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The Impact of Institutional Quality on Carbon Dioxide Emission : A Case Study in Asia-Pasific Countries

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Abstract:

Environmental issues occurring in the Asia Pacific region have become a highlight among state institutions. The recent increase in carbon dioxide emissions is considered a representation of environmental damage. The purpose of this study is to examine the effect of institutional quality on carbon dioxide emissions in 24 Asia Pacific countries. The interaction variables of GDP per capita and institutional quality, EKC hypothesis, urbanization and energy consumption are also used. The data were processed using STATA version 17 using the Generalize Moment of Method (GMM) estimation. The results of the study indicate that institutional quality, the interaction of GDP per capita and institutional quality have a significant negative effect on carbon dioxide emissions. GDP per capita has a significant negative effect on carbon dioxide emissions, but GDP per capita squared is significantly positive, meaning that the EKC hypothesis in the Asia Pacific case is contrary to the EKC Inverted U theory. Meanwhile, urbanization has a significant negative effect and energy consumption has a significant positive effect on carbon dioxide emissions. Finally, this study also suggests some valuable policy suggestions for governments/policymakers in general/specifically regarding developing countries to support their environmental sustainability.

Keywords: *Institutional Quality, Environmental Quality, Asia-Pasific, Emission*

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1. Introduction

Nowadays, environmental threats are increasing day by day due to increasing population growth, industrialization, and increasing economic growth (Yu et al., 2020). Seeing this, greenhouse gas (GHG) emissions, especially CO2 related to human activities are considered the main representation of global warming (Sadiq et al., 2022). CO2 emissions contribute more than 60% to global warming. According to the World Meteorological Organization (2021), CO2 levels have reached 149% higher than pre-industrial levels, an increase compared to 2017 data of 145%. This has the potential to change the climate system on earth for the worse due to the continuous use of fossil fuels from various sectors so that CO2 levels continue to increase (Our world in Data, 2017).

According to the International Energy Agency-IEA (2018)), the electricity sector is the dominant sector, reaching 13,625 MtCO2 or 49.04% of the total CO2 from fossil

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fuel use in 2014. The transportation sector is 7,547.3 $MtCO_2$, the manufacturing and construction industry sector is 6,230 $MtCO_2$, and other sectors are 1,683 $MtCO_2$. In Asia-Pacific countries, they are currently ranked first as contributors of CO_2 emissions in the world, reaching a value of 17,955 million metric tons, while in second place is North America which reaches 5,851 million metric tons, Europe which reaches 3,770 million metric tons, and followed by the Middle East, Commonwealth of Independent Countries, Africa, and finally South & Central America which reaches 1,258 million metric tons. This indicates that environmental quality in the Asia-Pacific region dominated by developing countries faces a lot of pressure and needs more attention to find a strategy to minimize it (Kamal et al., 2021).

Several empirical studies have been conducted to determine the appropriate anthropogenic model to identify the main driving forces behind CO_2 emissions and environmental degradation in general. Paul R. Ehrlich and John P. Holdre (1970) introduced the IPAT (Impact-Population-Affluence-Technology) model to explain the interaction between population, affluence, and technology on environmental impacts. Grossman & Krueger (1991) reproduced the Kuznets Curve to define a particular prosperity pattern measured by the inverted U-shaped relationship between income and environmental degradation. This curve is then known as the Environmental Kuznets Curve - EKC (Chow & Li, 2014). On the other hand, Dietz & Jorgenson (2015) developed a structural human ecology approach based on the interaction between humans and the environment to explore the effects of demographic variables such as population, urbanization, dependency ratio, and household size on environmental degradation (Li & Zhou, 2019; McGee & Greiner, 2018). Meanwhile, North (1990) introduced the relationship between institutional quality and the environment. Among these variables, institutional quality has come under the spotlight and is considered to be a factor influencing the increase in CO_2 emissions (Haldar & Sethi, 2021)

In recent years, institutional quality has attracted the attention of economists and policy makers in terms of environmental quality. Based on previous empirical studies, there are contrasting views on the impact of institutional performance on environmental quality. Some economists observe a positive relationship between institutional performance and environmental quality (Abid, 2016; Haldar and Sethi, 2020; Tuda & Machumu, 2019). For example, some studies argue that democracy improves environmental quality through freedom and political rights that create awareness among people about the optimal use of natural resources (Gallagher & Thacker, 2008). Similarly, Bhattacharya et al. (2017) studied that institutional quality and renewable energy significantly boost economic growth by reducing CO_2 emissions across different groups of countries.

On the other hand, few studies have observed that institutional performance has a negative impact or no impact on environmental quality (Ali et al., 2019). Another study, Azam et al., (2021) conducted a regression on the relationship between institutional performance, energy consumption, and environmental quality for 66 developing countries in 1991−2017. GMM estimation revealed that institutional performance is positively correlated with CO_2 emissions, forest area, and CH_4 emissions.

