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Institutional quality, employment, FDI and environmental degradation in developing countries: evidence from the balanced panel GMM estimator

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Abstract

Purpose – The main purpose of this research is to examine the impact of institutional quality and sectoral employment on environmental degradation in developing countries. This paper also re-examined the validity of the Environmental Kuznets Curve (EKC) hypothesis and estimated the long run impact of explanatory variables on CO_2 emissions.

Design/methodology/approach – In this paper, the balanced panel data for the period 2002–2016 was used based on data availability and applied two-step SYS-GMM estimators.

Findings – The results showed that institutional quality such as government effectiveness (GE) and the rule of law (RL) reduce CO_2 emissions and promote environmental quality in developing countries. Interestingly, the authors found new evidence that employment in agriculture and industry has a positive impact on pollution, while employment in the service sector was negatively associated with CO_2 emissions, and the validity of the EKC hypothesis was confirmed. In addition, the research suggests that strong institutional frameworks and their effective implementation are the most important panacea and should be treated as a top priority to counteract environmental degradation and achieve the UN Sustainable Development Goals.

Originality/value – This is the first study to examine the short run and long run effects of institutional quality and sectoral employment on environmental degradation using the balanced panel data for a large sample of developing countries. This paper also used a special technique of Driscoll and Kraay standard error approach to confirm the robustness results and showed the different roles of sectoral employment on environmental quality.

Keywords Environmental degradation, Institutional quality, Sectoral employment, EKC hypothesis, Two-step SYS-GMM, Developing countries

Paper type Research paper

1. Introduction

Environmental degradation has become one of the burning issues and major concerns affecting the Sustainable Development Goals due to the rapid increase in carbon emissions and global warming (Ahmed *et al.*, 2020; Ibrahim and Law, 2016). It has been extensively

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discussed and frequently raised by several researchers from both developed and developing countries. Many governments have made every effort to address environmental issues (Dasgupta *et al.*, 2001) and their adverse effects on the human and green SDGs (Xaisongkham *et al.*, 2019). To the best of our knowledge, the effectiveness of institutional performance has played an indispensable role in reducing CO_2 emissions and improving environmental quality. However, developing countries today face major challenges in dealing with pollutants, as the majority of CO_2 emissions still come from developing countries (Ahmed *et al.*, 2020; Lau *et al.*, 2014; Sah, 2021; Wawrzyniak and Doryń, 2020). In addition, the causes of pollutant emissions in developing countries are still unclear and controversial (Ha and Nguyen, 2021).

Numerous studies have confirmed that countries with a strong institutional framework are more likely to contribute to mitigating CO_2 emissions, greenhouse gases, climate change and improving environmental quality (Ahmed *et al.*, 2020; Dées, 2020; Ibrahim and Law, 2016; Khan and Rana, 2021; Ntow-Gyamfi *et al.*, 2020; Sah, 2021). Institutional quality can contribute to advocating for sustainable development (Hunjra *et al.*, 2020), as improving institutional performance is an essential tool to control and reduce pollutant emissions in economic development progress (Lau *et al.*, 2014). Another study argued that institutional quality has a positive impact on per capita CO_2 emissions growth (Runar *et al.*, 2017) and degrades environmental quality (Islam *et al.*, 2021). Institutional performance plays a significant role in linking FDI and pollutants, climate change lowers productivity growth, but good institutions help reduce the negative impacts of climate change by adjusting the process of technology adoption in developing countries (Ha and Nguyen, 2021; Kumar and Managi, 2016). In this regard, it is imperative to strengthen institutions to manage more effective and efficient practices where a well-functioning institution could be imposed by appropriate regulations, laws, property rights and corruption control that help mitigate pollutant emissions (Ali *et al.*, 2019). Although, institutional quality attracts FDI to developing countries (Masron, 2017; Masron and Abdullah, 2010), the growth of FDI leads to an increase in CO_2 emissions, and appropriate institutional frameworks and decision-making mechanisms are crucial to address environmental issues (Karki *et al.*, 2005). Therefore, the relationship between institutional quality and CO_2 emissions remains a key challenge in research circles to achieve the United Nation's SDGs (Haldar and Sethi, 2020). Regarding the links between pollution and employment, previous studies have documented that foreign job creation leads to an increase in environmental atrophy, even in countries with shrinking domestic employment (Zhong and Su, 2021). Environmental regulations are becoming an important means of curbing CO_2 emissions, affecting both direct and indirect employment levels by promoting technological innovation and industrial structures (Cao *et al.*, 2017). In general, a reduction in CO_2 emissions leads to high job losses, but promotes labor-intensive sectors. In particular, the service sector could achieve a win-win situation for economic development, reduction of environmental degradation and stable employment (Bai *et al.*, 2021), while long working hours for households cause CO_2 emissions and degrade environmental quality in the United States (Fremstad *et al.*, 2019).

The links between renewable energy consumption (REC) and environmental degradation remain unclear and are widely discussed in the existing literature. Recent studies have confirmed that REC contributes to reducing CO_2 emissions (Ehigiamusoe and Dogan, 2022; Salahodjaev *et al.*, 2022; Khan *et al.*, 2021), while Murshed *et al.* (2022) argued that REC degrades environmental quality but becomes an important impetus to reduce pollution (Sun *et al.*, 2022) and achieve long-term climate goals (Haldar and Sethi, 2020). In general, foreign direct investment (FDI) not only boosts economic growth, but also contributes to environmental degradation in developed and developing countries through resource consumption and industrial growth. Some literature showed that FDI inflow has a negative impact on CO_2

emissions (Xaisongkham *et al.*, 2019) and can effectively improve environmental quality through technological progress (Yuan *et al.*, 2021) because it brings modern and clean technologies to the recipient countries (Zakaria and Bibi, 2019). In contrast, Ha and Nguyen (2021) and Wawrzyniak and Doryń (2020) indicated that an increase in FDI inflow leads to a rise in pollutant emissions. However, the relationship between FDI and environmental degradation is still mixed (Muhammad and Long, 2021) and controversial in the existing studies. In summary, many researchers have focused on key macroeconomic variables as research alternatives in addressing environmental issues but still ignore the role of government effectiveness (GE) and the rule of law (RL) in mitigating CO_2 emissions, where these two indicators, in facts could contribute to better environmental quality. In our opinion, the impact of institutional quality and sectoral employment on pollutant emissions remains opaque and has not been thoroughly studied in a large sample of developing countries, while there may be a "double-edged sword" between employment and environmental degradation. Based on the main issues discussed above, there is an urgent need to examine in-depth the relationship between institutional quality and sectoral employment with environmental atrophy in order to gain further insights into the policy implications in the selected developing countries.

