industries such as construction and manufacturing to less carbon-intensive industries such as education and banking. Ambrozova and Fialova (2014) have stated that the rising share of the service sector is harmonious with the growth of the economic level of countries, thus, justifying the roles of the structural change in reducing $CO_2$ emissions, advocates generally use the argument of the Environmental Kuznets Curve (EKC) hypothesis.

A prominent theory of the Environmental Kuznets Curve (EKC) and its relation to the structural change was introduced by Kuznet (1955). The EKC hypothesis postulated that the earlier stage of development leads to a deterioration in the environmnet due to the industrialisation process and expansion of urbanisation. However, as income rises, the demand for more service and a better sustainable environment consequently leads to a decrease in pollution (Gill et al.,2018). The diminishing pollution level may also cause by the process of tertiarisation will enlarge the number of low-carbon emitters industries such as schools, hospitals, and tourism in the economy. The idea of tertiarisation may influence the inverted U-shaped (Marsiglio et al., 2016).

Nevertheless, previous findings have shown that the service sector and pollution nexus vary across countries, econometric methods, regional differences, and different levels of economic growth. In single country studies, Alam (2015) deduced that the services sector intensify the $CO_2$ emissions in Bangladesh, India, Nepal, and Sri Langka, while Okamoto (2013) and Li et al. (2017) argues that tertiarisation will reduce $CO_2$ emissions. These studies did not explicitly examine the EKC hypothesis unlike Hashmi et al. (2020) who corroborated the subsistence of an inverted U-shaped in Pakistan. Withal, $CO_2$ emissions are global which indicates that there is a possibility that $CO_2$ emissions country spreads to another country especially within the same region due to the globalisation process and trade openness (Sohag et al. 2017). Moreover, Rafiq et al. (2016) believed that it is unrealistic to undertake homogeneous factors which influence $CO_2$ emissions across countries. So far, only Sohag et al. (2017) and Yassin and Aralas, (2019a) examined the services sector and pollution nexus using a panel method that accounted for cross-sectional dependence and also allows for country-specific effect. Nonetheless, these studies did not consider the dynamic nature of $CO_2$ emissions. Winkler (2004) highlighted that it is essential to take into account the lagged value of pollution to estimate the factor that influences the current pollution. Due to the scarcity of empirical study on the nexus between services sector and pollution in the non-linear framework and acknowledging the dynamic nature of $CO_2$ emissions, this current study sought to assess the effects of the services sector on emissions in nonlinear frameworks by utilising the dynamic panel method.

By record, Asia is the largest emitter which accounts for 53 per cent share of $CO_2$ emissions (Ritchie and Roser, 2017). Aside from becoming the prime emitters of $CO_2$ emissions, Asian countries also have experienced obvious transformation in their economic structure. Clearly as shown in Figure 1, the contribution of the industry sector to GDP in Asian middle-income countries such as China, India, Malaysia, and Thailand as well as high-income countries such as Bahrain, Qatar, and Japan are declining in 2016 compared to 2010. Meanwhile, in figure 2, the trend portrayed that the share of the services sector in most of Asian countries increases. Although the studies on services sector-environment nexus in Asian countries are not new, for instance, Okamoto (2013), Alam (2015), and Li et al. (2017), nevertheless, they did not empirically test the EKC hypothesis. To date, only Yassin and Aralas (2019) technically tested the EKC hypotheses concerning non-linear nexus between services sector-pollution in Asian countries. While Hahsmi et al. (2020) and Taghvaee and Parsa (2015) only from a national point of view which ignore the effects of regional differences.

The study on the effects of the growth of the services sector on the $CO_2$ emissions in the Asian country's merits investigation for three reasons. Firstly, today, the Asia region is pointed out as the region producing the most $CO_2$ emissions (Olivier et al., 2017). Secondly, to date, the Asian region is recognised to experience a rapid shift towards the service sector. In 2016, the service shares in the Asian region accounted for 54 per cent of total Asian output, which indicates the domination of the service sector and will become more prominent in the future (Kim & Wood 2020). Third, the scarcity of evidence on the role of the service sector in influencing $CO_2$ the emissions in Asian countries required serious academic attention. Moreover, mixed results in a single country study motivate us to revisit the association between the service sector and $CO_2$ emissions in Asian countries considering the dynamic nature of $CO_2$ emissions in panel data study.

Further, the next section or the second section presents the literature review focusing on empirical studies that test the EKC hypothesis and the services sector-carbon emissions nexus. Next, the third section highlighted the model specification and proposed estimator, the fourth section presented the estimation results, and the fifth section presented the conclusion and discussions.

## LITERATURE REVIEW

A vast number of empirical studies examined the EKC hypothesis in a variety of econometric approaches, different samples, and times span. The plausibility of the EKC hypothesis is mainly on the non-linear nexus between the income and the pollution level and later extended to global studies with the inclusion of different variables. Among prominent studies are by Grossman and Krueger (1991). They found that $CO_2$ emissions are determined by income as well as trade. The inverted U-shaped between economic growth is also confirmed by Al-Mulali et al. (2015) and shows such as openness to trade is found to influence pollution emissions. Meanwhile, Bekhet and Othman (2017) and Ahmed et al. (2019) revealed that evidence of EKC also exists between urbanisation-$CO_2$ emissions nexus.

