

**Causal Link between Urbanization, Industrialization, and Carbon
Emissions: Empirical evidence from Pakistan**
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ABSTRACT

The main aim of the study to examine the causal nexus in industrialization, urbanization and carbon emissions in Pakistan and used the time series data from 1990 to 2019. Based on the data behavior, an ARDL technique is used for estimation. This study originates that the energy consumption, exports, GDP, industrialization has optimistic and noteworthy effect on carbon emission. However, the urbanization has optimistic and noteworthy effect on CO₂ emission. Moreover, there are exist two-way casualty between EC and CO₂ emission, and UP and CO₂ emission, while, One-way causation from GDP to CO₂ emission, energy consumption to exports, urbanization to exports. However, no causality exists between exports and CO₂ emission, industrialization and CO₂, GDP and exports, industrialization and exports, Industrialization and GDP, UP and GDP, and UP and industrialization. The study recommended that the minimize energy consumption, control the emission from factories and focused on those industries like tourism which has small effect on the environment degradation. This study also suggests discouraging urbanization and promoting exports of goods which emission free.

Keywords: Industrialization; Urbanization; Carbon emission; ARDL; Pakistan

Background of the Study

The primary goal of every economy is to achieve sustainable economic-growth, which means meeting the requirements of the current cohort without depleting the resources available for the following cohort (WCED, 1987). There are various aspects that contribute considerably to maintaining and achieving sustainable economic growth, with energy supply playing a critical role. A green and clean environment is also an important aspect and an unquestionable requirement for long-term growth. Many variables influence environmental quality, including energy usage, industrialization, urbanization, and trade openness, among others. The effective use of energy is beneficial since it reduces manufacturing costs per unit output and pollutants (Dincer & Rosen, 1999). According to Azam and Khan (2016) that modernization, industry, and the rapid development in UP all contributed meaningfully to pollution, which is a major worry for the environment worldwide, but more so in low-income nations.

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CO₂ is the leading cause of world warming and environmental damage. Since the 1990s, there has been an surge in environmental contamination as an outcome of the increasing trend of urbanization and industrialization (Parveen et al., 2019). The world community recognizes a optimistic and significance link between ID and urbanization. This relationship is motivated by a desire to achieve better levels of development (Sadorsky, 2013). This connectivity has two impacts. On the one hand, it promotes the size of construction and stimulates GDP development in all economies. Instead, more energy was utilized at the home and manufacturing levels, which was the major source of smog such as CO₂ emission (Nasreen et al., 2018). Urbanization and industrialization are integral components of contemporary civilization and a high level of living, but they have serious consequences like health issues (Ahmad & Zhao, 2018).

Many previous research empirically studied the connection between urbanization associated with industrial development and increased energy consumption and CO₂ emissions (Yazdi & Dariani, 2019), found a constructive association among urbanization and CO₂, whereas the other originate a negative connection (Lv & Xu, 2019). Similarly, numerous previous studies have found that increased trade openness has resulted in lower pollution levels (Lv & Xu, 2019). Several other studies, on the other hand, have determined that trade has a harmful impression on the CO₂ emission (Le et al., 2016). Thus, all of these previous research show that the influence of the industrial development, urbanization and trade on environment is still debatable, and more rigorous studies are needed to re-explore the effects of these factors on the CO₂ emission.

Pakistan's environmental crisis is definitely critical, since the country has taken no measures to combat global warming. Pakistan, instead, is publicly acknowledging the worldwide environmental crisis. The Pakistani industry has improved its environmental credentials greatly, both in terms of manufacturing and long-term usage. Pakistan has consistently supported the development of technology to detention carbon emissions and techniques to reduce climate-change. There is no convincing evidence that Pakistan uses fossil fuels and emits CO₂.

Existing research shows that urbanization has a harmful influence on CO₂ (Liu & Bae, 2018), industrialization (Liu & Bae, 2018), and trade by (Khan & Ozturk, 2020). The experimental outcomes on the link between GDP, industrialization, trade, urbanization and CO₂ are still murky, according to the extant research. Furthermore, unlike the estimation techniques of the past studies whether they rely on one technique or used inappropriate techniques like Munir and Ameer (2020) used NARDL and granger casualty techniques in the case of Pakistan but used data period from 1975-2016, and Jiang et al. (2022) present an enhanced CCD model, spatial autocorrelation, and other approaches for assessing past and future coordination states. Most previous research also overlooked the application of ARDL and granger causality methodologies in the case of Pakistan, as well as key factors. To close the gap, this study employed time series data of Pakistan, the ARDL approach, and Granger causality to produce accurate and more trustworthy conclusions that we could generalize to all developing countries. As a result, in order to achieve sustainable development, this research will look at the impact of industrialization, urbanization, and national wealth on CO₂ in Pakistan from 1975 to 2020.

