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Fatma Taşdemir (ftasdemir@sinop.edu.tr)
Sinop University https://orcid.org/0000-0001-8706-7942

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INDUSTRIALIZATION, SERVICIFICATION AND ENVIRONMENTAL KUZNETS CURVE: NON-LINEAR PANEL REGRESSION ANALYSIS

Fatma Taşdemir
Boyabat Faculty of Economics and Administrative Sciences,
Sinop University, Sinop, Turkey
E-mail: ftasdemir@sinop.edu.tr

ABSTRACT

This paper investigates whether the impact of income on CO_2 emissions is invariant to endogenously estimated threshold levels for the economic structure (ES) represented by value added in manufacturing, industry and services sector shares in GDP for a panel of 54 economies over the 1971-2017 period. Our panel smooth transition regression estimation results strongly suggest that the sensitivity of CO_2 emissions to income is substantially much higher in countries with higher manufacturing and industry sector shares whilst it is much lower in servicified economies. Given the argument that manufacturing is the engine of growth, this finding may not necessarily downgrade the crucial importance of an industrial policy which places the manufacturing at the core. The empirical findings in this paper suggest that countries may better to design and implement a strategic and systematic industrial policy which promote the use of emission reduction technologies and encourage manufacturing and industrial sectors with lower carbon emissions.

Key words: Environmental Kuznets Curve, Industrialization, Servicification, Panel Smooth Transition Regression

JEL Classification: L60, L80, Q50, Q56

1. Introduction

The conventional environmental Kuznets curve (EKC) maintains that CO_2 emission increases with income and after a turning point, higher income leads to a deceleration. According to the EKC, during the earlier stage of development, the content of economic activities may include substantial deleterious impacts on environment because the economies are “too poor to be green” (Martinez-Alier, 1995). After a certain income level, countries aim to grow by considering the impacts of economic activities on environment and thus begin to follow a “green growth” path. Therefore, environmental economists often maintain that income is both the cause and cure of degradation as suggested by the inverted-U shaped EKC. In this context, investigating the driving forces behind the inverted-U shaped EKC is crucially important research topic in environmental economics.

The seminal study by Grossman and Krueger (1991) suggests the validity of inverted-U shaped relation between income and emissions based on the scale, composition and technique effects. The scale effect implies the deterioration in environmental quality with the increase in income. The composition and technique effects, respectively, denote the improvement in environmental quality mainly by the movement of economic structure from polluted industrial to greener services sector and employment of environment-friendly technologies. In this context, Grossman and Krueger (1991) maintains that the upward sloping part of EKC may be explained with the scale effect while the downward sloping part of EKC may be illustrated with the composition and technique effects. Following Grossman and Krueger (1991), the bulk of the literature often investigates the validity of inverted-U shaped EKC relation by using different income and environmental degradation measures. Shahbaz and Sinha (2019) provides a recent literature survey on EKC. The conventional EKC maintains that income, the aggregated measure of economic activities, intimately explains the evolution of environmental deceleration and improvement. However, the recent literature also suggests that economic structure is crucially important in explaining the impacts of income on environmental degradation and thus the ignorance of this issue may lead to misleading conclusions on the validity of EKC.

The recent literature including Kearsley and Riddel (2010), Marsiglio et al. (2016), Neve and Hamaide (2017) and Shahbaz and Sinha (2019) notes that economic structure, often represented by manufacturing share in GDP, is one of the most important determinants of CO_2 emissions. Chen et al. (2020) reports that almost half of the CO_2 emissions is related with economic activities in the industrial sector including mining and quarrying, manufacturing, electricity, gas and water supply and construction. The empirical findings by Friedl and Getzner (2003) and Mulder and de Groot (2012) suggest that the prevalence of services sector leads to improvement in environmental quality. Therefore, it may be plausible to suggest that CO_2 content of economic activities differ in the countries with higher manufacturing and industrial sector shares than servicified economies represented with high services sector share. These are, indeed, consistent with the composition effect argument by Grossman and Krueger (1991). Barra and Zotti (2018), on the other hand, reports that the effects of economic structure on emissions may change depending on the net impacts of scale, composition and technique.

