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Heterogenous Effect of Industrialisation on Environmental Degradation in Southern African Customs Union (SACU) Countries: Quantile Analysis

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Abstract: Southern African Customs Union (SACU) countries are under pressure to commit themselves to sustainable environmental activities. This study employed data from 2007 to 2021 using quantile regression to determine the heterogenous effects of industrialisation on environmental degradation in SACU countries. Prior to the main results, this study investigated and confirmed the existence of a long-run relationship between industrialisation and environmental degradation. This study confirms the heterogeneous effect of industrialisation on environmental degradation. The results through quantile process estimates demonstrated an inverted U-shaped curve. The inverted U-shape suggests that industrialisation at lower and higher quantiles has a minor effect on the environment compared to medium quantiles, where it has a higher effect. This study found that industrialisation increases environmental degradation in the 4th to 6th quantiles, whereas in the 7th to 8th quantiles, industrialisation reduces environmental degradation. Therefore, it is recommended by this study that to mitigate environmental degradation, firms in SACU countries are encouraged to adopt environment-friendly technologies in their production.

Keywords: industrialisation; environmental degradation; SACU; panel quantile regression

JEL Classification: A10; C31; F18; L60

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1. Introduction

Africa contributed about 4% of global carbon emissions in 2017 and 3.9% in 2021; however, the pattern in which Africa is developing may mean that Africa's emissions continue to increase undesirably (Ayompe et al. 2021). In the modern world, the global community is desperately seeking ways to mitigate the scale and impact of climate change in many ways. The Southern African Customs Union (SACU) countries, consisting of Botswana, Eswatini, Lesotho, Namibia, and South Africa, has, since 1910, formed a customs union. SACU is one of the oldest unions in Africa, and, recently, the environment they are operating within has significantly changed since its establishment. The fundamental intention of the union is to make trade free or easier for its members. SACU strategic plan for the period 2022–2027 acknowledges that it relates to changes in the environment and the energy transition away from economic activities that harm the environment. The plan further indicates that there are major developments emerging on new methods in industrial production, commodity demand, trade, and investment flows.

SACU regards industrialisation as one of the strategic pillars for its development and growth. However, it can be argued that industrialisation without innovative processes might bring heavy emissions for the region, leading to repercussions of environmental degradation. Industrialisation is the process through which agrarian economies transform into an industrial one through mass manufacturing (Mgbemene et al. 2016). According to Biernacki (2001), industrialisation is described as the process of using mechanical, chemical, and electrical sciences to transform production with inanimate sources of energy. Other

scholars such as Dong et al. (2021) mentioned that industrialisation causes the concentration of production and labour in specific areas. Furthermore, they mentioned that it may lead to urbanisation, which may appeal to more production factors, create employment opportunities, and promote new methods of production. Industrialisation can be viewed to play an important part in economic development. Firstly, it stimulates economic activities through value chains, from raw materials to final goods. Also, it tends to create formal employment, which may prevent many social instabilities. In addition, it helps in maintaining a trade surplus by producing goods for export and reducing import dependence. Lastly, it encourages manufacturing and processing capabilities, leading to strong sustainable economic development, in turn creating wealth in the country.

However, it should be mentioned that although industrialisation may bring economic growth and development, it may come with problems of environmental degradation. According to Maurya et al. (2020), environmental degradation is defined as "deterioration of the environment through depletion of resources which includes all the biotic and abiotic element that form our surrounding that is air, water, soil, plant, animals, and all other living and non-living element of the planet of earth". There are two arguments in this process that both natural and human actions are perceived to be participating in increases in environmental degradation. Human activities are one of the reasons for accelerating environmental degradation. These activities can be automobiles and industries increasing poisonous greenhouse gases in the atmosphere. Some critics observe that reducing greenhouse gases is a pointless and prejudicial burden on African low-income countries. However, such critics are clearly climate-blinded and cannot anticipate what would come with high costs in the future. Medinilla and Byiers (2023) suggested that there are four strategies for African countries to consider green industrialisation: (1) decarbonise the existing industries, (2) produce inputs for global green industries, (3) manufacture green goods for African markets, and (4) leverage brown capabilities to jump to green industries. The relationship between industrialisation and the environment involves both threats and opportunities that will impact SACU countries in different ways. It is mentioned in this paper that being capable of foreseeing these adjustments will help these countries to adapt and respond better as part of their regional economic planning.