Based on previous studies, our research contributes to five aspects. First, we consider balanced panel data to re-test the validity of the environmental Kuznets curve (KC) hypothesis (Bilgili *et al.*, 2016; Wawrzyniak and Doryń, 2020) by incorporating sectoral employment (i.e. employment in agriculture, industry and services) into the estimated model for a large sample of developing countries, which is still questionable in the existing literature (Dinda, 2004). Second, this paper responds to call for research by integrating the impact of selected explanatory variables on CO_2 emissions in the context of developing countries (Bilgili *et al.*, 2016). Third, we simulated the estimated model to incorporate new control variables through sectoral employment that are believed to have an impact on environmental degradation but are still ignored in the previous literature. The simulation of sectoral employment as an explanatory variable is interesting to gain new insights into the relationship between sectoral employment and CO_2 emissions in developing countries. Fourth, our research is considered one of the relatively few studies that will uncover the unsolvable problems, namely: Does institutional quality actually mitigate environmental atrophy in developing countries? We also consider the crucial role of institutional quality in reviving environmental quality, which is still criticized in previous studies, and none of them considered the impact of institutional quality and sectoral employment on CO_2 emissions for developing countries. Fifth, we estimate the long run coefficient according to the statistically significant variables in the short run to analyze the comparative effect between the short run and long run relationship.

Finally, this paper uses the balanced panel data over the period 2002–2016 (15 years) for 115 developing countries, as we argued that using a large sample and more complete data would provide more accurate results and avoid estimated errors. We also employ the two-step GMM estimator, and one of the advantages of this technique is that it can handle serial correlation, heteroscedasticity, non-normal distribution and endogeneity problems. The remaining aspects of the work are structured as follows. Section 2 briefly manifests the reviews of the previous literature. Section 3 presents methodology, data collection, model specification and testable hypotheses. Section 4 illustrates the empirical findings and discussions, and Section 5 summarizes the main findings and some policy implications.

2. Reviews of the related literature

2.1 Environmental Kuznets curve hypothesis

Over the decades the relationship between economic development and income inequality has become one of the seminal works of (Kuznets, 1955). The main concept of the KC posits that income inequality increases in the early stages of economic development and then decreases as a result of economic growth, and this phenomenon is known as the inverted U curve relationship (KC). Later, a seminal study by (Grossman and Krueger, 1995) was extended as an inverted U-shaped relationship between pollution and GDP per capita or presence of the EKC hypothesis. The concept of the EKC hypothesis is widely used in theoretical and empirical studies to test a hypothetical relationship between environmental atrophy and GDP per capita. Previous studies have shown that the process of economic growth in which pollutant emissions first increase and then decrease as GDP increases after reaching a threshold. This phenomenon shows an inverted U-shaped relationship between per capita income and pollution. Despite the fact that much research has been extensively tested for the existence of the EKC hypothesis, the persistence of an inverted U-shaped relationship between economic growth and CO_2 emissions in developing countries remains ambiguous (Dinda, 2004). To the best of our knowledge, the validity of the EKC hypothesis is still questionable from several aspects, such as (Bilgili *et al.*, 2016) mentions that the EKC hypothesis occurs only in developed countries and may not occur in developing countries. Therefore, this paper responds to call for research by re-testing the EKC hypothesis in 115 developing countries.

2.2 Institutional quality related to CO_2 emissions

Recently, previous literature studies (Khan and Rana, 2021) used panel data from 1996–2015 for 41 Asian countries to examine the link between institutional quality and CO_2 emissions. The results showed that better economic and political institutions lead to a reduction in environmental degradation. Subsequently (Sah, 2021) suggested the need to clean up the institutional arrangement by improving GE, anti-corruption mechanisms, regulatory compliance and the implementation of legal and institutional reforms to ensure that they have a high institutional quality to deal with environmental issues. Ntow-Gyamfi *et al.* (2020) found that a strong institutional framework helps to mitigate the long run adverse effects of financial development on CO_2 emissions, and that improving institutional quality is more likely to promote sustainable development in South Asia (Hunjra *et al.*, 2020). Furthermore, institutional quality, trade, openness and financial development are the main factors to enhance environmental quality (Ahmed *et al.*, 2020).

Ali *et al.* (2019) recommended that it is imperative for developing countries to strengthen institutions and operate effectively, since the effective functioning of institutions will deliver appropriate regulations and laws that could reduce carbon emissions; Kumar and Managi (2016) confirmed that the process of technological exploitation can address pollutants and climate change at low cost in developing countries; Ibrahim and Law (2016) claimed that the impact of trade on environmental degradation depends on countries' institutional formation, trade openness increases CO_2 emissions in countries with low institutional quality, but benefits in improving environmental quality for countries with high institutional quality. In general, institutional quality becomes an important tool to mitigate environmental degradation in the process of economic development, and strong institutional frameworks are key factors to achieve high economic growth without sacrificing environmental risk (Lau *et al.*, 2014). Conversely, Runar *et al.* (2017) showed that institutional quality has a positive impact on CO_2 emissions, boosts economic growth and produces a positive indirect effect on pollution in the global samples; Wawrzyniak and Doryń (2020) found that countries with low institutional quality show diminishing increases in CO_2 emissions as GDP increases and vice versa. This suggests that emerging and developing countries should strive to enhance the institutional backgrounds to reduce environmental degradation.

Hassaballa (2015) showed that trade openness, income per capita, manufacturing valued added and corruption are key determinants of environmental degradation. The research also suggested that law enforcement, increasing transparency and spreading public awareness lead to reductions in pollutant emissions. Corruption control and the RL are negatively associated with CO_2 emissions, and a strong relationship between the size of industrial sector and trade openness with environmental degradation was confirmed in the study by (Azamat, 2012), while Sekrafi and Sghaier (2018) pointed out that corruption control is positively associated with carbon emissions and economic growth; Castiglione *et al.* (2015) found a negative association between the RL and pollutant emissions, and RL matters both the environment and economic growth. The RL acts as a facilitator and promotes a win-win situation, and strong institutional quality increases income levels in high-income countries. Furthermore, Gholipour and Farzanegan (2018) revealed that government spending on environmental protection mitigates CO_2 emissions when institutional quality is improved; however, government spending alone did not play an important role in promoting environmental quality.