This study, in accord with the conventional EKC, investigates the determinants of CO_2 emissions. Considering that economic structure of countries may differ across the energy-intensity and thus carbon emission levels of the main sectors, we plausibly postulate that the impacts of income on CO_2 emissions may be different in economies with higher manufacturing and industry sector shares than servicified ones. The bulk of the studies investigate the EKC relation by employing the conventional panel data estimation procedures. The studies attempting to estimate the turning point of the conventional EKC often employ some quadratic or cubic regression models. These approaches, however, “may not identify other forms of non-linearity that may exist” as suggested by Şentürk et al. (2020, p.5). Furthermore, as suggested by Richmond and Kaufmann (2006) the studies finding that the turning point of EKC that beyond the sample data may be misleading. Aslanidis and Iranzo (2009), in this context, notes that the employment of panel smooth transition regression (PSTR) procedure provides more flexibility than the quadratic or cubic EKC regression models. Therefore, the investigation of income-environment relation and peak/turning point of EKC based on data-driven estimation procedures like PSTR may be more reliable. The literature, however, is yet to fully investigate whether the economic structure represented by manufacturing, industry and services sectors shares in GDP provide endogenous thresholds for the impact of income on CO_2 emissions. Therefore, this study mainly aims to investigate whether economic structure constitutes endogenous thresholds for the impact of income on CO_2 emissions in a sample of 54 economies over the 1971-2017 period by employing PSTR procedure of Gonzalez et al. (2005; 2017).

The results of this study suggest that the sensitivity of pollution to income changes with the endogenously determined threshold levels of economic structure. The income elasticity of pollution is substantially much higher in countries with higher manufacturing and industry shares. On the other hand, we find that the impact of income on emissions is substantially much lower in servicified economies with high services share. These findings all, indeed, may suggest the industrialization and servicification, respectively, sharpens and dampens the positive impact of income on CO_2 emissions. Therefore, the empirical results in this study provide a support to the explanation of EKC with the scale effect argument by Grossman and Krueger (1991) and suggest this effect varies across the structure of economies.

The plan for the rest of this study as follows. Section 2 presents a brief review of the literature on income-CO_2 relation. Section 3 introduces the empirical methodology and reports the estimation results. In this section, we postulate that economic structure is a potential endogenous thresholding (sample-splitting) variable for the impact of income on CO_2 emissions. Finally, Section 4 concludes and provides some policy implications.

2. Literature Review

There is now a large and growing literature investigating the income-environment relation by using different pollution measures. Andreoni and Levinson (2001) notes that technology employed in the production drives the income-environment relation. Millimet et al. (2003) reports that EKC appears to be valid regardless of the modelling assumptions. On the other hand, there is no universal and robust EKC according to Stern (2004). The empirical results by Akbostanci et al. (2009) and Özokcu and Özdemir (2017) indicate that an N-shaped EKC appears to be the case, respectively, for Turkey and emerging markets. The estimation results based on panel smooth transition regression by Aslanidis and Iranzo (2009) suggest that an increase in income leads to an increase in emissions, albeit the income elasticity of emission is slightly much higher for low income countries. Similarly, by finding a monotonically increasing relation between income and environmental degradation, Şentürk et al. (2020) suggests that the income elasticity of pollution differs across the income level of the economies.

The empirical findings by Torras and Boyce (1998) suggest that literacy, political rights and civil liberties are amongst the important determinants of emissions in low income countries. He and Wang (2012) finds that capital/labor ratio, trade openness and regulations are important variables in explaining the determinants of EKC in China. The cointegration based empirical results by Shahbaz et al. (2019) suggest that energy consumption, sectoral activities, foreign direct investments and urbanization are important determinants of CO_2 emission in Vietnam. Barra and Zotti (2018) finds that there is a monotonically increasing relation between environment and income after controlling the impacts of trade openness, urbanization and electric consumption. The empirical findings by Lin and Li (2020) suggest that population, economic growth, urbanization and industrialization accelerate whilst the usage of electricity decelerates the CO_2 emission.