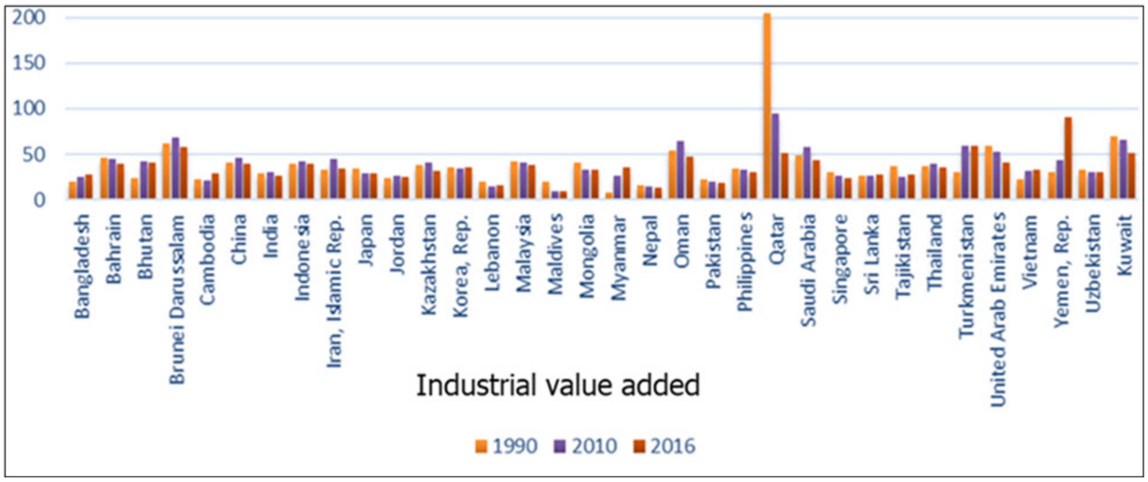


FIGURE 1. Industrial value added (% of GDP) in Selected Asian countries during 1990, 2010, and 2016
*Source:* World Development Indicators (2019)

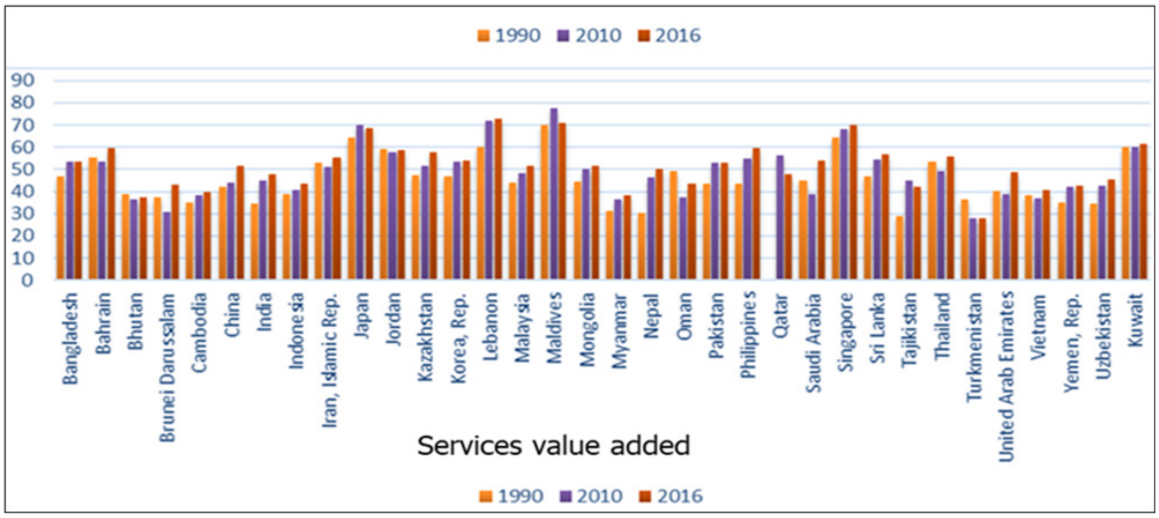


FIGURE 2. Services value added (% of GDP) in Selected Asian Countries during 1990, 2010, and 2016
*Source:* World Development Indicators (2019)

On the other hand, Hassan and Salim (2015) included the ageing population to complement the relationship between income and pollution. The ageing population is also supported by Kim et al., (2020) in $CO_2$ emissions reduction. Trade openness is also extensively adopted in explaining the EKC hypothesis. Meanwhile, Shahbaz et al. (2015) stated that high trade openness induces higher economic growth which deteriorates the environment. Nonetheless, few studies found an inverted U-shaped between trade openness and pollutions such as Ansari et al. (2020) and Muhammad et al. (2020).