This study contributes to the literature by being the first to investigate the effect of industrialisation on the environment in SACU countries. Also, this study employs the panel data estimation method of quantile regression, which is powerful to help determine the heterogenous effect of industrialisation on environmental degradation in SACU countries. Secondly, although the work of Opoku and Aluko (2021) investigated the role of industrialisation on environmental degradation in 37 African countries, in their sample, SACU countries were not all included, including Namibia and Lesotho. It is, therefore, from this perspective and the interest of this paper to provide an exclusive study on SACU as one of the oldest customs unions. This attempt will provide an appropriate policy direction to the bureaucracy of SACU. Furthermore, to investigate the effect of industrialisation on environmental degradation in SACU countries, this study estimates its model by controlling for urban population and foreign direct investment (FDI). These control variables were never considered in previous studies such as Opoku and Aluko (2021). These variables are critical, with SACU as an old customs union, and this can be affected by these two variables. According to Darkoh (1997), it is projected that through 1950 to 2025, the urban population in developing economies will have increased from 300 million to 4 billion, which is 14-times more. This statistic provides an interesting claim to control for urbanisation in the current study to understand its heterogenous effect on the environment in SACU to help in policy making. Also, FDI has become a critical cause of private external finance for developing economies. According to the literature, FDI can possibly be channelled from strict environmental economies to divert their production to SACU countries if they have weak environmental policies (Copeland and Taylor (1994) and Nyeadi (2023)). In addition, FDI is considered from the view that SACU countries are still developing countries and

to grow their economies, they have weak foreign investment policies that may possibly attract investments that are not environmentally friendly.

Therefore, the overall aim of this study is to examine the heterogenous effect of industrialisation on environmental degradation in SACU countries. This study attempts to answer the following research questions: (i) Is there a long-run relationship between industrialisation and environmental degradation? (ii) Is there a heterogenous effect of industrialisation on the environment? The outline of this study is as follows. Section 2 presents the literature survey. Section 3 describes the method adopted. Section 4 discusses the empirical results. Section 5 provides the conclusion and policy implications of this study.

2. Literature Survey

There has been a reasonably vast literature on the effect of industrialisation and climate change across the world. Environmental economics scholars have hypothesised that as a country develops, environmental degradation will first increase and then decrease in the long run. Therefore, the shape of the relationship between industrialisation and environmental degradation takes the form of an inverted U-shaped curve, and this hypothesis can be explained by the theory of the environmental Kuznets curve (EKC), Capps et al. (2016). Okereke et al. (2019) maintains that transparency and a clear discussion between industries and government are critical in warranting policies to take account of the effects regarding both sustainability and industrialisation agendas for corporations of all sizes. Industries are important to fast track the pace of economic growth, but disorganised industrialisation in the name of development can affect the people and deteriorate its local ecosystem (Mech and Hazarika 2018). Andronie et al. (2021) indicated that industrial big data analytics and sustainable product lifecycle management can assist throughout the decarbonisation process by the use of digital technologies.

In the literature, Mgbemene et al. (2016) descriptively analysed the aftereffects of industrialisation on environmental change. The study found that since industrial development, individuals have extremely enlarged the rate of adjustment in the climate and the environment through moving from agricultural to industrial practices and the pumping of carbon gases into the atmosphere. Majeed and Tauqir (2020) studied a panel of 156 countries for the period 1990 to 2014. This study sorted the countries into different income levels and used the dynamic generalized moments method (GMM) and common correlated effects mean group (CCEMG) to examine the relationships. The study suggested that industrialisation increases carbon emissions in all developmental stages. From industrialised economies, the work of Idowu et al. (2023) investigated whether energy consumption due to industrialisation leads to environmental degradation in OPEC and highly industrialised economies. The findings of their study found that industrialisation on emissions is negative for OPEC countries, and for highly industrialised countries, it is positive and significant. Yusuf et al. (2023) investigated the effect of trade and industrialisation on climate change in Australia. This study found that industrialisation does not have any significant effect on carbon emissions in the long run.