The recent literature also suggests that the impacts of economic activities on environment can be explained with the pollution haven hypothesis (PHH) that investigates the degradation effects of trade and FDI (Cole, 2004; He and Yao, 2017; Kearsley and Riddel, 2010; Marsiglio et al. 2016; Opoku and Boachie, 2020; Usman et al. 2019). Baldwin and Lopez-Gonzalez (2015) indicates that global manufacturing has been shifted from developed to developing economies during the recent decades. In this vein, PHH mainly postulates that economic activities incorporating higher levels of carbon-intensive industries moves from advanced to developing economies via trade linkages and multinational corporations. Global supply chains may have also contributed the movement of dirty industries to developing economies that have relatively lax environmental standards. Fang et al. (2020) investigates the impacts of trade openness on degradation in Chinese cities. Ren et al. (2014) finds the environmental degradation impacts of trade and FDI in China. The empirical results by He and Yao (2017) and Jayanthakumaran and Liu (2012) provide a further support to the validity of pollution haven hypothesis in China. Jiang et al. (2019) reports that developed countries have been able to locate some of their energy-intensive dirty industries to developing economies because of the trade linkages and in this sense, developed countries may appear to be more successful than developing economies in reducing their emission intensive productions.

According to Dinda (2004), EKC can be explained by considering the impacts of structural change and technological progress. Savona and Ciarli (2019) provides a brief recent literature review on the structural change and environment relationships. Marsiglio et al. (2016) investigates the driving forces of EKC by constructing two sector endogenous growth model consisting of manufacture and services sectors. They remark that there may be an N-shaped relation between income and degradation in the long-run, while the negatively sloped part of EKC, albeit temporarily, may be attributable to structural change postulation. The decomposition analysis by Akbostancı et al. (2018) suggests that manufacturing and construction sectors are crucially important drivers of CO_2 emissions in Turkey. The findings by Friedl and Getzner (2003) indicate that services sector leads to a decrease in CO_2 emissions. According to the shift share analysis by Henriques and Kander (2010), the transition to service-based economic structure provides only a slight deceleration in energy intensity. The transition of economic structure from manufacturing to services is the main reason of declining energy intensity (Mulder and de Groot, 2012). The empirical findings by Du and Xie (2020) indicates that turning point of EKC is faster in deindustrialized countries than industrialized ones. Ullah et al. (2020) finds that environmental degradation impact of industrialization and environmental improvement effect of deindustrialization appear to be the case not only in the short-run but also in the long-run. The cointegration based empirical results by Dogan and Inglesi-Lotz (2020) suggest that there is a U-shaped relation between industrial value added and CO_2 emissions. The investigation of the impacts of manufacturing sector share and manufacturing trade on emissions by Suri and Chapman (1998) suggests that manufacturing exports and imports between industrialized and industrializing countries may contribute, respectively, the upward and downward sloping parts of EKC. The empirical findings by Cole (2000) are mainly consistent with the implications of EKC and PHH for a sample of developed and developing economies. Du et al. (2019) suggests that transportation sector releases substantial amount of pollution to services and construction sectors whilst expose to emission from industrial sector. The investigation of EKC in China leads to the conclusion that EKC is valid in electricity and heat production sectors while there is a monotonically increasing relation between income and emission in the manufacturing sector (Wang et al. 2017). The empirical findings by Xu and Lin (2016) suggest that the impacts of industrial sector on emissions follow an inverted-U shaped relation.

The recent literature often suggests that pollution can be explained by income which is a measure of aggregated economic activities. Akbostancı et al. (2018), Friedl and Getzner (2003), Lin and Li (2020), Mulder and de Groot (2012), Shahbaz et al. (2019) and Ullah et al. (2020) mention the importance of economic structure for the evolution of emissions. In this context, this study aims to contribute to the environmental economics literature by maintaining that the impact of income on emissions may differ across the endogenously determined threshold levels for economic structure represented with manufacturing, industry and services shares in explaining the income-pollution relation.

3. Empirical Methodology and Results

3.1. Empirical Methodology

To investigate the impact of income on CO_2 emissions, we consider the following benchmark equation;

$$\mathrm{CO2}_{it} = \alpha_0 + \alpha_1 \, \mathrm{GDP}_{i,t-1} + e_{it} \quad (1)$$

In (1), the subscript i and t represent, respectively, country and time, CO_2 is natural logarithm of CO_2 emissions per tones per capita, GDP is natural logarithm of real GDP per capita (in constant 2010 US dollars). This equation maintains that CO_2 emissions may parsimoniously be explained with income. Considering the potential endogeneity of real GDP per capita for the evolution of CO_2 emissions, we prefer to use lagged real GDP per capita in (1). The main data source for CO_2 emissions is Joint Research Centre Emissions Database for Global Atmospheric Research. Real GDP per capita data are from World Bank, World Development Indicators.