2.3 Employment and CO_2 emissions

The relationship between employment and CO_2 emissions has received little attention and is still debated in the existing literature. For example, Fremstad *et al.* (2019) estimated the impact of working hours on CO_2 emissions using household data from the United States and confirmed strong evidence that households working long hours cause CO_2 emissions; Bai *et al.* (2021) pointed out that reducing pollution would normally lead to high job losses and promoting labor-intensive service sector can achieve a multi-win situation for economic development, stable employment and reduction of CO_2 emissions. Findings also confirmed that rising consumption and household incomes can boost economic growth and job creation and mitigate environmental degradation in China; Likewise, the existing literature comments that environmental regulations not only affect employment levels directly, but also have indirect effects by promoting upgrades in technological innovation and industrial structure in resource-based areas of China (Cao *et al.*, 2017). In addition, the effect of foreign job creation predominantly increases carbon emissions, even in economies with declining domestic employment, where carbon emissions growth has declined mainly through intensity effects, followed by structural changes in the labor market thanks to participation in value chains, while CO_2 emissions were driven by the impact of job creation and labor productivity (Zhong and Su, 2021).

2.4 Renewable energy consumption and CO_2 emissions

REC is a crucial panacea to mitigate environmental degradation. Recently, previous literature studies have shown that REC reduces CO_2 emissions for low-income countries (Ehigiamusoe and Dogan, 2022), Europe and Central Asia (Salahodjaev *et al.*, 2022), global income countries (Khan *et al.*, 2021), Argentina (Yuping *et al.*, 2021) and selected Asian countries (Anwar *et al.*, 2021). On the contrary, Murshed *et al.* (2022) pointed out that REC increases CO_2 emissions in G7 countries and suggested that a clean energy transition could enable these countries to switch production processes in an environmentally friendly way. One study found that REC can control CO_2 emissions in both the short and long-term (Bouyghrissi *et al.*, 2021), while another study found that REC mitigates pollution in the medium and long run (Adebayo *et al.*, 2021). Nevertheless, Haldar and Sethi (2020) argue that REC reduces CO_2 emissions in the long run and that developing countries need to deploy more REC to meet long-term climate goals. REC becomes the optimal solution to combat carbon emissions (Sun *et al.*, 2022); it plays a crucial role in achieving sustainable environmental goals (Abbasi *et al.*, 2022). Therefore, promoting renewable energy management could also lead to environmental sustainability through the reduction of CO_2 emissions (Raihan and Tuspekova, 2022).

2.5 Foreign direct investment and CO_2 emissions

The associated direction between FDI and environmental atrophy has long been debated and given much attention in many studies. For example, Yuan *et al.* (2021) found that FDI inflow could effectively improve environmental quality through technological advances; it has a negative impact on CO_2 emissions (Xaisongkham *et al.*, 2019), as it brings cutting-edge and efficient technologies to promote environmental quality in recipient countries (Zakaria and Bibi, 2019). On the other hand, FDI is the main channel to increase CO_2 emissions and degrade environmental quality. It is positively associated with pollutant emissions (Ha and Nguyen, 2021; Seker *et al.*, 2015; Wawrzyniak and Doryń, 2020). A study found that the impact of FDI on environmental degradation is mixed. For example, Muhammad and Long (2021) claimed that FDI increases CO_2 emissions in low, lower-middle and upper-middle-income countries while enhancing environmental quality and reducing CO_2 emissions in high-income countries; Whether FDI has a positive or negative impact on pollutant emissions depends on the choice of indicators used as control variables (Haldar and Sethi, 2020). To curb pollutant emissions, developing countries must carefully consider how to attract and welcome FDI into their countries and comply with international environmental agreements/regulations (Ha and Nguyen, 2021). In a word, this research has argued that the impact of FDI remains mixed and opaque in previous literature studies.

2.6 Conclusions of the existing literature

Based on the above discussions, this paper fills in the existing gaps as follows: (1) many literature studies mainly used pool OLS, fixed effects model, random effects model and difference GMM estimator. To overcome the shortcomings of these techniques, we applied the two-step system GMM estimator proposed by (Windmeijer, 2005). This technique can be severely downward biased for small sample sizes and outperformed the one-step system GMM. (2) Most studies used small samples for both developed and developing countries with unbalanced panel data, but this paper focused on the balanced panel with a large sample of 115 developing countries. In our opinion, using the balanced and complete panel data could provide more accurate results and avoid possible misjudgments. (3) We estimate the long run effects of explanatory variables on environmental degradation based on the two-step system GMM estimator, which is very useful for policy analysis, while previous studies only analyzed the short run effects. (4) The current research also used a special method introduced by (Driscoll and Kraay, 1998) to check the robustness of the results. This approach can fit both balanced and unbalanced panel data, solve cross-sectional dependency, heteroscedasticity, serial correlation and other problems in estimating panel data that provide robust results. (5) Previous studies have mainly focused on the overall effects between employment and CO_2 emissions for an ad hoc case, labor market dynamics and household surveys, but this paper thoroughly analyzes the impact of sectoral employment on environmental degradation in developing countries.