The empirical literature it is not without the work conducted in Asian countries as one of the fast-emerging economies. Firstly, a study by Panayotou et al. (1990) examined the association among industrial growth, structural change, and industrial policy on the environment in Thailand. In their paper, they recommended one aspect of policy transition. This idea emphases that alterations during the conversion phase must be made. They further claimed that the new policy is also possibly adequate for the industries if it is progressively phased in over time. Following this, Wang et al. (2020) examined a panel of Asia-Pacific Economic Cooperation countries for the period 1990 to 2014. This study applied a Westerlund panel cointegration test and dynamic seemingly unrelated co-integrating regression (DSUR) for determining the effect of industrialisation on carbon dioxide emissions. The findings indicated that there was a positive and significant effect of industrialisation on emissions. Similar results were found by Zafar et al. (2020) when

they studied a panel of 46 Asian countries for the period of 1991 to 2017. Their paper used various panel techniques, Westerlund cointegration and fully modified OLS, to determine the long-run parameters. This study found that industrialisation has a positive impact on carbon emissions in Asian countries. Furthermore, a study by Ahmed et al. (2022) explored a panel of 55 countries in the Asia-Pacific region. This study used an econometric method, the autoregressive distributed lag model, for the period of 1995 to 2020. The results of their study revealed that industrialisation is positively associated with the environment. Elfaki et al. (2022) examined the impact of economic growth, energy consumption, financial development, and industrialisation on environmental degradation for eight ASEAN countries. Their paper used an autoregressive distributed lag model pooled mean group (PMG/ARDL) method covering the period 1994–2018. The findings from their study concluded that industrialisation has a negative relationship with environmental degradation. Jermsittiparsert (2021) indicated that industrialisation has a positive impact on nitrous oxide emissions in the Association of Southeast Asian Nations (ASEAN). The study used stationary panel models for the period of 1995–2015.

A country-specific study by Yuan et al. (2020) indicated that industrialisation has brought China both prospects and challenges since 1978. The results indicate that rapid industrialisation has put Eastern China under serious pollution stress. The most tremendous effects of industrialisation on environmental degradation are reflected in aquatic and soil ecosystems. Their paper recommends that China needs to enhance the incorporation of environmental observation and conservation monitoring systems. Wang et al. (2011) found that heavy industries have a positive impact on promoting China's carbon emissions. The study concluded that a 1% increase will lead to a 0.27% increase in China's carbon emissions in the long run. A study by Liu and Bae (2018) explored the effects of energy intensity, real GDP, industrialisation, urbanisation, and renewable energy on the environment for China for the period from 1970 to 2015. The results show that the coefficients of industrialisation have a positive and significant effect on carbon emissions. This study showed that a 1% increase in industrialisation accelerates carbon emissions by 0.3%. It is clear from the above review in Asian economies that there is clear evidence of a detrimental effect of industrialisation on environmental quality.

Bekabil (2020) pointed out that in Africa, small and growing industries' development requires subsidies from their governments to stimulate GDP and create job opportunities. However, governments in these developing countries should encourage green production techniques. Aladejare and Nyipute (2022) and Lin et al. (2015) are among the authors who studied the relationship between industrialisation and climate change. The work of Aladejare and Nyipute (2022) examined a panel of 32 African countries for the period 1991 to 2019. This study used the generalised least squares mixed effect model and dynamic common correlated effect to investigate the phenomena at hand. The findings of the study suggest that industrialisation has an adverse effect on the environment, whereas a single country study by Lin et al. (2015) indicated that there is no evidence that industrialisation does not increase carbon emissions in Nigeria. This study applied the technique of Johansen cointegration, and the study period was between 1980 and 2011. An independent study in BRICS countries by Voumik and Sultana (2022) investigated how various types of industrialisation relate to environmental degradation in the BRICS region. Their study applied the CS-ARDL for the period spanning from 1972 to 2021. This study discovered that industrialisation contributes negatively to the environment. Throughout the literature, especially related to African countries, there has been no study conducted in SACU countries. Furthermore, the existing literature still lacks evidence on the relationship between industrialisation and climate change based on quantile analysis. The advantage of this econometric technique is that it provides the researcher with evidence of heterogeneous effects on the phenomena under study.

3. Empirical Model and Data

This study aims to examine the heterogenous effect of industrialisation on environmental degradation in SACU countries. In relation to the other control variables, this study makes use of the following variables: foreign direct investment, manufacturing value added, and urban population. Therefore, the econometric model of this paper is derived as follows:

$$LED_{it} = \gamma_i + \delta_1 LFDI_{it} + \delta_2 LMVA_{it} + \delta_3 LUP_{it} + V_t \quad (1)$$

where the following is the description of the notations in the above equation.