The main objective of this study is to investigate the effect of institutional quality on the environment, especially CO_2 emissions in Asia-Pacific countries during the period 1996-2021. This is considered important to do to fill the GAP related to the contrasting results of research on the topic. On the other hand, the use of institutional quality variables commonly used in previous studies includes 6 indicators at once such as voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law and control of corruption. According to Kim et al (2018) using all indicators of institutional quality can lead to over-parametrized specifications in the model. Thus, the current study uses control of corruption in assessing institutional quality. According to various studies, corruption is the most dominant factor in assessing institutional quality on the environment. Corruption has been considered to have both direct and indirect effects on the environment, because it weakens institutional performance, creates reent-seeking behavior and is an obstacle to the implementation of effective regulations (Wang et al., 2018). The selection of Asia-Pacific is also important, considering that the increase in CO_2 emissions has occurred in countries in the Asia-Pacific region. In fact, Asia-Pacific countries have become the top 30 largest contributors of CO_2 emissions in the world (Worldmeter, 2016) and Asia-Pacific has become the first largest contributor of CO_2 emissions in the world when compared to North America, Europe, and others (Statistia, 2021).

The framework used includes adopting Mehmood et al., (2021), Lau et al (2014), dan McGee and Greiner (2018) to test the impact of institutional quality, the interaction of GDP per capita and institutional quality on CO_2. This framework is also applied to test the EKC hypothesis and finally urbanization and energy consumption on CO_2. This study is expected to provide a contribution in the form of information regarding the effect of institutional quality on CO_2 emissions. In particular, this study is expected to provide benefits to stakeholders by providing new insights for further research as well as input and criticism for consideration in determining government policies.

2. Theoretical Background

Economy and Environment: In the economic system, the basic functions of production, distribution and consumption play an important role in the process of activity in the world. One of its roles is to provide input materials and energy. Without production and consumption, life would not be possible. Production and consumption activities also produce residual materials, or residuals, which will return to the earth.

The impacts caused by human activities on the environment are regulated in Law No. 23 of 1997 concerning environmental management. According to Suparmoko and Supamoko (2000), the environment acts as a source of raw materials for raw materials for consumption and assimilators for natural waste processing, as well as a source of entertainment. This shows the role of the environment as a provider of raw materials (M) and energy input for production and consumption. Production is the process of converting inputs into outputs carried out by producers including companies, public agencies, and non-profit organizations. Primary inputs from natural resources are raw materials such as minerals, wood, water, natural gas, and oxygen. All raw materials are processed using energy to produce goods and services (Field and Olewiler, 2011:27)

Institutional Quality: Institutional quality is good and effective institutional governance. This was introduced by Douglas North (1990), and he emphasized the importance of institutions in determining long-term economic outcomes, including natural resource management. Effective institutions create rules that enable sustainable use of natural resources and reduce environmental degradation. Along with its development, according to the World Bank (2021), it states that institutional quality can be assessed through 7 indicators, namely Accountability Voice, Political Instability, Government Effectiveness, Regulation, Rule of Law, Control of Corruption and Ease of Doing Business.

The Relationship Between Institutional Quality and Environment:

According to its development, since the theory of the relationship between institutional quality and the environment emerged, the degeneration of institutions in environmental management has caused widespread environmental challenges. Weak environmental laws, regulations, and policies, coupled with the lack of financial and human resources for their implementation and enforcement have created an institutional vacuum that has resulted in increased environmental degradation. Recently, based on previous empirical studies, it has been stated that controlling corruption has been considered the most dominant indicator because it weakens institutional performance, creates reent-seeking behavior and is an obstacle to effective regulatory implementation (Wang et al, 2018), but controlling corruption helps reduce emissions (Zhang et al., 2016) and Wang et al. (2018) found that controlling corruption reduces CO2 emissions not only directly but also indirectly through a moderating role. Several studies have found a non-linear relationship between regional quality and the environment and that high regional quality does not necessarily contribute to environmental efficiency

The interaction between GDP per capita and institutional quality also has an impact on CO2 emissions. This highlights the importance of effective governance structures and regulatory frameworks in promoting sustainability. Without strong institutional quality to support and enforce environmental policies, economic growth may not result in meaningful emission reductions, and may even worsen environmental degradation. Addressing institutional weaknesses and improving governance are critical to achieving economic development and environmental sustainability. This is in line with the research of Zhang et al. (2016) which underlines that institutional quality (such as environmental law enforcement, government oversight, or policies that support sustainability) can change the impact of GDP per capita growth on the environment, especially in reducing CO2 emissions.

Environmental Kuznets Curve (EKC): Economic growth has long been considered as one of the causes of increasing CO2. In the early phase of economic growth, it can cause pollution due to large energy input which will automatically increase pollution (Yang et al., 2021). In the second phase, the growth process will increase pollution at the maximum stage, after which it will be minimized in the final stage of economic growth, at this stage economic development is usually rationalized through the demand for natural resources, technological advances, and the addition of more renewable energy in energy consumption (Grossman & Krueger, 1995). This is called the Environmental Kuznets Curve (EKC) hypothesis.