The benchmark eq. (1) maintains that the impact of income on CO_2 emissions is invariant to economic structure. Alternatively, economic structure consisting of manufacturing, industry and services sectors share in GDP may be treated as thresholding or transition variables for the impact of income on CO_2 emissions. Given that there is a significant threshold, the income elasticity of CO_2 emissions can be estimated by dividing the sample as high regime containing observations higher than the threshold and low regime including observations less than the threshold. The literature on conventional EKC often tackles the nonlinearity and/or threshold issues by employing quadratic or cubic regression models. As suggested by Şentürk et al. (2020, p.5) these approaches, however, "may not identify other forms of non-linearity that may exist". In this vein, the threshold effect of economic structure on CO_2 emissions may better be investigated by employing data-driven estimation procedures. The literature, however, is yet to comprehensively investigate whether the economic structure provides endogenous thresholds for the income elasticity of CO_2 emissions. In this context, we investigate this important issue empirically for a balanced panel of 54[1] economies over the 1971-2017 period by employing panel smooth transition regression (PSTR) procedure of Gonzalez et al. (2005; 2017).

To investigate whether economic structure (ES) provides endogenous thresholds for the impacts of income on CO_2 emissions, we consider the following equation:

$$\mathrm{CO2}_{it} = \mu_i + \beta_0' \mathrm{GDP}_{i,t-1} + \beta_1' \mathrm{GDP}_{i,t-1}\, g(\mathrm{ES}_{i,t-1};\, \gamma, c) + u_{it} \qquad (2)$$

Alternatively, eq. (2) can also be written as;

$$\mathrm{CO2}_{it} = \begin{cases} \mu_i + \beta_0' \mathrm{GDP}_{i,t-1} + u_{it}, & \text{if } g(\mathrm{ES}_{i,t-1}; \gamma, c) = 0 \\ \mu_i + (\beta_0' + \beta_1') \mathrm{GDP}_{i,t-1} + u_{it}, & \text{if } g(\mathrm{ES}_{i,t-1}; \gamma, c) = 1 \end{cases} \qquad (3)$$

In equations (2) and (3), μ_i is the country-specific fixed effects, $g(\mathrm{ES}_{i,t-1};\, \gamma, c)$ is the transition function, $\mathrm{ES}_{i,t-1}$ is the thresholding variable, γ is the smoothness parameter, c is the location parameter (threshold) and u_{it} is the error term. The variable representing economic structure (ES) consists of manufacturing, industry and services sectors shares in GDP and the data are from United Nations Conference on Trade and Development database. The variables

[1] The choice of the sample is mainly determined by data availability and includes Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Denmark, Dominican R., Ecuador, Egypt, El Salvador, Fiji, Finland, France, Germany, Greece, Guatemala, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Korea R., Malaysia, Mexico, Netherlands, New Zealand, Panama, Peru, Philippines, Poland, Portugal, Romania, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, United States, Uruguay.

representing ES may be endogenous for the evolution of CO_2 emissions. We tackle the potential endogeneity of ES by considering the lagged ES. By varying between 0 and 1, transition function splits the sample as low and high regimes depending on the value of thresholding variable, ES. For instance, if ES ≤ c, then the transition function equals to zero and estimated parameter (β_0') shows the impact of income on CO_2 emissions in the low regime. On the other hand, if ES > c, then the transition function equals to one and estimated coefficient ($\beta_0' + \beta_1'$) shows the impact of income on CO_2 emissions in the high regime. Following Gonzalez et al. (2017), we use the logistic transition function as specified in (4);

$$g\left(ES_{i,t-1};\ \gamma, c\right) = \frac{1}{1+\exp\left(-\gamma \prod_{j=1}^{m}(ES_{i,t-1}-c_j)\right)} \tag{4}$$