LED_{it} is carbon emissions from SACU countries to capture environmental degradation.

$LFDI_{it}$ measures the inflow of foreign direct investment in SACU countries.

$LMVA_{it}$ measures industrialisation in SACU countries.

LUP_{it} captures the urban population in SACU countries.

V_t captures the residuals.

To capture the behaviour of the model in Equation (1), this study employs five countries of the SACU (i.e., Botswana, Lesotho, Namibia, Eswatini, and South Africa) for the panel time series of 2007 to 2021. The selection of this time span is purely based on the availability of data. Therefore, the description of the variable under study is presented in Table 1.

Table 1. Description of variables.

Abbreviation	Unit of Measure	Source
$LFDI_{it}$	Foreign direct investment, net inflows (% of GDP)	International Monetary Fund (IMF)
LED_{it}	CO_2 emissions (kt)	World Development Indicators (WDI)
$LMVA_{it}$	Manufacturing, value added (% of GDP)	World Development Indicators (WDI)
LUP_{it}	Urban population (% of total population)	World Development Indicators (WDI)

Modelling procedure: This study first assesses the description of the data, by applying the correlation analysis, normality test of the variables, panel unit root testing, and finally conducting the panel cointegration and estimating the quantile regression.

Panel unit root: This study applies two types of panel unit root tests, Levin et al. (2002) (LCC) and Im et al. (2003) (IPS). The LCC test works by pooling cross-sectional time series as a way of creating more powerful unit root tests. The test processes are created to assess the null hypothesis that the unit cross-section in the panel has in the integrated time series versus the alternative hypothesis that all cross-sections time series are stationary. In 2003, IPS proposed a panel stationarity test for dynamic heterogeneous panels based on the mean of cross-sectional stationarity statistics. The test was also applied in the literature by many authors such as Mosikari et al. (2016) and Fowowe (2012).

To assess the long-run relationship between industrialisation and environmental degradation, this study applies the Pedroni test. Pedroni (2004) pioneered the test of seven statistics that assess the null hypothesis of "no cointegration in the panels". The seven test statistics are categorised into two dimensions: group-mean statistics, which provides the average for the results of cross-country test statistics, and panel statistics that pool the statistics along the within dimension.

After determining the long-run equilibrium between industrialisation and environmental degradation, the following, according to the interest of the current study, is to heterogeneously determine the effect of industrialisation on the environment using the quantile panel analysis. Due to the unequal heterogeneity in SACU countries, an interaction between industrialisation and environmental degradation is likely to perform differently across different levels of emissions. The advantage of quantile regression is that it permits the parameters to vary with different quantiles. It also has a unique advantage of identify-

ing the variation in the effect of industrialisation on the distribution of carbon emissions. Following the work of Koenker (2004), the quantile regression for the study can expressed as follows:

$$ED_{yit}(\tau x_{it}) = x'_{it}\beta(\tau) + \alpha_i + \varepsilon_{it} \quad (2)$$

where $ED_{yit}(\tau x_{it})$ indicates the τth quantile of the dependent variable, and x_{it} captures the vector of the explanatory variables. α_i stands for the sectional effect, τ represents the quantile, and $\beta(\tau)$ denotes the regression coefficients of the τth quantile and can be computed through the following function:

$$\beta(\tau) = \frac{argmin}{\beta(\tau)} \sum_{k=1}^{q} \sum_{t=1}^{T} \sum_{i=1}^{N} (|y_{it} - \alpha_i - x'_{it}\beta(\tau)|w_{it}) \quad (3)$$

where q presents the number of quantiles, T denotes the number of years and N for cross-countries in the panel, and w_{it} is the weight of the ith countries in the tth year.

4. Empirical Analysis

The table below presents the correlation results of the study. The purpose of this is to examine if there is a possibility of high correlation among the independent variables.

Table 2 presents the correlation analysis for the variables under study. It is evident from the table that there is a negative relationship between environmental degradation (LED)and foreign direct investment (LFDI) also, there is a negative correlation between environmental degradation and industrialisation (LMVA). The descriptive results also show that there is a positive correlation between environmental degradation and urban population. Lastly, it can be observed among the independent variables, i.e., foreign direct investment, urban population (LUP), and industrialisation, that there is no high correlation (about 0.9), which might be considered a sign of high multicollinearity.