IPAT Model: The IPAT model was first introduced by Ehrlich & Holdren (1971) to identify anthropogenic drivers of environmental impacts. To overcome the shortcomings of the original version built with identity equations, Dietz & Rosa (1994) modified the model into a stochastic form known as STIRPAT (Stochastic Estimation of Impact by Regression on Population, Affluence, and Technology) to account for random errors in parameter estimates. It is calculated using the following relationship.

$$I_i = \alpha P_i^b \, A_i^c \, T_i^d \, e$$

Where *I* represents the impact measured based on several environmental indicators, P is the population size, *A* represents prosperity or economic activity usually expressed per capita and *T* is technology, which is evaluated as the environmental impact per unit of economic activity.

Other authors have extended the demographic aspect of the original IPAT model by replacing technology with some other indicators. For example, increasing urbanization has been widely accepted as a driver of CO2 emissions, especially in developing countries (Al-mulali et al., 2012). Urbanization is defined as the increase in the population of people living in urban areas leading to increased economic activity, energy consumption, and emissions. However, the accumulation of urban population can lead to economies of scale in the use of public goods, lifestyle changes, and the diffusion of technologies to reduce the level of energy consumption and emissions. It is also important to note that there is no general conclusion about the impact of urbanization on CO2 emissions according to previous empirical studies. For example, Hao et al (2016) found a positive effect of inequality on CO2 emissions while Chikaraishi et al (2015) reported negative effects.

Energy consumption is also believed to have an impact on CO2 emissions as indicated by the use of more fossil fuels. According to J. Li et al (2023) stated in their research that energy consumption is the main cause of global warming and climate change. These studies specifically highlight the impact of fossil fuel consumption which is the largest contributor of greenhouse gases. Therefore, it is important to understand that increased fossil fuel consumption is directly related to increased CO2 which then worsens global environmental conditions. Something similar also happened in the BRICS region that energy consumption measured in kilowatts/hours has an impact on CO2 (Mu Tashim & Rudatin, 2024).

3. Methodology

This study uses a dynamic panel data regression method to test the effect of institutional quality on CO2 emissions in Asia-Pacific. On the other hand, researchers will also look at the interaction effect of GDP per capita and institutional quality and test the EKC hypothesis. Control variables such as urbanization and energy consumption are added in this study. The Generalized Method of Moments (GMM) method with data processing using STATA 17 software is applied to analyze the model. The type of data used is secondary data, namely a panel consisting of 24 countries in Asia-Pacific with a period of 1996 to 2021. All data used in this study were collected from the World Development Indicators (WDI), and Our World in Data.

The model used in this study is based on research conducted by Mehmood et al., (2021), McGee and Greiner, (2018). However, in this study it is slightly different from previous studies, the institutional quality variable in this study is represented by corruption control. The analysis model used in this study is as follows:

$$CO2_{it} = \beta_0 + \beta_1 CO2\text{-}1_{it} + \beta_2\ IQCC_{it} + \beta_3\ InGDP{*}IQCC_{it} + \beta_4\ lnGDP_{it} + \beta_5\ (lnGDP)^{\wedge 2} + \beta_6\ lnUP_{it} + \beta_7\ lnEC_{it} + \varepsilon_{it} \ldots\ldots\ldots$$

Description CO2-1 means CO2 emissions; IQCC is institutional quality; lnGDP*IQCC is the interaction of GDP per capita and institutional quality; lnGDP is GDP per capita; $lnGDP^2$ is GDP per capita squared; lnUP is urbanization; lnEC is energy consumption; $\beta 1 \ldots\ldots n$ is the regression coefficient; it is in country i in year t; ε is the error term.

Table 1. Variabel Description

Variable	Symbol	Measurement	Sources
Carbon dioxide emission	CO2	Metric ton	Our World in Data
Institutional quality	IQCC	Percentage ranking 0 means having the lowest ranking, and 100 for the highest ranking.	World Development Indicators (WDI)
Interaction of GDP per capita and institutional quality	lnGDP*IQCC	Using the numbers from each variable by multiplying them using the following formula; lnGDP x IQCC = lnGDPIQCC	World Development Indicators (WDI)

Variable	Symbol	Measurement	Sources
GDP per capita	lnGDP	Per Capita constant calculated based on base year 2010 (US$)	World Development Indicators (WDI)
GDP per capita squared	$lnGDP^2$	Using constant per capita data calculated based on the base year 2010 (US$) by multiplying it	World Development Indicators (WDI)
Urbanization	lnUP	Urban per 100 total population	World Development Indicators (WDI)
Energy consumption	lnEC	Kilowatt/hour	Our World in Data

Note: lnGDP, $lnGDP^2$, lnUP, and lnEC values transformed using natural logaritme (ln)