where $c = (c_1, c_2, \ldots, c_m)'$ represents the vector of location parameters and the slope parameter γ determines how smooth is the transition from the low to high regime. $\gamma > 0$ and $c_1 < c_2 < \ldots < c_m$ are required conditions to estimate the model. Gonzalez et al. (2017) notes that the consideration of one or two threshold, i.e. m = 1 or m = 2, are sufficient in modelling the parameter changes across the regimes. For instance, the case of m = 1 implies that coefficients change monotonically from the low regime (β_0) to the high regime ($\beta_0 + \beta_1$) as the transition variable increases and the change is centered around threshold. The case of m = 2 corresponds to the quadratic logistic transition function that attains the minimum value at $(c_1+c_2)/2$ and indicates a symmetric coefficient changes for the low and high values of threshold.

The initial step for PSTR estimation is to employ the homogeneity test. Under the null hypothesis of H_0: $\gamma = 0$ or H_0': $\beta_1 = 0$, there are no significant thresholds and thus we obtain the linear model given by eq. (1). However, under the null hypothesis, the location parameters or thresholds are unidentified. This unidentified nuisance parameter is also valid for β_1 under H_0 and for γ under H_0'. To solve this problem, Gonzalez et al. (2017) proposes to replace the transition function $g(ES_{i,t-1};\ \gamma, c)$ by first-order Taylor series expansion around γ=0 and thus, we obtain the following auxiliary regression;

$$CO2_{it} = \mu_i + \beta_0'^{*} GDP_{i,t-1} + \beta_1'^{*} GDP_{i,t-1} ES_{i,t-1} + \cdots + \beta_m'^{*} GDP_{i,t-1} ES_{i,t-1}^{m} + u_{it}^{*} \tag{5}$$

Then, testing H_0: $\gamma = 0$ or H_0': $\beta_1 = 0$ becomes equivalent to testing H_0^*: $\beta_1^* = \cdots = \beta_m^* = 0$. Under the null hypothesis of H_0^* there are no significant thresholds and we obtain (1). Homogeneity test results are used to determine the order of logistic function based on the null hypothesis of H_0^*: $\beta_1^* = \beta_2^* = \beta_3^* = 0$ against the H_{01}^*: $\beta_3^* = 0$, H_{02}^*: $\beta_2^* = 0|\beta_3^* = 0$ and H_{03}^*: $\beta_1^* = 0|\beta_3^* = \beta_2^* = 0$. Amongst these alternative hypotheses, if the rejection of H_{02}^* is the strongest than the others, the order of logistic function is selected as m = 2. Otherwise, the order of logistic transition function is chosen as m = 1. The PSTR model is estimated by employing the fixed effects and nonlinear least squares (NLS) procedures. To start the NLS method, initial values are obtained by employing a two-dimensional grid search for the smoothness parameter (γ) and threshold (c).

As already discussed, we tackle the potential endogeneity of real GDP per capita and economic structure for the evolution of CO_2 emissions by considering the lagged real GDP per capita and economic structure. Yu and Phillips (2018) considers panel threshold models with endogeneity in the regressors and thresholding variables and shows that "both the threshold point and the threshold effect parameters are … identified without the need for instrumentation" (p.50). Therefore, our estimations may be interpreted as valid even under the potential endogeneity of real GDP per capita and the thresholding ES variables.

3.2. Empirical Results

The main aim of this study is to investigate whether economic structure provides an endogenous threshold for the impacts of income on CO_2 emissions in 54 economies over the 1971-2017 period. To this end, we consider the share of manufacturing, industry and services value added in GDP as economic structure. These sectoral classifications are mainly in accord with the International Standard Industrial Classification (ISIC, Rev.3). Accordingly, the share of manufacturing value added in GDP (MVA) includes the economic activities in the physical, or chemical transformation of materials, substances or components into new products, industrial sector value added in GDP (IVA) contains the economic activities in mining and quarrying, manufacturing, electricity, gas and water supply and construction sectors and services sector value added in GDP (SVA) incorporates the value added in wholesale and retail trade, hotels and restaurants, transport, storage and communications, financial intermediation, real estate, renting and business activities, education and health sectors.