3. Methodology and data collection

To test the validity of the EKC hypothesis, we follow a quadratic relationship model from a seminal work (Bilgili *et al.*, 2016). It is stated as follows:

$$CO_2 = f\left(Y,\ Y^2,\ F\right) \tag{1}$$

Where CO_2 emissions, Y and Y^2 denote environmental degradation, per capita income and its square, respectively. F represents other explanatory variables that assume to affect pollution. Here we consider the independent variables to be substituted in equation (1) and a new function can be re-written as:

$$CO_2 = f\left(Y,\ Y^2,\ REC,\ FDI,\ EMP\right) \tag{2}$$

Given REC, FDI and EMP represent REC, FDI and sectoral employment (agriculture, service and industry) respectively. We first re-examine whether there is an inverted U-shaped relationship between economic growth and pollution for 115 selected developing countries. As argued by (Wawrzyniak and Doryń, 2020), many studies used energy consumption as an independent variable, but our work extends a seminal work (Bilgili *et al.*, 2016) by incorporating REC in the estimated model to test the EKC hypothesis, because the relatively few studies have focused on it, and none of the previous studies have analyzed using balanced large panel data. To do this, we estimate the GMM estimator to test the validity of the EKC hypothesis as the following equation:

$$CO_{2it} = \beta_0 + \ln\beta_1 Y_{it} + \ln\beta_2 Y_{it}^2 + \beta_3 REC_{it} + \beta_4 FDI_{it} + \beta_5 EMP_{it} + \mu_{it} \quad (3)$$

Where β_0, β_1 and μ represents the intercept, the coefficient of each explanatory variable and the error term, respectively. The subscripts i and t are the time period and country. Based on the EKC hypothesis, we expect that the *coefficient of GDP per capita* (Y_{it}) and *its square* (Y_{it}^2) are positively and negatively associated with CO_2 emissions, suggesting the existence of an inverted U-shaped relationship between per capita income and pollution (H_1). By considering assumptions that institutional quality (IQ_{it}) improves environmental quality and mitigates CO_2 emissions (Ahmed *et al.*, 2020). For this reason, the *coefficient of* IQ_{it} is postulated with a negative sign (H_2). Theoretically, REC_{it} considers clean and green energy, where increasing the recycling process of various energies can help improve the quality of the environment. It is also postulated that due to the increase in pollutants in developing countries, some steps need to be taken to address environmental issues. At the same time, governments in developing countries will uphold the use of renewable energy as an additional option to reduce CO_2 emissions. As a result, we postulate that the *coefficient of* REC_{it} is negatively associated with the explained variables (H_3).

Some literature has argued that FDI is more likely to mitigate carbon emissions when it invests in and adopts cutting-edge, clean, green and advanced technologies (Tang and Tan, 2015). However, in this paper, we argue that FDI leads to carbon emissions because developing countries have some limitations, especially lack of capital to promote green investment sectors, low technology, uncontrolled environmental regulations, lenient environmental standards and most of them import the second materials and stuff from developed countries. Also, developing countries may only focus on attracting FDI, while they may not pay enough attention to taking the initiative to solve environmental problems, and these countries are more likely to bring older and used technologies from developed countries. Therefore, it is postulated that the *coefficient of FDI* is positively related to CO_2 emissions (H_4).

Interestingly, we also extend the estimated model by incorporating sectoral employment as a set of regressors, which is still neglected in the past literature. In this paper we assume that sectoral employment, in general increases CO_2 emissions, and one of the possible explanations can be attributed to the fact that the increase in employment occurs when business, industry and FDI grow in different sectors. This leads to high demand and structural changes in the labor market, labor participation, job creation and causes more CO_2 emissions (Zhong and Su, 2021). For this reason, we postulate that the *coefficient of sectoral employment* (i.e. employment in agriculture, industry: EII and services: EIS) is positively associated with the explained variable (H_5). To estimate the impact of institutional quality, employment, FDI and REC on environmental degradation, it can be re-written as:

$$CO_{2it} = \beta_0 + \ln\beta_1 Y_{it} + \beta_2 IQ_{it} + \beta_3 Y_{it} IQ_{it} + \beta_4 REC_{it} + \beta_5 FDI_{it} + \beta_6 EMP_{it} + \mu_{it} \quad (4)$$

Where, IQ represents dimensions of institutional quality as measured by GE and RL. We use the estimated institutional quality score, which ranges from −2.5 (weak government performance) to 2.5 (strong government performance). More importantly, we also applied the multiplicative interaction model by following a seminal work under the conditional hypothesis that a relationship between two or more variables under consideration depends on the value of other variables (Brambor *et al.*, 2006). We postulate that the impact of GDP per capita on environmental degradation depends on institutional quality. We then estimate the interaction model by substituting each constitutive term in the estimated model, namely (Y × GE) and (Y × RL), respectively. Nevertheless, all constitutive terms should be included in the estimated model, since omitting the constitutive term produces inconsistent and biased estimates in each coefficient of the explanatory variable (Brambor *et al.*, 2006). The rationale for the selection of 115 developing countries is based on data availability over the period 2002–2016. The authors emphasize the use of the balanced panel data, which can circumvent the problems of panel analysis, correct the biased estimates and provide more accurate results than the unbalanced panel data (missing value). More importantly, developing countries currently face major obstacles and bottle-necks to curb carbon emissions resulting from industrialization and many aspects of economic activity. In short, there is an urgent need for further research in developing countries with weak institutional quality and for a deeper understanding of the interaction effects between variables. Therefore, we believe the results of this research could provide useful guidelines for dealing with environmental atrophy in developing countries.

To uncover the impact of institutional quality, employment, FDI and REC on environmental degradation, we apply a generalized method of moments (GMM). This technique can handle autocorrelation, heteroscedasticity, endogeneity and other unexpected issues in panel estimation that may arise in the model. There are two forms of GMM estimators such as (1) difference GMM estimator (DIF-GMM) introduced by (Bond, 1991) and (2) system generalized method of moments (SYS-GMM) introduced by (Arellano and Bover, 1995; Blundell and Bond, 1998). The DIF-GMM estimator suffers from some shortcomings and may perform poorly when the dependent variable is close to a random walk because the previous levels convey little information about the future changes and untransformed lags are likely to be weak tools for transformed variables (Roodman, 2009a, b). Explanatory variables are persistent over time and the observation period used in the estimated model is small and limited (Alonso-Borrego *et al.*, 1999; Blundell and Bond, 1998). To deal with dynamic panel bias and yield more efficient estimates, we use two-step SYS-GMM to estimate both the short-run and long-run effects of the explanatory variables on CO_2 emissions. Since the estimated result are severely downward biased with small sample size, and the Wald test for estimates of the two-step SYS-GMM has more power than the Ward test for the one-step SYS-GMM (Windmeijer, 2005). To estimate this, we have collected data from various sources (see appendix).