In this study, the System GMM approach will be used. This approach is a general estimator designed for situations such as: panel data with N>T, independent variables that are not completely exogenous, the existence of dynamic relationships because they depend on past realizations, individual effects, heteroscedasticity problems, and individual autocorrelation (Roodman, 2009). The criteria for determining the best system GMM estimator is the GMM specification test. This can be done by conducting the validity of the instrument variables by looking at the Hansen test or Sargan test. Meanwhile, to test whether a model has autocorrelation or not, by looking at the value of the Arellano - Bond z-statistic distribution or called AR (1) and AR (2). The instrument is valid if the value of the Hansen test or Sargan test is > significance level of 1%, 5%, 10%. The model is said to be indicated to have autocorrelation or not if the first order p value of the Arellano-Bond Test (AR-1) < significance level of 1%, 5%, 10%, while the second order p value (AR-2) > significance level of 1%, 5%, 10%. Furthermore, there is the Difference in Hansen statistics which consists of the Hansen test GMM, Difference GMM, Hansen test iv, Difference iv which have the same purpose, namely to see the validity of an instrument.

Next, to conduct a hypothesis test there are two ways, namely Partial Test (t-test), where if the p-value is below the significance level of 1%, 5%, 10% then there is a relationship between the dependent variable and the independent variable. While the Simultaneous Test (F-test) we can see if the value of Prob> chi2 is below the significance level of 1%, 5%, 10% then Ho is rejected and H1 is accepted, meaning that the independent variables together have an effect on the dependent variable.

4. Empirical Findings/Result

Deskriptif Statistik Variabel

Table 2. Descriptive Variabel (24 Countries)

Variable	Observation	Mean	Std. Dev.	Min	Max
CO2	624	5,30	5,42	0,12	23,94
IQCC	624	54,78	29,87	0,48	100
lnGDP*IQCC	624	510.00	342.70	2.59	1103.41
lnGDP	624	8,51	1,68	4,64	11,41
$lnGDP^2$	624	6.17	1.21	10738.52	8.26
lnUP	624	3,90	0,58	2,56	4,60
lnEC	624	9,57	1,39	6,41	12,14

Source: World Development Indicator (WDI), and Our World in Data (Data processed)

Table 2 presents descriptive statistics of 24 countries of the variables used in the period 1997 to December 2021. CO2 has an average of 5.30 with a minimum value of 0.12 and a maximum of 23.94. IQCC has an average of 54.78 with a minimum value of 0.48 and a maximum of 100. The interaction lnGDP*IQCC has an average of 510.00 with a minimum value of 0.48 and a maximum of 100. lnGDP has an average of 8.51 with a minimum value of 4.64 and a maximum of 11.41. $lnGDP^2$ has an average of 6.17 with a minimum value of 10738.52 and a maximum of 8.26. The average lnUP is 3.90 with a minimum value of 2.56 and a maximum of 4.60. lnEC in 24 countries has an average value of 9.57 with a minimum value of 6.41 and a maximum of 12.14

Resulth of Model Analysis and Hypotesis Testing

Results of GMM Regression

In this study, the test uses the GMM dynamic panel method, namely a combination of time series and cross-section data to analyze the influence of institutional quality, interactions between lnGDP*IQCC, lnGDP, $lnGDP^2$, lnUP, and lnEC on CO2 in 24 Asia-Pacific countries.

Table 3. Two-step GMM Estimator Results for 24 Countries

Variable	GMM System 2	
	Coefficient	*Prob*
CO2it-1	0,8898***	0,000
IQCC	-0,0149*	0,075
lnGDP*IQCC	-0,0029***	0,007
lnGDP	-0,9305**	0,000
$lnGDP^2$	0,0667***	0.000

Variable	GMM System 2	
	Coefficient	*Prob*
lnUP	-0,1341***	0,010
lnEC	0,5448***	0,000
Cons	-4,0628	0,605
AR (1)		0,133
AR (2)		0,906
Sargan Test		0,073
Hansen Test		0,768
Hansen Test (GMM)		0,454
Hansen Test (Diff GMM)		0,992
Hansen IV		0,306
Prob>F		0,000

Description: (***) 1% significance level, (**) 5% significance level and (*) 10% significance level

The results of the twostep System GMM test meet all GMM test assumptions. The Hansen test value is 0.768, this indicates that the overidentifying model test is said to be valid because the values that appear are at levels above all levels of significance. The value of AR (1) is 0.133 and AR (2) is 0.906, which means that in the equation there is no autocorrelation between variables in the model. The results of the independent variable IQCC test, lnGDP*IQCC interaction, lnGDP, $lnGDP^2$, lnUP, and lnEC from the probability below the level of significance

Spesifications tes results

In the GMM dynamic panel method, there is an overidentifying test that aims to determine the validity of a model used in the study. This test can be known by looking at the value of the Hansen or Sargan test that appears from the GMM regression results. A model is said to be valid if the value of the Hansen or Sargan test is above the significance level of 1%, 5%, and 10%. The results of the GMM system estimation in Table 3 show the p-value of the Sargan test of 0.733 and the Hansen test of 0.763. This shows that the overidentifying model test is said to be valid because the Hansen test value is at a level above all levels of significance. Furthermore, there are Difference in Hansen statistics consisting of the Hansen test GMM, difference GMM, Hansen test iv, difference iv which have a similar purpose to see the validity of an instrument. The results of the GMM system estimation in Table 3 show the p-value of the four statistics are above the significance level of 1%, 5%, and 10%. The Hansen test GMM value is 0.454; GMM difference of 0.992; Hansen test iv of 0.306; and difference iv of 1.000.