We first proceed with investigating whether the share of manufacturing sector value added in GDP (MVA) provides an endogenous threshold for the impacts of income on CO_2 emissions. To this end, we consider the following specification:

$$\mathrm{CO2}_{it} = \mu_i + \alpha_0 \mathrm{GDP}_{i,t-1} + \alpha_1 \mathrm{GDP}_{i,t-1}\, g(\mathrm{MVA}_{i,t-1}; \gamma, c) + u_{it} \tag{2.1}$$

Industrial sector not only includes manufacturing activities but also the economic activities in construction, mining and quarrying that incorporates substantial hazardous emissions into the environment as suggested by the bulk of the literature including Akbostancı et al. (2018). In this vein, to examine whether the share of industrial sector value added in GDP (IVA) constitutes an endogenous threshold in explaining the sensitivity of CO_2 emissions to income, we estimate the following equation:

$$\mathrm{CO2}_{it} = \mu_i + \alpha_0 \mathrm{GDP}_{i,t-1} + \alpha_1 \mathrm{GDP}_{i,t-1}\, g(\mathrm{IVA}_{i,t-1}; \gamma, c) + u_{it} \tag{2.2}$$

The literature suggests that the economic activities in services sector produces less CO_2 emissions. Therefore, we finally proceed to analyze whether the share of services sector value added in GDP (SVA) provides an endogenous threshold for the impacts of income on CO_2 emissions. To this end, we consider the following specification:

$$\mathrm{CO2}_{it} = \mu_i + \alpha_0 \mathrm{GDP}_{i,t-1} + \alpha_1 \mathrm{GDP}_{i,t-1}\, g(\mathrm{SVA}_{i,t-1}; \gamma, c) + u_{it} \quad (2.3)$$

As already discussed in Section 3.1, the initial step of the PSTR estimation procedure consists of homogeneity test and results for equations (2.1), (2.2) and (2.3) are reported in Table 1. According to the heteroscedasticity and autocorrelation corrected test results (HAC_X and HAC_F), the null hypothesis of linearity is strongly rejected against the PSTR alternative for m = 1, 2, 3 when the thresholding variable is MVA in eq. (2.1), IVA in eq. (2.2) and SVA in eq. (2.3). The order of logistic transition function is selected as one for all the equations since the rejection of H_{01}^{*} is the strongest than the others.

[INSERT TABLE 1 AROUND HERE]

Eq. (2.1) in Table 2 reports the estimation results of eq. (2.1) by employing the Gonzalez et al. (2017) procedure. The endogenously estimated threshold level of MVA is as around 21%. Almost 64 percent of observations are in the low regime, whilst 36 percent of the observations are in the high regime. The results in eq. (2.1) are mainly in line with the scale effect argument by Grossman and Krueger (1991) suggesting an increase in income leads to higher CO_2 emissions and thus indicate a monotonically increasing relation with income and CO_2 emissions. The results also suggest that income elasticity of CO_2 emissions depend on the manufacturing share of the economies. The impact of income on CO_2 emissions is positive and statistically significant both in the low regime consisting of observations less than the threshold level (MVA $\leq$ 21.37) and high regime comprising observations higher than the threshold (MVA > 21.37). However, this impact is substantially much higher in economies with higher manufacturing share in income. This result is mainly in accord with Barra and Zotti (2018) and suggests that the impacts of income on pollution are substantially much higher in economies with higher manufacturing share. In the context of income-environment relation, this result may also suggest that manufacturing sector sharpens the upward sloping part of EKC. Figure 1.a. presents the logistic transition function across the manufacturing share of the economies.

[INSERT TABLE 2 AROUND HERE]

Eq. (2.2) in Table 2 reports the PSTR estimation results of eq. (2.2). The endogenously estimated threshold level of IVA is almost 33%. Approximately 60 percent of the observations are in the low regime while 40 percent of the observations are in the high regime. Similar to the findings in eq. (2.1), the results in eq. (2.2) suggest the monotonically increasing relation amongst the income and CO_2 emissions but the income elasticity of pollution changes across the industry share of the economies. The income elasticity of pollution is significantly positive not only in the low regime (IVA $\leq$ 33.23) but also in the high regime (IVA > 33.23). According to the results in eq. (2.2), the income elasticity of pollution is substantially much higher in countries with higher industry shares. These empirical findings in eq. (2.1) and eq. (2.2) are mainly in line with the recent literature including Akbostancı et al. (2018) and Ullah et al. (2020) and suggest that the impacts of income on environmental degradation are substantially much higher in economies with higher manufacturing and industry sector shares. Figure 1.b. reports the logistic transition function for the industrial sector share in GDP.