4. Results and discussions

4.1 Results

To conduct this research, we estimated SYS-GMM estimators developed by (Arellano and Bover, 1995; Blundell and Bond, 1998) and included time dummies to eliminate universal time related shocks from error terms and correlation across individuals in the idiosyncratic disturbances (Roodman, 2009a). We also addressed the problem of instrument proliferation by collapsing the number of instruments to produce less bias (Roodman, 2009a, b).

Table 1 shows the estimated results of the EKC hypothesis for both the one-step SYS-GMM and two-step GMM estimator. As suggested by (Windmeijer, 2005), the two-step SYS-GMM are severely downward biased for small sample size, and the Wald test, which is based on the two-step SYS-GMM has more power than the Ward test for the one-step SYS-GMM. Therefore, we decided to use the results of the two-step SYS-GMM estimator by (Windmeijer, 2005) for our research. Empirical evidence showed that GDP per capita and its

Table 1.
Estimation outcomes of the EKC hypothesis with one and two-step SYS-GMM

Regressors	(1)	One-step SYS-GMM (2)	(3)	(4)	(5)	Two-step SYS-GMM (6)	(7)	(8)
CO_{2t-1}	0.9326^{***} (0.0525)	0.9486^{***} (0.0440)	0.9306^{***} (0.0527)	0.9311^{***} (0.0541)	0.9024^{***} (0.0636)	0.9294^{***} (0.0520)	0.8978^{***} (0.0658)	0.9055^{***} (0.0622)
Y	1.3924 (0.9737)	2.4218^{***} (0.8628)	1.1916 (1.0671)	1.5027^{*} (0.8299)	1.7643^{**} (0.8455)	2.3226^{***} (0.6219)	1.5732^{*} (0.9654)	1.8072^{***} (0.6711)
Y^2	−0.0804 (0.0626)	-0.1430^{***} (0.0528)	−0.068 (0.0681)	−0.0832 (0.0540)	-0.1031^{*} (0.0562)	-0.1384^{***} (0.0377)	−0.0909 0.0638	-0.1035^{**} (0.0447)
REC	−0.0022 (0.0025)	−0.0022 (0.0024)	−0.0020 (0.0022)	−0.0030 (0.0028)	−0.0023 (0.0025)	−0.0022 (0.0024)	−0.0022 (0.0021)	−0.0029 (0.0027)
FDI	0.0069 (0.0047)	0.0073 (0.0046)	0.0070 (0.0048)	0.0076 (0.0047)	0.0078^{**} (0.0038)	0.0069^{*} (0.0037)	0.0081^{**} (0.0040)	0.0077^{*} (0.0040)
EIA		0.0051^{*} (0.0032)				0.0039 (0.0029)		
EII			0.0034 (0.0062)				0.0030 (0.0063)	
EIS				-0.0068^{*} (0.0042)				−0.0051 (0.0037)
TD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F (18, 114)	2432.14	2674.18	2698.75	2372.37	1328.92	1333.18	1345.62	1095.32
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AR(1)	0.0030	0.0020	0.003	0.002	0.0030	0.0030	0.004	0.003
AR(2)	0.8490	0.8650	0.846	0.852	0.8590	0.8720	0.854	0.86
Hansen	0.1190	0.1530	0.113	0.151	0.1190	0.1530	0.113	0.151
Obs	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610
Instrument	26	28	27	29	26	28	27	29

Note(s): Robust standard errors are in parenthesis
Source(s): Author's calculation
Instruments and Lags: We used (Y, REC, FDI); (Y, REC, FDI, EIA); (Y, REC, FDI, EII) and (Y, REC, FDI, EIA, EII, EIS) as instruments with lags 2 to 3 in the estimated model (1–4) and (5–8) respectively
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

squared variable are positively and negatively associated with CO_2 emissions in all models, confirming the validity of the EKC hypothesis, in particular we found the existence of an inverted U-shaped relationship between GDP per capital and pollution levels in developing countries.

Since the two-step SYS-GMM can provide more reliable results than the one-step SYS-GMM estimator as suggested in the seminal work by (Windmeijer, 2005). Hence, we only focus on the interpretation for the two-step SYS-GMM estimator. Table (2) illustrates the estimated results of the two-step SYS-GMM estimator with GE. Results showed that GE was negatively associated with carbon emissions in all models, suggesting that strong GE reduces environmental degradation in developing countries. Similarly, REC had a negative impact on CO_2 emissions, meaning that REC helps reduce pollution. Interestingly, empirical evidence found that employment in agriculture (EIA) and industry sector (EII) was positively associated with CO_2 emissions. This explains that an increase in EIA and EII leads to environmental degradation, while employment in service sector (EIS) is negatively associated with CO_2 emissions. This confirms that an increase in EIS contributes to a reduction in pollution. In addition, the results also showed that the interaction term (Y × RL) between economic growth (Y) and GE had a positive and statistically significant effect on CO_2 emissions in all models. In other words, the inverse effect of economic growth on environmental degradation could not be addressed through GE.

Taking into account the institutional quality related to the RL as shown in Table 3. The results showed that when the estimated model is driven by service sector employment, the RL has a negative impact on carbon emissions, implying that strong RL leads to a reduction in environmental atrophy. While FDI is positively related to CO_2 emissions, this suggests that

	Two-step SYS-GMM			
Regressors	(1)	(2)	(3)	(4)
CO_{2t-1}	0.8864^{***} (0.0472)	0.8846^{***} (0.0512)	0.8843^{***} (0.0463)	0.8822^{***} (0.0522)
Y	0.2125^{**} (0.0870)	0.2875^{**} (0.1181)	0.2006^{***} (0.0800)	0.3192^{***} (0.1241)
GE	-0.4877^{*} (0.2692)	-0.6282^{***} (0.3150)	-0.5208^{**} (0.2569)	-0.7452^{**} (0.3366)
(Y × GE)	0.0538^{*} (0.0318)	0.0703^{*} (0.0369)	0.0566^{*} 0.0638	0.0833^{**} (0.0390)
REC	-0.0041^{***} (0.0015)	-0.0056^{***} (0.0021)	-0.0032^{***} (0.0012)	-0.0055^{***} (0.0021)
FDI	0.0077^{*} (0.0046)	0.0077^{*} (0.0044)	0.0081^{*} (0.0047)	0.0083^{*} (0.0044)
EIA		0.0055^{**} (0.0023)		
EII			0.0081^{*} (0.0046)	
EIS				-0.0093^{***} (0.0035)
Time dummies	Yes	Yes	Yes	Yes
F (18, 114)	1923.67	1608.76	1918.91	1611.06
Prob > F	0.0000	0.0000	0.0000	0.0000
AR(1)	0.0030	0.0030	0.003	0.003
AR(2)	0.8230	0.8260	0.8190	0.8270
Hansen's p-value	0.214	0.157	2.740	0.156
Number of observation	1,610	1,610	1,610	1,610
Number of instruments	34	35	27	35