Autocorrelation test results

The Arellano – Bond test is a way to test whether a model is indicated to have autocorrelation or not by looking at the value of the Arellano – Bond z-statistic distribution or also known as AR (1) and AR (2). From the results of the GMM system estimation on the model in Table 3, it is known that the value of AR (1) is 0.133 and AR (2) is 0.906`, which means that in the equation there is no autocorrelation between the variables in the model.

Partial test results (t-test)

Partial tests are conducted with the aim of knowing how each independent variable influences the dependent variable in the study. Based on Table 3 above, the following are the values of each independent variable in influencing the dependent variable:

1) The lag of the endogenous variable explained by CO2it-1 is significant at the 1% level with a p-value of 0.000 (H0 is rejected) in each equation. This means that the output is inertial because it has a correlation between times or in the analysis of year t is still influenced by year t-1.
2) Institutional quality (IQCC) in Table 3 has a p-value of 0.075 which is significant at the 10% level (H0 is rejected) and a coefficient value of -0.0149. The negative value of the IQCC coefficient indicates that an increase in one percentage ranking index will reduce CO2 emissions by 0.0149 metric tons.
3) The interaction of lnGDP*IQCC in Table 3 has a p-value of 0.007, which means it is 1% significant (H0 is rejected) and has a negative effect with a coefficient value of -0.0029. The negative and significant coefficient value (p = 0.007) indicates that the interaction of lnGDP and IQCC reduces 0.0029 metric tons of CO2 emissions.
4) lnGDP and lnGDP2 are interpreted together. GDP per capita (lnGDP) in Table 3 has a p-value of 0.000 which is significant at the 1% level (H0 is rejected) and has a negative effect with a coefficient value of -0.9305. The negative value of the lnGDP coefficient indicates that a 1% increase will reduce CO2 by 0.9305 metric tons. While $lnGDP^2$ has a p-value of 0.000 which is significant at the 1% level (H0 is rejected) and has a positive effect with a coefficient value of 0.0667. This means that the EKC hypothesis is U-shaped. In this context, in the early stages of economic growth (when GDP per capita is still low), an increase in lnGDP may be associated with a decrease in CO2. However, after GDP reaches a certain level (turning point), further increases in GDP will increase CO2.
5) Urbanization (lnUP) in Table 3 has a p-value of 0.010 which is significant at the 5% level (H0 is rejected) and a coefficient value of 0.1341. The negative value of the lnUP coefficient indicates that a 1% increase in urban population will reduce carbon dioxide by 0.1341 metric tons.
6) Energy consumption (lnEC) in Table 3 has a p-value of 0.000 which is significant at the 1% level (H0 is rejected) and a coefficient value of 0.5448. A positive coefficient value indicates that an increase in lnEC by 1% will increase carbon dioxide by 0.5448 metric tons

Simultaneous test results (F-test)

Simultaneous tests are conducted to determine how independent variables simultaneously affect dependent variables. Simultaneous tests are conducted by comparing the prob value > F with a significance level of 1%, 5%, and 10%. If the resulting value is greater than the significance level, it can be said that the independent variables simultaneously do not affect the dependent variable (H0 is accepted), and vice versa. The results of Table 3 show a prob value > F of 0.000 or significance at the 1% level (H0 is rejected). This explains that all independent variables (IQCC, lnGDP*IQCC interaction, lnGDP, $lnGDP^2$, lnUP, and ln EC) simultaneously affect the dependent variable (CO2).

5. Discussion

The effect of institutional quality on CO2 emissions

The estimation results of the Twostep System GMM model (Table 3) show that institutional quality affects CO2 reduction by 0.0149 metric tons. This result is in line with the research of Zhang et al (2016) where in APEC countries mostly inhabited by Asia-Pacific members, the results show that strong institutions will improve the environment, but weak institutions will damage the environment. This confirms the findings by Kim et al (2018) that greater corruption worsens the environment and that institutional quality improves the environment.

On the other hand, the results of this study are in contrast to the study conducted by Azam et al. (2020) who conducted a regression on the relationship between institutional performance, energy consumption, and environmental quality for 66 developing countries during the period 1991-2017. GMM estimation revealed that institutional performance was positively correlated with CO2 emissions, forest area, and CH4 emissions. These results occur because developing countries have a level of democratic political system that mostly focuses on industrial progress and a large constituency level, so that the effect of improving institutional quality does not occur and on the contrary, that improving institutional quality can increase CO2 emissions. Likewise, Le & Ozturk (2020) also found a positive relationship between institutional activity and CO2 emissions. The results of Hussain & Dogan (2021) study also recently stated that institutional quality has a positive and significant effect on CO2 emissions. This can be strengthened by the poor role of institutions in a country, due to the low level of institutional quality in terms of corruption, political instability, accountability voices, religious groups or terrorism, and law and order, justice and law.