[INSERT FIGURE 1 AROUND HERE]

Eq. (2.3) in Table 2 reports the PSTR estimation results of eq. (2.3). The endogenously estimated threshold level of SVA is as around 62%. Accordingly, around 56 percent of the observations are in the low regime and 44 percent are in the high regime. The estimation results indicate that the income elasticity of pollution is not invariant to the services sector shares. In the low regime containing observations with services sector share is less than 62%, the income elasticity of CO_2 emissions is 0.68 and it is statistically significant. In the high regime covering observations with services sector share is higher than the threshold, the income elasticity of emissions is 0.37 and it is almost half of the coefficient in the low regime. This result mainly suggests that the impacts of income on CO_2 emissions are substantially much lower in economies with high services share or servicified economies and provides a support to the literature including Friedl and Getzner (2003), Henriques and Kander (2010), Mulder and de Groot (2012) and Marsiglio et al. (2016). Figure 1.c. shows the logistic transition function across the threshold level of services sector.

Considering that de-industrialization and servicification are the flip side of the same coin, the low regimes in eq.s (2.1) and (2.2) and high regime in eq. (2.3) mainly represent the income elasticity of pollution in servicified and de-industrialized economies whilst the high regimes in eq.s (2.1) and (2.2) and low regime in eq. (2.3) denote the sensitivity of pollution to income in economies with the high industry and manufacturing sector shares. All the estimation results reported in Table 2 mainly suggest that income elasticity of pollution is substantially much higher in economies with high manufacturing and industry shares whilst substantially much lower in economies with high services share.

4. Conclusion and Policy Implications

The conventional environmental Kuznets curve (EKC) investigates the relation between CO_2 emissions and income that represents the aggregated measure of economic activities. EKC maintains that income leads to an increase in the pollution and after a certain threshold level of income, environmental quality improves with income. Thus, EKC posits an inverted-U shaped relation and postulates that income is both the cause and cure of environmental degradation. The bulk of the environmental economics literature maintains that the impacts of income on pollution may not vary with the economic structure (ES). This study aims to contribute to the literature by investigating whether the income elasticity of pollution is different in economies with high manufacturing and industry shares than the economies with high services share i.e. servicified (de-industrialized). To this end, our results based on panel smooth transition regression (PSTR) procedure by Gonzalez et al. (2017) strongly suggest that ES, indeed, provides endogenous thresholds for the impact of income on CO_2 emissions.

Our results are mainly in line with the scale effect argument by Grossman and Krueger (1991) suggesting income leads to an increase in pollution. Thus, the empirical findings in this paper indicate the validity of monotonically increasing relation between income and pollution and do not provide a support to the postulated inverted-U shaped EKC. Our findings also suggest that the income elasticity of CO_2 emissions may not be invariant to the endogenously estimated threshold level of ES. In this context, we find that the income elasticity of CO_2 emissions is substantially much higher in economies with high manufacturing and industry shares whilst it is much lower in servicified economies. All these results, indeed, may suggest that the intensity of industry and services sector shares matter for the impacts of income on CO_2 emissions. In the context of income-environment relation, our findings indicate that the high intensity of industry sector, i.e. industrialization sharpens whilst the high intensity of services sector, i.e. servicification dampens the upward sloping part of EKC.

The empirical findings of this study, in accord with the recent literature, suggest that income is an important determinant of CO_2 emissions. In contrast to the conventional wisdom suggesting that service sector is “green” because it provides an improvement in environmental quality, the findings in this paper indicate that there is a positive association between income and CO_2 emissions even in servicified economies, albeit this impact is substantially much lower than the economies with higher manufacturing and industry shares. In accord with the Kaldorian postulation suggesting that manufacturing is the engine of growth (Kaldor, 1966; Aiginger and Rodrik, 2020), countries can change their relative income status, for instance, from low to middle income or from middle to high income, by investing and upgrading their manufacturing sector. Due to the evidence that manufacturing and industrial sectors are often regarded as "dirty" sectors with higher carbon emissions, the pulling and pushing impacts for greener and healthy economy, climate change and emission reduction technologies require the consideration of also societal goals along with economic ones in preparing the industrial policy. Consistent with the findings of Ikram et al. (2019), such a policy may be expected to contain also the adoption of an environmental management system to sustain better environmental protection and higher contribution to society. All these results may be interpreted as suggesting that countries may better to design and implement a strategic and systematic industrial policy placing the manufacturing industry at the core which promotes the use of emission reduction technologies and encourages manufacturing and industrial sectors with lower carbon emissions.