Marsiglio et al (2016) stated that the structural changes which highlighted the process of industrialisation and tertiarisation may also explain the EKC hypothesis. Most previous literature agreed that industrialisation can lead to environmental degradation. For instance, Cherniwchan (2012) investigate the relationship industrialisation process and environmental pollution for 157 countries in the year 1970 until 2000 using the two-sector model. The result shows that the industrialisation intensifies the sulfur emissions. Under other conditions, Akin (2014) and Li and Lin (2015) argued that the industry sector influences on $CO_2$ emissions differently depending on the countries' income levels. Their studies concluded that the industry sector has a significant impact in the middle and low-income group, while the industry's share of output has a less significant in influencing $CO_2$ emissions in the high-income group. A more recent study conducted by Chen et al. (2020) in China also agreed that $CO_2$ emissions higher in cities which are dominated by industry-based economic activities.

However, the monotonic relationship between industrialisation and pollutions levels is quite debatable. Du and Xie (2019) provided different perspectives regarding industrialisation and environment quality. Unlike Cherniwchan (2012), Akin (2014), and Li and Lin (2015), they considered the EKC theory. Interestingly, the results have shown evidence of inverted U-shaped where countries that are in the path of deindustrialisation is making progress toward reducing its emissions. Ulla et al. (2020) also provide a similar conclusion for Pakistan in the short and long-run estimations. Li et al. (2019), on the other hand, examined 31 regions in China and found an N-shape association between air pollution and industrialisation in China. The results show that industrialisation move in a similar direction with air pollution but later decreases as industrial level continuously increases. Nevertheless, air pollution will rebound as the industrialisation moves further. Nonetheless, these studies overlooked the role of the structural transition to service sector on carbon emission.

The structural change hypothesis postulated that the high pollution industry sector will shift from the low pollution services sector which also known as the process of deindustrialisation and tertiarisation, generally with the process of tertiarisation or the expansion of services sector (Kaldor 1961). Several studies highlighted the role of the service sector in influencing the environment at the country level, however, the findings are mixed depending on certain factors such as country selection, econometric modelling, and development status. Alam (2015) examined the effect of industry and services value-added on carbon emissions in Bangladesh, India, Nepal, and Sri Langka. The study extended the sectoral output study proxies by a contribution of the industry sector and the service sector in the South Asian cases. Using the OLS regression, the resulted revealed a positive effect of the industry's share of total output and implied that the shift from manufacturing to service sector does not diminish the $CO_2$ missions rather increase in accordance with income. The result contradicted with Okamoto (2013) who examines the effect tertiarisation on $CO_2$ emissions in Japan throughout the 1995-2005. By using the decomposition analysis, it was revealed that the transition to the service sector mitigates $CO_2$ emissions. Meanwhile, Li et al. (2017) adopted an input-output method to evaluate the effect of changes in industrial composition on carbon emission in China and Japan. The results revealed that although the industrial structure is improving in China, however, the $CO_2$ emissions does not decrease. Nonetheless, the $CO_2$ emissions in Japan have shown a declining trend as they shift toward the service sector.

In panel setting, Sohag et al.,(2017) adopted panel estimation and consider the heterogeneity among the panel in examining the role of sector value addition to GDP by decomposing into three sectors, namely, agriculture, industrial, and services value-added on $CO_2$ emissions for middle-income countries. They adopted the heterogeneous panel estimators such as the cross-correlated effect mean group and augmented mean group. The results found that the share of the service sector significantly increase $CO_2$ emissions in the upper-middle-income group but it produces different conclusions in the lower-middle-income group.

However, Alam (2015), Okamoto (2013), and Sohag et al.,(2017) did not assess the non-linearity to consider the existence of EKC. To date, a study that assesses the non-linearity association between the sectoral composition and $CO_2$ emissions were extremely limited and only several studies the EKC hypothesis. Taghvaee and Parsa (2015) for instance, examined the non-linearity between sectoral composition and $CO_2$ emissions in a single country framework which focuses on Iran. In their study, economic growth is proxied by value-added in manufacturing and value-added services. They adopted the Auto-Regressive Distributed Model (ARDL) to investigate the long-run association between industry and services sector and $CO_2$ emissions. Interestingly, an N-shape relationship was found which indicated that as both sectors inflate the $CO_2$ emissions will follow an ascending trend, nevertheless, the trend is temporary. In a more recent study, Hasmi et al. (2020) also examined the role of the service sector in influencing the environment in Pakistan's non-linear framework. Using the ARDL model, it was shown that confirmation of an inverted U-shaped association between the service sector and $CO_2$ emissions existed in Pakistan. The inverted U-shaped between the services sector and $CO_2$ emissions also confirmed by Yassin and Aralas (2019a) in Asian countries. This study takes into consideration the cross-sectional and temporal dependencies by performed the Driscoll and Krayy standard error for robust estimation.

In summary, although previous studies overcome the problem of cross-sectional bias and consider heterogeneity, nevertheless study such as Sohag et al.,(2017) did not consider the dynamic nature of $CO_2$ emissions and non-linearity. Yassin & Aralas (2019b) perhaps consider the heterogeneity among panel and non-linearity but does not consider the dynamic nature of $CO_2$ emissions. Thus, the current paper aims to narrow the gap by appraising the service sector and $CO_2$ emissions nexus while incorporates the existences of the dynamic nature of $CO_2$ emissions in the panel non-linearity model. As discussed earlier, the evidence of non-linearity between the service sector and $CO_2$ emissions is extremely limited in a single country framework, thus this study also extended the contribution to panel data studies.