Institutional quality can actually reduce CO2 emissions. This was revealed by Mehmood et al (2021) in their research in Pakistan and Bangladesh where institutional quality can reduce CO2 emissions. One indicator in assessing institutional quality against CO2 emissions is controlling corruption. Corruption has been considered to weaken institutional performance, create reent-seeking behavior, and hinder the implementation of effective regulations in the Asia-Pacific region (Wang et al, 2018). So based on the research results obtained and strengthened by various previous studies, improving institutional quality in the Asia-Pacific region is very important in reducing CO2 emissions. Some of them are through controlling corruption.

The effect of interaction between GDP per capita (lnGDP) and institutional quality (IQCC) on CO2 emissions (CO2)

The results of the GMM Twostep System model estimation (Table 3) show that the interaction variable of GDP per capita and institutional quality has a significant negative effect on CO2. Judging from the regression results, the lnGDP*IQCC coefficient is 0.0029 with a significance value of 0.007. Based on these results, it means that the effect of GDP per capita on CO2 emissions depends on the level of institutional quality, negative interaction implies that institutional quality will reduce the positive impact of GDP per capita on CO2 emissions, in other words, countries with good institutional quality are better able to manage their economic growth so that they produce less CO2 emissions.

Few studies have conducted interactions between GDP per capita and institutional quality variables in the Asia-Pacific region. Researchers found some of them Mehmood et al (2021) where the results of this study contradict the results of our study which show that the interaction effect of institutional quality and GDP can increase emissions in Pakistan, but the independent role of institutional quality has an effect on reducing CO2 emissions. This is because Pakistan has a dependence on economic growth by emphasizing carbon-intensive industrial sectors, thus spurring the use of greater energy consumption, and having an impact on increasing CO2 emissions. However, his research also states that in India and Bangladesh, the independent role of GDP is indeed bad for environmental pollution, but the interaction role of institutional quality and GDP per capita significantly reduces CO2 emissions in the short and long term. Which means that institutional quality moderates the negative impact of economic expansion in India. This result is similar to Wawrzyniak & Doryń (2020)

Other empirical studies that support the results of our research, especially in the Asia-Pacific region, state that institutions consist of rules and regulations that can be important catalysts for achieving sustainable development. In addition, failure of institutional functions can damage the environment. When environmental regulations are strictly enforced, environmental quality can improve (Ibrahim & Law, 2016). Efficient institutions can also allocate dirty industries in the right way to increase economic growth without damaging the environment. His research also states that institutional quality can improve air quality and trade is detrimental to air quality in countries with low institutional quality, but trade is beneficial in countries with high institutional quality.

Based on the results of our research, of course, an increase in GDP per capita requires institutional intervention through appropriate laws and regulations so that it can reduce the effect of GDP per capita growth on CO2 emissions (Ali et al. 2019). The results of a study by Wang et al. (2018) in China, showed that increasing IQCC such as stricter policies on polluting industries can help reduce CO2 even though GDP per capita growth remains the same. Similar results were also obtained by Kumar & Madlener (2016) who stated that in India economic growth increases energy consumption which contributes to CO2 emissions, while better institutional quality can help reduce the negative impact of GDP per capita growth. This is in line with research by Zhang et al (2016), which emphasizes that institutional quality (such as environmental law enforcement, government supervision, eradication of corruption or policies that support sustainability) can change the impact of economic growth on the environment, especially in reducing CO2.

EKC hypothesis testing

The estimation results of the Twostep System GMM model (Table 3) GDP per capita initially gave a significant negative effect on CO2 of 0.9305 metric tons. The coefficient result for $\ln GDP^2$ was then 0.0667 which means it has a positive and significant value at the $p = 0.000$ level. This indicates a nonlinear relationship to CO2 which is inversely proportional to the pattern known in the Environmental Kuznets Curve (EKC). We can examine the detailed explanation in the two scenarios below;

First, the negative lnGDP per capita coefficient (-09305) can be interpreted that at lower lnGDP levels, economic growth in Asia-Pacific can significantly reduce CO2. This can be caused by several factors. First, initial efficiency in several Asia-Pacific countries still focuses on energy efficiency to increase productivity and reduce waste. The results of Adrian (2024) state that Vietnam also shows something similar, where at the beginning of economic growth it has resulted in increased energy efficiency and cleaner technology so that there is a decrease in CO2. Because the country is still focused on increasing industrial efficiency, investing in renewable energy and implementing policies aimed at reducing environmental impacts, this is also supported by the ASIAN Development Bank (2016) which occurred in India.