Declarations

Ethics approval and consent to participate: Not Applicable.

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Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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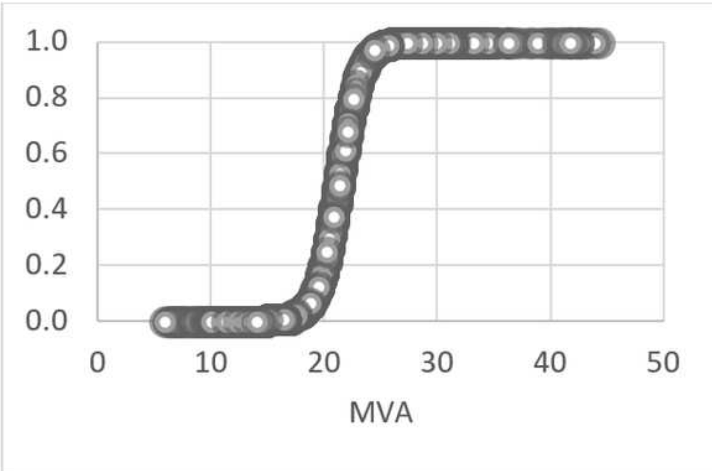
Figures



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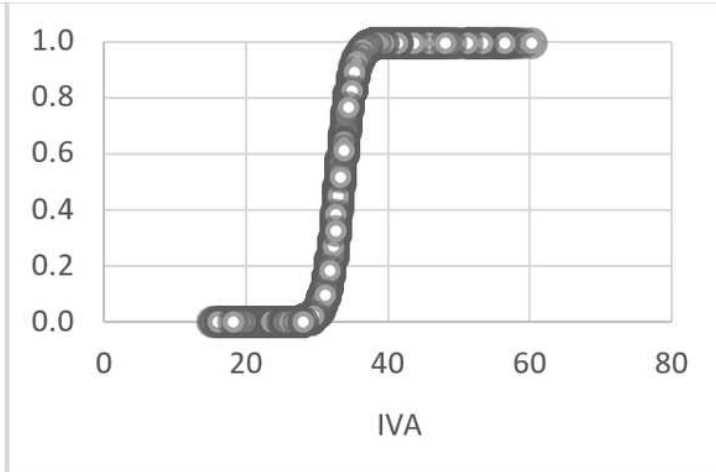

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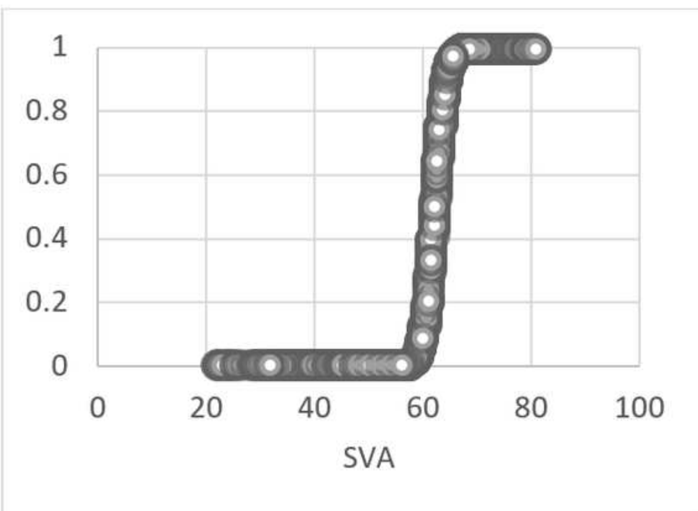

Figure 1.c

Figure 1

Transition function with respect to threshold/transition variables