## METHODOLOGY

### MODEL SPECIFICATION

The prominent model of EKC was extensively used to examine the non-linear interrelation between economic development and pollution emissions. The general non-linear regression model can be presented as follows (see Stern 2004):

$$\text{InCO2}_t = \beta_0 + \beta_1\, InY_t + \beta_2\, lnY_t^2 + \beta_3\, lnZ_t + \varepsilon_t \qquad (1)$$

Where $CO2_t$ is pollution proxy by natural logs of $CO_2$ emissions, $Y_t$ is GDP per capita measure the economic growth, $Y_t^2$ is a square term of GDP per capita, $Z_t$ are other factors that may influence the in $CO_2$ emissions and $e_t$ is the error term. All variables are converted into a natural log form.

To discover the existences of the EKC hypothesis, the first-order partial derivatives was performed to equation (1) concerning time (t) as follows

$$\frac{dI}{dt} = \text{EKC}' = \beta_1 + 2\beta_2 A_{it} + 3\beta_3 A^2{}_{it} + \beta_3 \qquad (2)$$

If $\beta_1 > 0$ and $\beta_2 < 0$, this proposed that pollution emissions have an inverted-U shape pattern in line with economic development. However, if $\beta_3 < 0$, the pollution will follow the N-shape pattern.

Nevertheless, this study proposed an alternative variable to replace the GDP per capita and specify the economics into services value added (SER) in a panel setting as equation 3 and designated as model 1:

$$\text{InCO2}_{it} = \beta_1\, InSER_{it} + \beta_2\, lnSER_{it}^2 + \beta_3\, lnU_{it} + \beta_4\, lnPOP65_{it} + \beta_5\, lnTO_{it} + \alpha_i + \varepsilon_{it} \qquad (3)$$

In the panel model, the subscripts i (*=1,….,N*) denoted the countries and the time presented by the subscripts t (t=1,…., T); $a_i$ presented the country-specific effect and $e_{it}$ denoted as a random error term. In this paper, this model is extended to include several control variables, namely; urbanisation, ageing population, and trade openness. The urbanisation is expected to negatively related to $CO_2$ emissions. According to Ahmed et al. (2019) urban population tend to prioritise in improving the living condition concurrent with environmental sustainability. An increase in the ageing population also expected to be negatively related to $CO_2$ emissions as they will demand better services such as health services and a healthy environment (Hassan and Salim, 2015). Meanwhile, trade openness is anticipated to positively influence $CO_2$ emissions. Jun et al. (2020) stated that trade openness increases domestic production and emits more carbon emissions.

Then, the model is extended by the inclusion of cubic term following Zhang et al., (2017) to observe whether the moderating effect of the expansion of the service sector on $CO_2$ emissions are considered permanent or temporary and designated as model 2.

$$\text{InCO2}_{it} = \beta_1\, InSER_{it} + \beta_2\, lnSER_{it}^2 + \beta_3\, lnSER_{it}^3 + \beta_4\, lnU_{it} + \beta_5\, lnPOP65_{it} + \beta_6\, lnTO_{it} + \alpha_i + \varepsilon_{it} \qquad (4)$$

### DATA SOURCES

This study adopted a panel data framework in 34 Asian countries from 1990 to 2016. The total number of countries covered is 34 which represents 71 per cent of total Asian countries. The choice of sample for this analysis is primarily dominated by the availability of reliable data. In the model, the level of pollution that prevails in the economy treats as the dependent variable. To measure the environmental pollution level, this study adopted the Carbon dioxide *($CO_2$)* emissions per capita as the pollution indicator used in many other studies (Alam 2015; Sohag et al.2017). Next, this study intends to explore the non-linear nexus between the services sector and carbon dioxide *($CO_2$)* emissions. The service sector includes education, communication, transportation baking, and other services which proxy by the value of the services added (Yassin & Aralas 2019a). Other than that, this study also includes some control variable, namely; urbanisation (Sadorsky 2014), the ageing population (Menz & Welsch 2012), and trade openness (Munir & Ameer 2018). These data sets were obtained from Crippa et al. (2019) and World Bank's ranging between 1990 and 2016 based on data availability. The variables' descriptions are presented in Table 1.