Note(s): Robust standard errors are in parenthesis
Source(s): Author's calculation
Instruments and Lags: We used (Y, REC, FDI, GE, Y × GE); (Y, REC, FDI, GE, Y × GE, EIA); (Y, REC, FDI, GE, Y × GE, EII) and (Y, REC, FDI, GE, Y × GE, EIS) as instruments with lags 2 to 3 in the estimated model (1)–(4) respectively
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

Table 2. Estimated outcomes of two-step SYS-GMM with government effectiveness (GE)

Regressors	Two-step SYS-GMM (1)	(2)	(3)	(4)
CO_{2t-1}	0.8918*** (0.0491)	0.8947*** (0.0511)	0.8914*** (0.0484)	0.8923*** (0.0520)
Y	0.1935** (0.0886)	0.2505** (0.1111)	0.1757** (0.0810)	0.2802** (0.1138)
RL	−0.2547 (0.2692)	−0.3343 (0.2084)	−0.2610 (0.1905)	−0.3688* (0.1952)
(Y × RL)	0.0241 (0.0263)	0.0343 (0.0255)	0.0233 (0.0235)	0.0368 (0.0390)
REC	−0.0037*** (0.0014)	−0.0049*** (0.0018)	−0.0026** (0.0012)	−0.0049** (0.0019)
FDI	0.0084* (0.0051)	0.0083* (0.0050)	0.0090* (0.0054)	0.0093* (0.0052)
EIA		0.0048** (0.0022)		
EII			0.0086* (0.0050)	
EIS				−0.0086*** (0.0033)
Time dummies	Yes	Yes	Yes	Yes
F (18, 114)	1508.65	1548.44	1410.15	1464.67
Prob > *F*	0.0000	0.0000	0.0000	0.0000
AR(1)	0.0030	0.0030	0.003	0.003
AR(2)	0.8330	0.8360	0.8310	0.8360
Hansen's *p*-value	0.117	0.127	0.126	0.151
Number of observation	1,610	1,610	1,610	1,610
Number of instruments	34	37	35	37

Note(s): Robust standard errors are reported in parenthesis
Source(s): Author's calculation
Instruments and Lags: We used (Y, REC, FDI, RL, Y × RL); (Y, REC, FDI, EIA, RL, Y × RL); (Y, REC, FDI, EII, RL, Y × RL) and (Y, REC, FDI, EIS, RL, Y × RL) as instruments with lags 2 to 3 in the estimated model (1)–(4) respectively
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

Table 3. Estimated results of two-step SYS-GMM with rule of law (RL)

an increase in FDI contributes to environmental degradation in developing countries. The present research also found that the interaction term (Y × RL) between economic growth (Y) and RL has a positive effect but no statistical significance on environmental atrophy, indicating that economic growth cannot solve environmental problems through the RL. In addition, empirical results also confirmed that the associated directional impacts of FDI, REC, Y, EIA, EII and EIS on environmental degradation are identical to those of the estimated models controlled by GE (see Table 2).

To capture the long run impact of institutional quality, employment, FDI and REC on environmental atrophy in selected developing countries, we estimated the long run coefficient based on the statistically significant variables in the short run coefficient. This can be written mathematically as follows:

$$\beta_n = [1 - \delta] \tag{5}$$

Table 4 illustrates the estimated results for the long run effect of the explanatory variables on CO_2 emissions with GE. The empirical results showed that a 1% increase in GE helps reduce CO_2 emissions by 6.33% at the 5% significance level and concluded that the relationship between GE and environmental degradation is inelastic. When REC was used as an explanatory variable, our results found a negative effect of REC on pollutant emissions, suggesting that a 1% increase in REC reduces CO_2 emissions by 0.0470%. As a result, we confirmed an inelastic relationship between REC and pollution. Furthermore, the results also confirmed an inverse effect of EIS on environmental degradation, implying that a 1% increase in EIS contributes to a 0.0787% reduction in CO_2 emissions at the 1% significance level. This result indicated that there was an inelastic relationship between EIS and pollutant emissions in developing countries.

Interestingly, we also analyzed the long run impact of the RL on environmental degradation. As shown in Table 5, our empirical results showed that RL is statistically significantly and negatively associated with pollution, meaning that a 1% improvement in RL quality contributes to a 3.42% reduction in CO_2 emissions. This asserts an inelastic relationship between RL and environmental degradation in developing countries. Economic growth had an elastic relationship with environmental degradation, while the relationship between the remaining explanatory variables and CO_2 emissions was inelastic. Furthermore, the present research confirmed that estimates of the long run effect of independent variables on the explained variable only adjust the value of the coefficient, while the associated directions between variables remain unchanged across all models.

4.2 Robustness checking

To complement and ensure the above results, we also checked the robustness of the results by applying a special technique of Driscoll and Kraay standard errors developed as a seminal work by Driscoll and Kraay (1998). This approach can be appropriate whether dealing with balanced or unbalanced panel data, cross-sectional dependency, heteroscedasticity, serial correlation and other panel data estimation issues that provide robust results and valid statistical conclusions.