Table 2. Correlation analysis results.

	LED	LFDI	LUP	LMVA
LED	1	−0.187	0.865	−0.512
LFDI	−0.187	1	−0.186	−0.048
LUP	0.865	−0.186	1	−0.796
LMVA	−0.512	−0.048	−0.796	1

Table 3 presents the normality test results. This study applied the Kolmogorov–Smirnov and Anderson–Darling tests developed by Smirnov (1939) and Anderson and Darling (1954), respectively. According to these two tests, they assume the null hypothesis that the data are normally distributed. According to the results, it can be observed considering the p-values that this study rejects the null hypothesis since all the p-values are significant. This implies that environmental degradation, foreign direct investment, industrialisation, and urban population are not normally distributed. Therefore, Cheng et al. (2021) suggested that panel quantile regression is likely suitable in this regard.

Table 3. Normality test results.

Variables	Kolmogorov–Smirnov Test	Anderson–Darling Test
LED	0.245 (0.000)	6.567 (0.000)
LFDI	0.170 (0.000)	3.626 (0.000)
LMVA	0.136 (0.001)	2.035 (0.000)
LUP	0.182 (0.000)	4.761 (0.000)

Notes: p-values in brackets.

Before this study performed the empirical investigation, it was crucial to investigate the unit root in panel data.

Table 4, above, presents the panel unit root results for variables considered in this paper. This study employed the LCC and IPS pioneered by Levin et al. (2002) and Im et al. (2003), respectively. It can be observed from the findings that the variable foreign direct investment is not stationary at levels, whereas environmental degradation, industrialisation, and urban population are found to be integrated in the order of 1. In using the IPS test, only industrialisation was found to be integrated in the order of zero, whereas variables environmental degradation, foreign direct investment, and urban population were found integrated in the order of one. The results from these two tests demonstrate, overall, that the variables in hand are in a mixture in the order of 1 and 0. Therefore, this study proceeds to determine the long-run equilibrium.

Table 4. Panel unit root test results.

Variables	LCC Test (Intercept and Trend)	ΔLCC Test (Intercept and Trend)	IPS Test (Intercept and Trend)	ΔIPS Test (Intercept and Trend)
LCO2	−1.402 (0.080) *	−8.375 (0.000) ***	−0.664 (0.253)	−6.268 (0.000) ***
LFDI	0.232 (0.591)	−12.353 (0.000) ***	0.896 (0.815)	−5.964 (0.000) ***
LMVA	−3.285 (0.000) ***	−4.942 (0.000) ***	−1.521 (0.064) *	−2.999 (0.000) ***
LUP	−1.503 (0.066) *	−1.637 (0.050) *	−0.719 (0.236)	0.178 (0.570)

Notes: 1% ***/5% **/10% *.

Table 5 presents the Pedroni cointegration. The method provides the three test statistics, which are Modified Phillips–Perron, Phillips–Perron, and Augmented Dickey–Fuller, to determine the possible existence of cointegration. The results show that with a significant *p*-value at 5%, this study rejects the null hypothesis of "no cointegration". This implies that there is a long-run equilibrium existence between foreign direct investment, environmental degradation, and urban population. After the confirmation of cointegration in the system, this study estimates the parameters using quantile regression.

Table 5. Pedroni test for cointegration results.

	Test Statistics	*p*-Value
Modified Phillips–Perron	1.6613	0.048 *
Phillips–Perron	−2.8340	0.002 **
Augmented Dickey–Fuller	−2.5783	0.005 **

Notes: 1% ***/5% **/10% *.

Since the data series in this paper does not follow the assumption of normal distribution, the study applies panel quantile regression. In comparison to the existing methods, such as pooled effect, fixed effect, and random effect regression methods, the current paper uses the panel quantile regression method, which provides the regression results for each quantile. Interestingly, it can offer more evidence regarding the heterogenous effect of industrialisation on environmental degradation in SACU countries.

To offer a comprehensive presentation for different quantiles, this study adopted 10 quantiles (i.e., 1st quantile to 9th quantile) throughout the regression process. The quantile regression results are shown in Table 6 and Figure 1 below. As can be observed from the results, environmental degradation was explained with variables LFDI, LMVA, and LUP. As can be observed, the effect of industrialisation on the environment is positive, demonstrating that industrialisation is detrimental to the environment in SACU countries. In terms of observation, the effects are heterogeneous across different quantiles, with an inverted U-shape (see Figure 1 for LMVA curve). The results suggest that industrialisation at lower and higher quantiles has a small effect on the environment compared to

medium quantiles, where it has a higher effect. This confirms the heterogeneous effects of industrialisation across various distributions of emissions in SACU economies.