### DYNAMIC PANEL DATA MODELS

According to Winkler (2004), the current level of pollution influences by the lagged of pollution from the previous period. Thus, it is essential to include the lagged value of  emissions in response to endogeneity concerns. Therefore, this study will utilize the GMM method, since it incorporates the lagged value through instrumental variables (Abid 2017). The GMM estimators introduced by Arellano and Bond (1991) and Arellano and Bover (1995). For simplicity, based on equation 1 and 2, the dynamic panel regression takes the following form:

Model 1:

$$\text{InCO2}_{it} = \beta_0\, \text{InCO2}_{it-1} + \beta_1\, InSER_{it} + \beta_2\, lnSER_{it}^2 + \beta_3\, lnU_{it} + \beta_5\, lnPOP65_{it} + \beta_6\, lnTO_{it} + \alpha_i + \varepsilon_{it} \qquad (5)$$

Model 2:

$$\text{InCO2}_{it} = \beta_0\, \text{InCO2}_{it-1} + \beta_1\, InSERV_{it} + \beta_2\, lnSERV_{it}^2 + \beta_3\, lnSERV_{it}^3 + \beta_4\, lnU_{it} + \beta_5\, lnPOP65_{it} + \beta_6\, lnTO_{it} + \alpha_i + \varepsilon_{it} \qquad (6)$$

Based on equations 5 and 6, the presence of lagged dependent variables will lead to an endogeneity issue. According to Arellano and Bond (1991), endogeneity can be addressed by transforming the data using the differentiation method. However, a later study by Blundell and Bond (1998) argued that the difference GMM might affect huge sample bias, thus, proposed the system GMM estimators to improve efficiency by using both lagged levels and different information. Therefore, in this paper, we adopted both estimators, namely difference and system-GMM in two-step to ascertain the results' robustness. Roodman (2009) stated that the two-step system GMM is more efficient and robust and the statistical tests are more reliable. Nevertheless, according to Windmeijer (2005), the validity of the instrument needs to be tested using Hansen Test and Autocorrelation test to prevent the two-step GMM from producing a biased standard error and the parameter lead to a weakened over-identification test.

## EMPIRICAL ANALYSIS

### STATIONARITY TEST

To begin with the empirical estimation, the panel unit root test of Im, Pesaran, and Shin (2003) test (IPS) for stationary with and without trend and intercept at a level and first difference. The panel unit root test was based on IPS (2003) test for Asian countries is reported in Table 2. Panel unit root was based on the Im, Pesaran, and Shin (2003) test without trend revealed that the probability value for the lagged value of the *($CO_2$)* emissions, urbanisation, trade openness effect is less than 0.05 marginal level implying that the null hypothesis of no stationary can be rejected at a 5 per cent significance level. While other variables found to be not stationary at level. In the first differences, is it discovered that for all variables, the probabilities' values obtained are less than 0.05 marginal levels and implied that all models are stationary. When trends were considered, urbanisation and trade openness were found to stationary at level (p-value<0.05). Meanwhile, the unit root in the first difference with the trend shows that all variables become stationary as the probability value obtained (p-value<0.05) indicated that the null hypothesis of non-stationary can be rejected. This result implied at any shock affecting the variable is likely to experience a temporary effect on the 34 selected Asian countries and the selected variable is beneficial to be used to forecast the *($CO_2$)* emissions volatility. Ergo, we can proceed with the data model estimation.

## ESTIMATION RESULTS

The results of the non-linear estimations regarding the two-step difference and system GMM for model 1 reported in Table 3 and model 2 reported in Table 4. For additional robust checks, we also estimated models 1 and 2 with a static panel model using Pooled Ordinary Least Square (Pooled OLS) and fixed effect methods. In a static panel model, the Wald test shows that variables are jointly significant in explaining the $CO_2$ emissions at a 1 per cent significance level. The Hausman test revealed that the p-value for the test of significance is at less than 5 per cent. The result implied that unobserved effects and other variables are correlated and the random-effects model would lead to inconsistent results (Hill et al. 2008). Therefore, the fixed-effect estimator is opted. Next, in a dynamic panel model, the estimation results of the Hansen specification test indicated that the two-step in difference and system GMM model has been correctly specified. On the other hand, the Wald test indicated that the coefficient is not equal to zero and implied that the variables are jointly significant in explaining the $CO_2$ emissions at a 1 per cent significance level. Turning to the serial correlation tests, the estimated *p*-value had shown evidence against the null hypothesis of no autocorrelation in the first differences but failed to reject the null hypothesis no second-order serial correlation for both models. These

TABLE 1. Description of variables

| Variable | Definition |
|---|---|
| Carbon dioxide emissions (CO2) | Colourless, odourless, and non-poisonous stemming from the burning of fossil fuels and the manufacture of cement. Measured in metric tons per capita |
| Services Value added (SER) | Consists of the net output for activities that provides a service such as government, transportation, financial, health care, and real state services. |
| Urbanization (U) | Urban population refers to people living in urban areas (%) |
| Ageing Population (POP65) | All residents who aged 65 and above regardless of legal status or citizenship. |
| Trade Openness (TO) | The export and import output divided by GDP |

*Source:* World Development Indicators (2019)

TABLE 2. Panel unit root test with IPS (2003) test

| Variables | (IPS) without trend | | IPS with trend | |
|---|---|---|---|---|
| | At level | 1st difference | At level | 1st difference |
| *lnCO*2 | -0.1228 | -12.268*** | -0.8281 | -13.049*** |
| *lnserv* | 1.545 | -2.361*** | -1.965 | -1.273*** |
| *lnU* | -3.937*** | -13.701*** | -5.617*** | -11.42*** |
| *lnp65* | 15.572 | 5.145*** | 8.715 | 2.686*** |
| *lnTO* | -5.00*** | -6.206*** | -2.797*** | -16.64*** |

*Note:* IPS represents the Im, Pesaran, and Shin (2003) test for stationary with and without trend and intercept at a level and first difference. *, **, *** indicate statistical significance at 10%, 5% and 1 % level respectively. The null hypothesis is that the variable if non-stationary

results indicated that using lags of these variables from this dynamic panel model removes autocorrelation in the second order. The estimation of the GMM difference and system model in one-step may not fit in this context, hence, the estimation results generally discussed based on the two-step GMM estimation results.