	Two-step SYS-GMM			
Regressors	(1)	(2)	(3)	(4)
CO_{2t-1}	7.8035** (3.6567)	7.6655** (3.8447)	7.6425** (3.4556)	7.4922** (3.7643)
Y	1.8705*** (0.3762)	2.4915*** (0.4887)	1.7340*** (0.3669)	2.7106*** (0.5082)
GE	−4.2939* (2.4242)	−5.4432** (2.6233)	−4.5008** (2.2828)	−6.3286** (2.7384)
(Y × GE)	0.4739* (0.2934)	0.6092* (0.3189)	0.4892* (0.2720)	0.7072** (0.3298)
REC	−0.0363*** (0.0077)	−0.0488*** (0.0097)	−0.0278*** (0.0078)	−0.0470*** (0.0086)
FDI	0.0674* (0.0046)	0.0665* (0.0370)	0.0703* (0.0415)	0.0705* (0.0362)
EIA		0.0479*** (0.0158)		
EII			0.0696** (0.0314)	
EIS				−0.0787*** (0.0196)

Note(s): Robust standard errors are reported in parenthesis
Source(s): Author's calculation
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

Table 4. Estimated result of long-run coefficient with government effectiveness (GE)

	Two-step SYS-GMM			
Regressors	(1)	(2)	(3)	(4)
CO_{2t-1}	8.2459** (4.1988)	8.4980* (4.6141)	8.2109** (4.1051)	8.2846* (4.4891)
Y	1.7887*** (0.4131)	2.3794*** (0.4933)	1.6180*** (0.4089)	2.6014*** (0.4860)
RL	−2.3547 (2.0651)	−3.1756 (2.0595)	−2.4045 (1.8844)	−3.4244* (2.0138)
(Y × RL)	0.2230 (0.2591)	0.3254 (0.2594)	0.2150 (0.2337)	0.3420 (0.2480)
REC	−0.0345*** (0.0077)	−0.0464*** (0.0103)	−0.0242*** (0.0086)	−0.0453*** (0.0088)
FDI	0.0778* (0.0426)	0.0785* (0.0411)	0.0824* (0.0444)	0.0867** (0.0420)
EIA		0.0460*** (0.0176)		
EII			0.0794** (0.0377)	
EIS				−0.0794*** (0.0215)

Note(s): Robust standard errors are reported in parenthesis
Source(s): Author's calculation
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

Table 5. Estimated result of long-run coefficient with rule of law (RL)

The robustness of the results presented in Table 6, which shows that the estimated results remain unchanged compared to the estimates of the two-step SYS-GMM estimators, confirming that GE contributes to improving environmental quality. That is, a 1% increase in GE helps reduce CO_2 emissions by 7.46% at the 1% significance level. This suggests that high GE is becoming an important panacea to address environmental issues and ensure sustainable development goals in developing countries. REC reduces pollution, showing that a 1% increase in REC results in a 0.05% reduction in pollution at the 1% significance level. Surprisingly, the results highlighted innovative evidence that EIS plays a significant role in mitigating environmental degradation. In other words, a 1% increase in EIS could reduce CO_2 emissions by 0.07% at the 1% significance level. In contrast, EIA and EII degrade the quality of the environment in developing countries, meaning that a 1% increase in employment in these two sectors leads to a 0.04 and 0.09% increase in CO_2 emissions, respectively.

4.3 Discussions

Many developing countries have committed to reducing carbon emissions and achieving environmental sustainability. Although the impact of institutional quality, FDI and REC on environmental atrophy has been extensively studied in previous literature studies, the relationship between sectoral employment and environmental atrophy remains opaque and has not been examined in developing countries. By recalling the empirical findings with the hypothesis, our results demonstrated the validity of the EKC hypothesis and confirmed that there was an inverted U-shaped relationship between pollution and economic growth for 115 selected developing countries. Unlike (Bilgili *et al.*, 2016) claims that the existence of the EKC hypothesis occurs only in developed countries and may not hold in developing countries. As a result, we argue that the existence of the EKC hypothesis is still ambiguous (Dinda, 2004), requires re-examination using an innovative method and may depend on the alternative of indicators controlled in the estimated model. GE contributes to improving environmental quality, and this

	Robustness of Drisc/Kraay Std. Err			
Regressors	(1)	(2)	(3)	(4)
Y	2.0692*** (0.0930)	2.5827*** (0.0898)	1.9960*** (0.0964)	2.9619*** (0.0954)
GE	−5.2735*** (0.4454)	−6.0736*** (0.4660)	−6.0719*** (0.5269)	−7.4649*** (0.5344)
(Y × GE)	0.5408*** (0.0568)	0.6422*** (0.0575)	0.6295*** 0.0669	0.8077*** (0.0650)
REC	−0.0400*** (0.0011)	−0.0513*** (0.0012)	−0.0267*** (0.0015)	−0.0495*** (0.0013)
FDI	0.0058 (0.0062)	0.0078 (0.0061)	0.0105 (0.0066)	0.0136** (0.0061)
EIA		0.0422*** (0.0008)		
EII			0.0897*** (0.0050)	
EIS				−0.0787*** (0.0018)
Constant	−12.5480*** (0.7752)	−17.6984*** (0.7643)	−14.2276*** (0.9071)	−15.7508*** (0.7252)
F-statistics	3740.82	7915.36	3930.10	11,407.22
Prob > *F*	0.0000	0.0000	0.0000	0.0000
R-Squared	0.4220	0.4323	0.4332	0.4510
Max: Lag	3	3	3	3
Root MSE	3.1541	3.1267	3.1243	3.0748
Number of Observation	1725	1725	1725	1725
Number of group	115	115	115	115

Note(s): Robust standard errors are in parenthesis
Source(s): Author's calculation
Asterisks (***, ** and *) denotes the significance level at 1%, 5 and 10% respectively

Table 6. Robust checking of the relationship between independent variables and dependent variables by applying Drisc/Kraay Std. Err approach

finding is consistent with the previous literature (Abid, 2016; Azamat, 2012). In our opinion, GE is an important moderating indicator of intuitional quality and plays a crucial role in controlling and reducing environmental atrophy. It is a central panacea to achieve environmental sustainability in developing countries. Furthermore, we argue that GE can address CO_2 emissions and improve environmental quality itself, while the interaction effect ($Y \times GE$) between GE and per capita income on pollutant emissions was positive and statistically significant. One of the possible explanations is that the quality of GE is relatively weak, the implementation of environmental protection may not work well and has different practical policies, and developing countries are still unable to establish the optimal points between CO_2 emissions and economic development. The results also confirmed the role of REC in mitigating pollution and this result is consistent with the previous literature (Bilgili *et al.*, 2016; Dogan and Seker, 2016). This may be because developing countries can take steps to counteract environmental degradation by promoting the use of renewable energy as innovative choices that help reduce carbon emissions.