Table 6. Quantile regression results.

Variables	Quantile	Coefficients	*t*-Statistics
LFDI	0.1	−0.015	−0.178
	0.2	−0.025	−0.339
	0.3	0.009	0.130
	0.4	0.082	0.757
	0.5	0.079	0.499
	0.6	−0.170	−0.495
	0.7	−0.029	−0.105
	0.8	−0.132	−0.501
	0.9	−0.049	−0.216
LMVA	0.1	1.365	1.929 ***
	0.2	1.290	1.610 **
	0.3	1.234	1.758 **
	0.4	1.633	1.770 **
	0.5	2.165	1.722 **
	0.6	4.088	2.409 ***
	0.7	2.804	2.302 ***
	0.8	1.295	1.619 **
	0.9	1.159	1.723 ***
LUP	0.1	3.745	3.865 ***
	0.2	3.890	3.478 ***
	0.3	3.898	3.921 ***
	0.4	4.425	3.374 ***
	0.5	5.226	2.924 ***
	0.6	8.832	7.212 ***
	0.7	8.203	10.176 ***
	0.8	7.254	15.241 ***
	0.9	7.210	18.015 ***
Intercept	0.1	−9.919	−1.835 ***
	0.2	−10.094	−1.634 **
	0.3	−9.910	−1.822 ***
	0.4	−12.833	−1.797 ***
	0.5	−17.014	−1.754 ***
	0.6	−34.435	−3.670 ***
	0.7	−28.454	−4.449 ***
	0.8	−20.426	−5.451 ***
	0.9	−19.864	−6.313 ***

Notes: 1% ***/5% **/10% *.

Specifically, the highest positive effect was at the 6th quantile at 4.088, decreasing to 1.159 at the 9th quantile. The result shows that there is a negative relationship between foreign direct investment and environmental degradation. The negative effects are observed at the 1st, 2nd, 6th, 7th, 8th, and 9th quantiles, whereas the positive effect is observed at the 3rd, 4th, and 5th quantiles. The effects in all quantiles are not significant. For the urban population variable, the effect is positive in all quantiles, and they are statistically significant. It can be observed (see Figure 1 for LUP curve) that the effects are heterogeneous across the different quantiles with an inverted U-shape, specifically peaking at the 6th quantile and becoming relatively stable throughout.

Table 7 presents the Chi-square statistic value of 106.298, which is statistically significant at the 1% level. Therefore, the null hypothesis of "slope equality" across quantiles is rejected. This result confirms the conclusion imposed by Figure 1 and serves as proof that the relationship between industrialisation, FDI, urban population, and the dependent variable (environmental degradation) is heterogenous across quantiles. These findings are

critical because they demonstrate that in some cases, the study might model industrialisation and environmental relationships with only linear models; this can lead to inappropriate conclusions. Also, the Chi-square statistic value of 34.746 results for the test of "symmetry". The test assumes the null hypothesis of symmetric quantiles. This study rejects the null hypothesis at the 1% significance level. These findings confirm the heterogeneous effect of industrialisation on environmental degradation in SACU countries.