Referring to the lagged value of $CO_2$ emission, it indicated that the lagged value of $CO_2$ emissions is a statistically significant positive related to the current values of the $CO_2$ emissions at a 1 per cent significance level in static and dynamic panel data models. This justified the use of a dynamic panel data model in estimating the association between variables. Hence, the GMM is a superior estimator when dealing with the assumption of a dynamic model. Nonetheless, the Pooled OLS and fixed effect also provide information regarding the lower and upper bound. The estimations have shown that the different GMM estimate is smaller than the lower bound (fixed effect estimate). Referring to Bond (2002), the difference GMM is most likely to be downward biased because of a weak instrument, therefore the system GMM estimation was preferred in this study.

First, the coefficient of services sector output shows to have a positive effect on the $CO_2$ emissions at a 1 per cent level based on system GMM in both models. In model 1, it indicated that an increase in services value added by 1 per cent will lead to an increase in $CO_2$ emissions by 1.1780 per cent. Similar results were found in model 2, the $CO_2$ emissions increased by 1.1672 per cent. Further, an increase in services value-added proxy by the quadratic value of services value added exerted a significant negative effect at 1 per cent based on both estimators for both models. This implied that at a 1 per cent increase of square term of services value added to reduce the $CO_2$ emissions 0.1604 per cent in model 1. Meanwhile, in model 2, the $CO_2$ emissions decrease by 0.1642 per cent. The finding provides affirmation of inverted U-shaped association between services value-added and $CO_2$ emissions in model 1. Nonetheless, the inverted U-shaped is only a temporary trend, where the $CO_2$ emissions will rise again when the share of service sector increases further. It is demonstrated in model 2, 1 per cent of increase in the cubic term of services value added will increase the $CO_2$ emissions by 0.0376 per cent. The finding proposed evidence of N-shape nexus between services value-added and $CO_2$ emissions.

Referring to other variables, an increase in urban population and higher degree openness to trade in selected Asian countries can intensify the $CO_2$ emissions. Technically, a 1 per cent increase in an urban population increase $CO_2$ emissions by 1.1683 per cent (model 1) and 1.4799 per cent (model 2). Meanwhile, a 1 per cent increase in trade openness will increase $CO_2$ emissions by 1.3158 per cent (model 1) and 2.4238 per cent (model 2). Lastly, an increase in the ageing population will reduce the $CO_2$ emissions in ASEAN countries. Statistically, it is shown that a 1 per cent increase in the ageing population reduces the $CO_2$ emissions by 3.9350 and 2.2859 per cent in model 1 and model 2, respectively.

## DISCUSSION AND CONCLUSION

This study offers empirical evidence on the services output effect on $CO_2$ emissions for 34 Asian countries from 1990 to 2016. Based on the results of the estimation, initially, the service output proxy by the services value-added was found to positively influence the $CO_2$ emissions and later reduced as there was an increase in the service sector as indicated by the inclusion of the square term of services value-added. This finding is similar to Hashmi et al. (2020) and Taghvaee and Parsa (2015). Although our result asserted the existence of an inverted-U shaped between the services value-added and $CO_2$ emissions, as the service sector grows, the later phase of the services sector will rebound the e $CO_2$ missions. Hence, this indicated an N-shape trend of the services-$CO_2$. This phenomenon occurs as the initial development of the service sector was associated with electricity or indirect energy consumption. According to Marsiglio et al.(2016) as the economic structure shift from high industry sector to the services sector will reduce the $CO_2$ emissions due to industry sector dominated by manufacturing activities

TABLE 3. Result of estimation for non-linear dynamic model (Model 1)

| | MODEL 1 | | | |
|---|---|---|---|---|
| Variable | Pooled OLS | Fixed Effect | Two-stepDiff-GMM | Two-stepSys-GMM |
| *Carbon emissions* ($CO2_{it-1}$) | 0.7269*** (0.0398) | -0.7175 (0.0366) | 0.7168*** (0.0299) | 0.6974*** (0.0018) |
| *Services Output* (serv) | 2.2615*** (1.6772) | 2.2536*** (1.1233) | 2.2260*** (0.0952) | 1.1780*** (0.0138) |
| *Urbanization* (U) | 3.5451*** (1.4220) | 2.5559*** (1.2438) | 2.1041*** (0.2914) | 1.4799*** (0.4587) |
| *Aging Population* (pop65) | -5.1098** (0.9911) | -4.1231** (1.891) | -4.8209*** (0.8895) | -3.9350*** (1.3413) |
| *Trade Openess* (TO) | 0.8400*** (0.5170) | 0.8201** (0.6722) | 0.7622*** (2.972) | 1.3158*** (0.2425) |
| *$serv^2$* | -0.2062*** (0.1142) | -0.2470*** (0.0911) | -0.2953*** (0.11605) | -0.1604*** (0.1721) |
| *Constant* | -11.2732*** | -11.2384*** | 26.837** (14.00) | 47.68** (23.36) |
| *Hausman Test* | | chi2(6) =3.96 Prob>chi2=0.032 | | |
| *R-squared* | 0.645 | 0.689 | | |
| *Wald*[a] | | 20.2 (0.000) | 657.46 (0.000) | 751 (0.000) |
| *Hansen Test*[b] | | | 24.89 (0.810) | 29.81 (0.8200) |
| *A-B test 1st order*[c] | | | -1.6080 (0.0170) | -1.6120 (0.0700) |
| *A-B test 2nd order*[d] | | | 1.0324 (0.3019) | 1.034 (0.3008) |
| Obs. | 918 | 918 | 850 | 884 |