Surprisingly, the results also uncovered innovative evidence that EIA and EII have a positive impact on pollution in all models, and this finding is partially supported by the previous literature (Bai *et al.*, 2021; Fremstad *et al.*, 2019). The reasons are that (1) EII is mainly based on the production line, which transforms raw materials into finished products through various production processes, thus generating waste and air pollution. If employment increases, the use of raw materials increases and the more CO_2 emissions rise. (2) EIA leads to pollutant emissions, since most developing countries are largely dependent on agricultural production and this sector causes environmental problems through the cultivation of crops and animal husbandry. Therefore, our results suggest that the main sources of agricultural emissions come from livestock and manure, crop management, soil and environmental conditions via employment. Conversely, EIS is negatively associated with CO_2 emissions, and this result does not support our expected hypothesis, but partially supports the study by (Zhong and Su, 2021). This can be explained by the fact that EIS is becoming a crucial driver for the strengthening of innovative technological processes. This sector may not be the production-based line and has not used raw materials to transform them into finished products through production processes. Therefore, it generates little waste and pollution. Based on the results, we argue that the relationship between environmental degradation and sectoral employment remains opaque and call for further evidence in a group of developed and developing countries.

4.4 Theoretical implications

This study has significant theoretical implications for the existing literature. In particular, GE and RL reduce pollutant emissions and promote environmental quality. Therefore, the present research strongly supports the theoretical relationship between two indicators of institutional quality and other explanatory variables with environmental degradation. Interestingly, this study uncovered new evidence that EIS plays a crucial role in reducing carbon emissions and improving environmental quality, while EIA and EII promote environmental degradation. As a result, our research concludes that EIS tends to produce fewer pollutants than EIA and EII. Nevertheless, this paper has strongly argued that GE and RL alone can deal with environmental atrophy, while economic growth cannot solve CO_2 emissions through these two institutional indicators. This showed that the negative impact of economic growth on pollution does not depend on institutional quality. Furthermore, the results suggest that GE and RL should be the main backbone and implemented in innovative ways to achieve environmental sustainability in developing countries.

4.5 Practical implications

Nowadays, global warming, climate change and environmental atrophy have become the major concerns and challenges in the era of modern economic development to meet the environmental standard and ensure the United Nations Sustainable Development Goals. Based on the results, our empirical findings have highlighted the importance of policy implications in response to CO_2 emissions and detrimental impacts on people, nature and sustainable development goals. In particular, GE and RL have become the crucial elixir in reducing pollution and play a central role in achieving environmental standards and sustainability. Therefore, we strongly recommend the following practical implications for combating environmental degradation in developing countries. First, developing countries should seriously strengthen institutional quality by improving GE and RL as the top national priority for mitigating carbon emissions. Second, it is imperative to strictly enforce environmental laws, restructure environmental protection mechanisms and pay special attention to improving institutional performance. Third, developing countries should formulate innovative strategies to underpin the institutional framework as an essential underpinning for reducing CO_2 emissions and achieving long-term sustainable environmental quality. Finally, it is strongly recommended to support the use of recycling and renewable energy as innovative options and to promote clean energy technologies and green investment sectors to reduce CO_2 emissions in developing countries. Furthermore, sectoral employment is a key factor in influencing the quality of the environment and trade-offs between CO_2 emissions and employment can arise in developing countries. Our empirical evidence based on sectoral employment suggests that these countries should formulate ad hoc laws, rules and regulations related to the agricultural and industrial employment sectors to control and mitigate environmental degradation in developing countries.

5. Conclusions

This paper examines innovative perspectives on the impact of institutional quality and sectoral employment on CO_2 emissions and estimates the interaction effects between economic growth and institutional quality with pollution in 115 developing countries. The results confirmed the validity of the EKC hypothesis and showed that two indicators of institutional quality, such as GE and RL were negatively associated with environmental degradation. However, this study argued that GE can reduce CO_2 emissions and improve environmental quality itself, while the interaction effect ($Y \times GE$) between GE and per capita income with pollutant emissions was positive and statistically significant, suggesting that economic growth cannot mitigate environmental degradation when GE was used as the modifying variable, while the interaction effect ($Y \times RL$) was a positive effect but not statistically significant for environmental pollution. Interestingly, we found new evidence that EIA and EII increase CO_2 emissions, while EIS is an important indicator of reducing environmental atrophy and promoting green investment sectors. The results also confirmed that EIS was more likely to emit fewer pollutants than EIA and EII. In addition, this paper suggests that GE and RL contribute to reducing CO_2 emissions in developing countries in both the short and long term.

Nevertheless, this research has some limitations. First, we consider only two main indices of institutional quality while there are remaining proxies for institutional quality. Second, series (2002–2016) used in this paper are still limited as the authors emphasize the availability of balanced panel data while major environmental changes may occur from 2017 to present. Therefore, future research should consider comparative studies between regions for the relationship between the new indicator of institutional quality and sectoral employment to environmental degradation. It is also interesting to examine the determinants of sectoral emissions using recent data for both developed and developing countries. We recommend focusing on the theoretical analysis and causal relationship between sectoral employment and CO_2 emissions and call for the role of institutional quality in modifying the impact of sectoral employment on environmental atrophy in the countries with the highest and lowest unemployment rates.

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Appendix

Variables	Definition	Data sources
Environmental Degradations	CO_2 emissions (metric tons per capita)	World Bank
Institutional Quality	Government effectiveness/rule of law are the Estimate of governance (ranges from approximately −2.5 (weak) to 2.5 (strong) governance performance)	World Governance Indicator
Employment in Agriculture (EIA)	Employment in agriculture (% of total employment) (modeled ILO estimate)	World Bank
Employment in Industry (EII)	Employment in industry (% of total employment) (modeled ILO estimate)	World Bank
Employment in Service (EIS)	Employment in Service (% of total employment) (modeled ILO estimate)	World Bank
GDP per capita	GDP per capita (constant 2010 US$)	World Bank
Renewable Energy Consumption	Renewable energy consumption (% of total final energy consumption)	World Bank
FDI inflow	Foreign direct investment, net inflows (% of GDP)	World Bank

Note(s): The list of developing countries are based on WorldData.info and international monetary fund (IMF)

Table A1. Definitions of data and sources

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