Second, the results of the $\ln GDP^2$ coefficient are significantly positive, indicating that environmental degradation increases after a certain GDP per capita. This is due to several factors, including economic growth that drives industrialization, thus increasing energy needs which are often still based on fossil fuels, the dominant of which is coal. According to data from the International Energy Agency (2023), global coal demand reached a record high in 2022, increasing by 4% year-on-year to 8.42 billion tonnes (Bt). China experienced growth (around 5%) and India more than 8% as did Indonesia, Vietnam, and the Philippines which together represent more than 70% of global coal demand. This is quite concerning because of course this will result in high CO2. Some examples of countries and projects in the Asia Pacific region that illustrate this context are Indonesia and Myanmar. According to data from the World Population Review (2024), Indonesia has experienced a change in forest area of 101,997 miles2, meaning -22.28% and is in second place after Brazil. Then, followed by the 4th position, namely Myanmar, which is -41,213 or -27.22%. So this causes quite high CO2 not only in the Asia Pacific Region, but in the World.

This result is slightly different from Leitão (2010). There are two main reasons from our perspective. For one, we focus on Asia-Pacific members in this paper and each country has different characteristics and tendencies to become developing countries, but Leitao (2010) selected 94 countries with varying levels of development and corruption from 1981 to 2000. Second, other studies such as (Xu et al., 2024) also produced similar and different results from this study. This is because the study has 8 countries with fairly high income levels and tends to become developed countries such as the United States, Japan, China, and Brazil. The results of the EKC hypothesis are also validated in the Mediterranean Area (Ohajionu et al., 2022).

The above results show that the EKC hypothesis is not always in accordance with the theory. In empirical studies that support the results of this study, such as Alam et al (2016) in their research stated that India is one of the countries that does not follow the classic EKC pattern. In India, despite increasing GDP per capita, CO2 actually increased. Similar research results also show that in China but in the short term (Alam et al., 2016; Lin et al., 2014)), Nepal, Afghanistan, Bangladesh and Sri Lanka (Mehmood & Tariq, 2020), Philippines and Vietnam (Shahbaz, 2022). Based on the explanation above, Asia-Pacific countries face the challenge of balancing economic growth with CO2 reduction.

The effect of urbanization on CO2 emissions

Urbanization affects the reduction of CO2 by 0.1341 metric tons, this is in accordance with the research of Poumanyvong et al (2012) which revealed that in several low- and middle-income countries, urbanization can contribute to the reduction of CO2 due to the shift to more efficient technology and better infrastructure in urban areas. In addition, another study by Sadorsky (2014) showed that urbanization in developing countries has a significant negative relationship with CO2, which can be caused by changes in energy consumption patterns or more environmentally friendly urban policies. Similar results were also found by Kusumawardani & Dewi (2020) who stated that urbanization has a significant and negative effect on CO2. cikaAlthough these results do not comply with the existing theoretical basis, the relationship between urbanization and CO2 tends to occur in different ways. One of them is in the Asia Pacific countries which are dominated by developing countries (Martines-Zarsoso and Maruotti, 2011).

The significant negative impacts shown by urbanization on CO2 can also be explained in two categories. First, strict urban management is supported by the research of Makido et al (2012) by analyzing the relationship between urban form and CO2 of urban areas in fifty cities in Japan. The results showed that there was a correlation between the spatial index of urban form and sectoral CO2 for the residential and passenger transport sectors. The inverse relationship between the compactness index and CO2 in their study indicated that less fragmented cities could emit less CO2 from the passenger transport sector than more dispersed cities. This suggests that less complex cities reduce CO2 per capita, but overly dense settlements in monocentric forms could cause greater CO2 per capita.

Second, what kind of pro-environmental government policies are produced by Ali et al (2017), in their research stating that a 1% increase in urbanization can result in a decrease in CO_2 in Singapore of 6,967 metric tons. This finding supports Sharma (2011) in 69 countries and Saidi & Mbarek (2017) for 19 developing countries. The results of the study also stated that urbanization does not cause environmental degradation in Singapore due to effective environmental policies and the resilience of state policy makers in implementing them efficiently.

The results of this study differ from previous theories and studies which state that urbanization can affect the increase in CO_2 emissions in the APEC Asean region (Mehmood and Mansoor, 2021). This is because growing cities are generally richer and more energy intensive than the rural areas where they obtain their populations. Thus, city dwellers will consume more energy when compared to rural lifestyles, so that urbanization itself drives an increase in CO_2 emissions (Little, 2016).

The effect of energy consumption on CO_2 emissions

Energy consumption (lnEC) has a significant effect on increasing CO_2 by 0.5448 metric tons. This is in accordance with the findings of several previous studies, such as Al-Mulali & Ozturk (2015) whose results state that energy consumption can increase environmental damage. In his research focused on the Middle East and North African Region during 1996-2012. On the other hand, the same relationship was found that energy consumption had an effect on increasing CO_2 emissions in China, India, Japan, US and Russia (J. Li et al., 2023).