*Notes:* (*) significant at the 10 per cent level, (**) significant at 5 per cent level, and (***) significant at 1 per cent level. The Hausman test null hypothesis is that unobservable individual effects are not correlated with the explanatory variables. Figure in parentheses is the standard error, except for the Hansen test, Arellano-Bond test, and Wald test which are p-value. The test statistics for Arellano-Bond tests of autocorrelation are presented with *P*-value as shown in parentheses. a: The null hypothesis of wald statistic is that all coefficient except the constant is equal to zero. b: the null hypothesis that over-identifying restrictions are valid. c: The null hypothesis is that the errors in the first-differenced regression exhibit no first-order serial correlation. d: The null hypothesis is that the errors in the first-differenced regression exhibit no first-order serial correlation.

while service sector partly reflected low polluting industries such as schools, hospitals, information, and communication technology (ICT), recreational and leisure, and government services. Nevertheless, as the services sector shifted more aggressive, it will tend to attract investment, promote trade, and urbanisation (Kim & Wood 2020)

Turning to the control variables, consistent with Yassin and Aralas (2019b) the growth in urbanisation in Asian countries increased the $CO_2$ emissions. This implied that urban areas in Asian countries still highly dependent on the vast usage of energy, vehicles, and constructions that emitted emissions. Meanwhile, the more trade openness confirmed to intensify the $CO_2$ emissions. This finding is in accordance with Shahbaz et al. (2015). This study also revealed that an increase in the numbers of the ageing population may reduce the emissions in linear estimations. A possible explanation for such results lies on the point that as people grow older, they will demand better services such as health care and less as well as greener lifestyle and less use of private transportation and car usages (Kim et al.2020)

Several policy implications were identified in this study. First, this study discovers that, when the share of the service sector increases, at a certain turning point, it can counteract the positive effect of the service sector on the environment. Hence, Asian countries still dominate the share of the industry sector should expedite the process of tertiarisation. As mentioned earlier, the service sector may enlarge the environmental-friendly services-based activities and will reduce the level of $CO_2$ emissions, thus an industrial policy to accelerate Asian's transition to service economy need to be performed. Nevertheless, the N-shape trends indicated that the expansion of the services sector fails to reduce the $CO_2$ emissions permanently. As the development of the service sector

TABLE 4. Result of estimation for non-linear dynamic model (Model 2)

| | MODEL 2 | | | |
|---|---|---|---|---|
| Variable | Pooled OLS | Fixed Effect | Two-stepDiff-GMM | Two-stepSys-GMM |
| *Carbon emissions* ($CO2_{it-1}$) | 0.7180***<br>(0.0379) | 0.7010***<br>(0.0369) | 0.6975***<br>(0.0104) | 0.7069***<br>(0.0070) |
| *Services Output* (serv) | 2.3377***<br>(1.5733) | 2.3470***<br>(1.0574) | 2.2732***<br>(0.0326) | 1.1672***<br>(0.0205) |
| *Urbanization* (U) | 3.6419***<br>(1.0966) | 2.5658***<br>(1.1181) | 2.0266***<br>(1.550) | 1.1683**<br>(0.5034) |
| *Aging Population* (pop65) | -5.3384***<br>(1.8147) | -4.2215***<br>(1.1706) | -3.0048**<br>(0.0180) | -2.2859<br>(1.7634) |
| *Trade Openess* (TO) | 1.7585**<br>(1.0126) | 1.4280**<br>(1.0127) | 1.6498***<br>(0.5073) | 2.4238***<br>(0.7468) |
| $serv^2$ | -0.5024***<br>(0.0842) | -0.3051***<br>(0.0084) | -0.2975***<br>(0.2387) | -0.1642***<br>(0.1686) |
| $serv^3$ | 0.0054***<br>(0.0047) | 0.049***<br>(0.0025) | 0.0341*<br>(0.0143) | 0.0376**<br>(0.0241) |
| *Constant* | -11.231***<br>(0.3770) | -11.212***<br>(0.0416) | 19.295***<br>(0.2479) | 19.249**<br>(27.71) |
| *Hausman Test* | | chi2(6) =10.45<br>Prob>chi2 =0.021 | | |
| *R-squared* | 0.646 | 0.689 | | |
| *Wald*[a] | | 24.5<br>(0.000) | 1003<br>(0.000) | 1658<br>(0.000) |
| *Hansen Test*[b] | | | 23.09<br>(0.790) | 27.62<br>(0.823) |
| *A-B test 1st order*[c] | | | -1.5709<br>(0.0162) | -1.6158<br>(0.0061) |
| *A-B test 2nd order*[d] | | | 1.0202<br>(0.3077) | 1.0421<br>(0.2974) |
| Obs. | 918 | 918 | 850 | 884 |