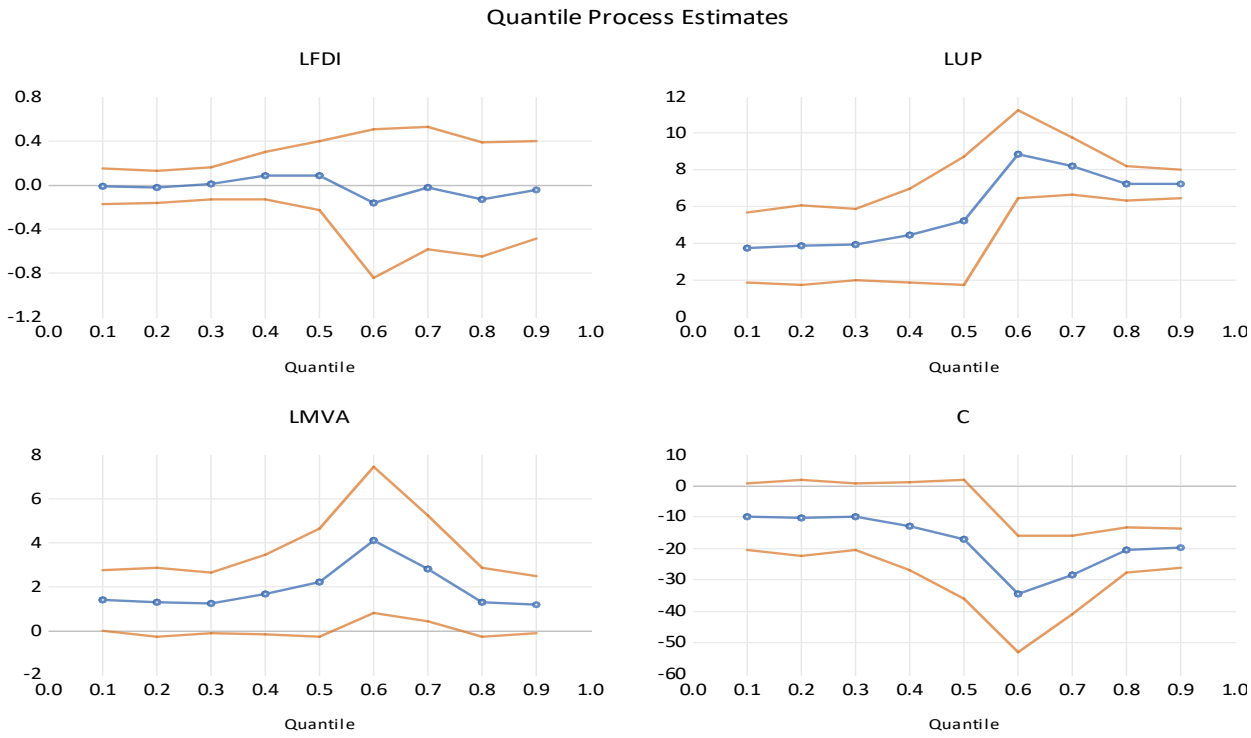

Figure 1. Graphical quantile process.

Table 7. Slope equality and symmetric quantile test.

Tests	Chi-Square Statistics	*p*-Value
Slope equality test	106.298	0.000 ***
Symmetric quantile test	34.746	0.004 ***

Notes: 1% ***/5% **/10% *.

5. Conclusions and Policy Implications

The empirical research in this study explored the heterogenous effect of industrialisation on environmental degradation in SACU countries. This study used the method of quantile regression to examine the proportions of industrialisation on environmental degradation for the period 2007 to 2021. This study also used the urban population and foreign direct investment as control variables. However, prior to quantile results, this study employed the Pedroni cointegration test, and the results confirmed the long-run existence of a relationship between industrialisation and environmental degradation in SACU countries. Furthermore, this study explored the parameter estimates through quantile effects. The results show that for FDI and environmental degradation, there is a negative relationship existing between them, but it is not statistically significant. These results are in line with Voumik and Ridwan (2023). The result for urban population shows that there was a positive relationship. This finding implies that as the urban population is increasing, there is a tendency to impact negatively on the environment. This can be explained as the behaviour of urban people to the increasing demand for food, construction (building

houses), and rapid transportation. These activities might put pressure on the environment. These findings are consistent with a study by Mosikari and Eita (2020). The results between industrialisation and environmental degradation show a significant positive relationship. These results are consistent with the work of Ahmed et al. (2022).

The policy implications based on the findings of this study are as follows: On the positive relationship between urban population and environmental degradation, policy makers may consider encouraging the urban population to use local transportation that is environmentally friendly, such as electric cars, and for household lighting may encourage renewable lights. Also, on the positive relationship between industrialisation and environment, it is suggested by this study that SACU firms should start to think of greener innovative measures in their production processes to mitigate environmental degradation. There are several critical ways to ensure environmental friendliness: Firstly, industries should have treatment plans for the waste released by them. Waste management should be an integral part of the production process in each industry. Secondly, financial institutions need to broaden the area of green financing and incentives. Lastly, industries should reduce the use of fossil fuels and invest in renewable energy, including energy generated by wind, the sun, and rain. The suggestion for further research is that future studies should consider technological innovation in the manufacturing sector and consider the spatial effect of industrialisation in SACU countries.

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