Previous empirical studies in the Asia-Pacific region also obtained the same results as those conducted by Balli et al (2023) which stated that energy consumption had a significant positive effect on CO_2 emissions in the APEC countries during the period 1981 - 2021, meaning that the higher the energy consumption, the worse the environmental conditions. Furthermore, Rahman & Alam (2022) in their research in 17 Asia Pacific countries during 1960-2020 found that energy consumption has a negative impact on the environment by increasing CO_2 emissions. The negative impact on the environment from energy use is not only limited to energy consumption itself, but also includes the process of exploiting energy resources. This process often involves mining, drilling, and transportation activities that damage natural ecosystems and cause environmental pollution from waste and emissions from burning fossil fuels (Mu Tashim & Rudatin, 2024). Therefore, policy makers must be very careful in formulating and implementing energy policies. The policy must be designed in such a way that it can reduce the negative impact on the environment without hindering the energy consumption needs of the community.

The steps as conveyed by Malahayati & Masui (2021) state that increasing the efficiency of the use of fossil fuels, especially coal and gas, in the process of developing renewable energy infrastructure needs to be done to overcome environmental problems. In terms of employment, the government needs to prepare other sectors that can absorb workers, especially from the agricultural sector. Another crucial thing is to consider the possible economic impacts, especially in the medium term, the government needs to immediately implement the necessary mitigation policies. Otherwise, the government may need to prepare more spending to introduce more technologies and policies in the future. Policies such as the development of environmentally friendly technologies also need to be implemented, this is very important to achieve a balance between economic growth and environmental sustainability (Rahman & Alam, 2022).

6. Conclusions

Based on the results of the model estimation and the previous discussion, several conclusions emerge regarding the effect of institutional quality on CO2 emissions in Asia-Pacific countries. First, it is clear that improving institutional quality affects the reduction of carbon dioxide emissions. This means that the higher the institutional quality, the lower the CO2 emissions. Second, the interaction of GDP per capita and institutional quality has a significant negative effect on CO2. This means that the higher the GDP per capita, the higher the impact on increasing CO2 emissions due to dependence on the use of fossil fuels, so that an increase in GDP per capita is needed which is balanced by an increase in institutional quality to reduce the impact of GDP per capita on CO2 emissions. Third, GDP per capita has a significant negative effect and GDP per capita squared has a significant positive effect on CO2. These results indicate that the EKC hypothesis is U-shaped and inversely proportional to the actual "inverted U" pattern known as the Environment Kuznetz Curve (EKC). This means that at the beginning of growth, 24 countries in the Asia Pacific region tended to reduce CO2 emissions through energy savings. The next stage, when growth reached a certain point (turning point), there was an increase in GDP per capita, which resulted in a focus on industrialization, so that energy consumption was carried out on a large scale and automatically had an impact on increasing CO2 emissions. Control variables such as urbanization have a significant negative impact on CO2 emissions, meaning that the higher the population movement from rural to urban areas will reduce CO2 emissions. This can happen if regulations regarding urbanization are carried out strictly, such as urban planning that is not too complex in terms of population, then increasingly strict pro-environmental policies that reduce the potential for people who carry out urbanization to pollute the environment. Finally, energy consumption affects CO2 emissions, meaning that the higher the use of energy in a country, the worse the environmental degradation, especially CO2 emissions.

The conclusion of this article is very important for policy making, which can be described in the following aspects: To reduce CO2 emissions, government institutions need to then improve the democratic system, limit religious groups/terrorism, effective law enforcement, political stability and control of corruption. Control of corruption is considered the most dominant that can improve institutional performance, create profit-seeking behavior and even implement effective regulatory implementation. Thus, this corruption control is the most influential factor in assessing institutional quality and is able to reduce CO2 emissions. The government also needs to control the negative impacts of the continued increase in GDP per capita which still emphasizes the carbon-intensive industry. This control can be done through mitigation policies and the use of environmentally friendly technology. On the other hand, urbanization can also reduce CO2 emissions but with various notes, including the government can implement policies such as urban governance that is not too complex, then implement pro-environmental policies for people who are urbanizing. The good impact of urbanization can also reduce CO2 emissions when the level of public awareness of the environment increases. So, this needs to be a note for the government. Finally, in the context of energy consumption, the government needs to make efficient use of fossil fuels, especially coal and gas, in the process of developing the latest energy infrastructure also needs to be done to overcome environmental problems. The government can also shift the workforce to other sectors such as the agricultural sector.

However. It is important to acknowledge some limitations in this study. First, this study did not select countries based on the level of GDP per capita of a country, so that further research can select countries based on the level of GDP per capita such as middleincome countries, low income countries or high income countries and make comparisons based on the income level. Second, in this study using variables such as energy consumption and urbanization, the researcher suggests in the future to use culture as a variable especially in looking at its relationship with the environment. This is quite important because culture can cover one country with another country very differently.

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