*Notes:* (*) significant at the 10 per cent level, (**) significant at 5 per cent level, and (***) significant at 1 per cent level. The Hausman test null hypothesis is that unobservable individual effects are not correlated with the explanatory variables. Figure in parentheses is the standard error, except for the Hansen test, Arellano-Bond test, and Wald test which are p-value. The test statistics for Arellano-Bond tests of autocorrelation are presented with *P*-value as shown in parentheses. a: The null hypothesis of wald statistic is that all coefficient except the constant is equal to zero. b: the null hypothesis that over-identifying restrictions are valid. c: The null hypothesis is that the errors in the first-differenced regression exhibit no first-order serial correlation. d: The null hypothesis is that the errors in the first-differenced regression exhibit no first-order serial correlation.

was aligned with industrial and manufacturing activities, there is a need for strategic planning on managing the services sectors that are accompanied by a better sustainable solution to environmental pollution. Asian countries should emphasise on sustainable development which provides the opportunity for the adoption of cleaner and greed technology, conservations activities, and efficient service delivery to transform the services sector into low carbon emitters in the long-run. Secondly, the estimated results of the control variable such as urbanisation, trade openness, and ageing population assist in designing proper polices. Proper design and planning for sustainable lifestyles for the urban population are needed in Asian countries to encourage the development activities that not only contribute to economic growth but also reducing the carbon footprint such as eco-tourism and renewable energy consumption in the long-run. In terms of trade activities, policymakers should take serious consideration and attention on the environmental regulations related to trade activities without harming the contribution of trade on national income as well as international relations. Besides, this study expected that young people may emit more than the old people, thus the policymakers should account for the effect of population age composition in existing strategies to curb the pollutions.

Finally, this current study facilitates the understanding of the impact of sector-wise decomposed of the share of services sector on $CO_2$ emissions as well as providing a solid ground for designing a policy that incorporating the environmental standard while increasing economic development in line with the services sector. However, it is interesting and insightful for future researchers to extend the current study to assess the convergence speeds of economics and environmental efficiency in Asian countries to provide the policymaker useful information on the pathway toward achieving the sustainable development goals (SDGs). Perhaps future studies also can quantify the turning point the services sector-pollutions nexus.

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Jain Yassin
Faculty of Business and Management
UiTM Cawangan Sabah
Beg Berkunci 71
88997 Kota Kinabalu Sabah
MALAYSIA
E-mail: jainyassin@uitm.edu.my

Sarma Aralas*
Faculty of Business, Economics and Accountancy
Universiti Malaysia Sabah Jalan UMS
88400 Kota Kinabalu Sabah
MALAYSIA
Email: miasarma@ums.edu.my

*Corresponding author

## APPENDIX

TABLE 5. Selected Asian countries included in the study

| | Name | Region |
|---|---|---|
| 1 | Bahrain | West Asia |
| 2 | Bangladesh | South Asia |
| 3 | Bhutan | South Asia |
| 4 | Brunei | Southeast Asia |
| 5 | Cambodia | Southeast Asia |
| 6 | China | East Asia |
| 7 | India | South Asia |
| 8 | Indonesia | Southeast Asia |
| 9 | Iran | West Asia |
| 10 | Japan | East Asia |
| 11 | Jordan | West Asia |
| 12 | Kazakhstan | Central Asia |
| 13 | Korea | East Asia |
| 14 | Kuwait | West Asia |
| 15 | Lebanon | West Asia |
| 16 | Malaysia | Southeast Asia |
| 17 | Maldives | South Asia |
| 18 | Mongolia | East Asia |
| 19 | Myanmar | Southeast Asia |
| 20 | Nepal | South Asia |
| 21 | Oman | West Asia |
| 22 | Pakistan | South Asia |
| 23 | Philippines | Southeast Asia |
| 24 | Qatar | West Asia |
| 25 | Saudi Arabia | West Asia |
| 26 | Singapore | Southeast Asia |
| 27 | Sri Lanka | South Asia |
| 28 | Tajikistan | Central Asia |
| 29 | Thailand | Southeast Asia |
| 30 | Turkmenistan | Central Asia |
| 31 | United Arab Emirates | West Asia |
| 32 | Uzbekistan | Central Asia |
| 33 | Vietnam | Southeast Asia |
| 34 | Yemen | West Asia |

*Notes:* The countries classification based on the United National Population Division (2017). Total number of countries covered is 34 which represent 71 per cent of total Asian countries. The choice of sample for this analysis is primarily dominated by the availability of reliable data.