The impetus for this work stems from Wang et al. (2020) 's investigation of 18 APEC nations; this study covers Pakistan's time series and employs a distinct model, extended data

period, and the most appropriate assessment approach based on order of integration. It is the first research in Pakistan to look at the influence of various variables on the environment. By removing heterogeneity and erogeneity from the data, this study used the most appropriate estimating methodologies to investigate the unknown parameters. Because OPEC nations' CO₂ emissions are increasing, this study is necessary to discover and verify the link between these factors. The empirical findings will aid policymakers in minimizing the negative effects of CO₂ emissions. This study's range of factors is comprehensive, and it includes significant variables that have yet to be examined in previous research in Pakistan. This study analysis is motivated by the use of standard estimating methods in examining the influence of urban population and industry combined, as well as the inability to address differences in nations based on income levels. The literature on the influence of UP and ID on environmental deterioration yields varied results. This study adds to the current body of knowledge by investigating the nonlinear impacts of urbanization and industrialization on environmental quality in Pakistan. The report offers policymakers and the government with important instructions for developing successful policies regarding urbanization, industrialization, and CO₂ emissions. Individuals, corporations, environmentalists, researchers, and government organizations can all benefit from the conclusions of this study. The primary goal of this inquiry is to give critical evidence, information, and a better knowledge of the environment to important stakeholders.

As a result, this research is likely to provide a major contribution to the current literature, variables, and empirical methods, particularly in Pakistan. This study's findings will help us better understand the detrimental impacts of certain repressors on the environment. The findings will aid policymakers in increasing industry and commerce while reducing environmental costs.

Theoretical Framework

The ecological modernization hypothesis (Blowers, 1997) asserts that when nations progress from lower to intermediate developmental stages, they priorities growth above environmental sustainability. Further modernization, it is claimed, would reduce environmental difficulties, and societies will begin to emphasize technical innovation, environmental sustainability, and the transition from a manufacturing to a service-built economy (Hajer, 1995). According to the urban-environmental-transition (UET) hypothesis, pollution grows in tandem with the nation's wealth as cultures develop toward an industrialized economy (Marcotullio & Lee, 2003). According to compact city hypothesis, urbanization has reducing environmental harm and strain. However, development without adequate urban set-up tends to harm the environment (Burgess, 2000).

Pollution-heaven hypothesis and factor-endowment-hypotheses are two contrasting perspectives on the impact of commerce on CO₂. According to the PHH, rich countries and multinational corporations relocate pollution-intensive manufacturing units to developing countries. The world's pollution intensive businesses perceive expanding economies to be utopia. In terms of environmental quality, industrialized economies are expected to benefit, while emerging economies are expected to lose. The PEH contends that international commerce is determined by inequalities in technology or endowments, not by differences in environmental policies (Temurshoev, 2006).

Empirical Literature about urbanization and CO₂ emissions

For 86 economies from 1975 to 1998, Cole and Neumayer (2004) used OLS technique for estimation and found that population growth is matched by proportional surges in CO₂, but higher urbanization rates and smaller normal household size surge CO₂. From 1975-2003, Martínez-Zarzoso and Maruotti (2011) indicate an inverted U-link between UP and CO₂. Indeed, the elasticity of CO₂ and UP is positive at low levels of urbanization, which is consistent with the greater environmental effect reported in less developed countries. Elliott and Clement (2014) perform cross-sectional and panel regression studies of CO₂ at US, while accounting for spatial-autocorrelation. Their findings clearly support and demonstrate how multiple aspects of urbanization interact at the local level to impact CO₂ in significantly more consistent ways than home density and alternative transit use. Their discoveries shed light on the difficulties of urbanization as a regional force of environmental revolution with gradually more global implications.

Wang et al. (2015) use a lately built partial-parametric OLS fixed effect to check the bell shape (EKC) relationship between the UP and CO₂ for OECD nations from 1960-2010. They found the substantial link between UP and CO₂, confirming the EKC concept. According to Wu et al. (2016), urbanization causes a huge economic difference, which has a big influence on CO₂ emissions. According to Zhang et al. (2017), urbanization has a major impact on CO₂ as a key indication of modernity. They empirically assess the influence of UP on CO₂ using panel-data from 141 countries from 1961-2011 and use a FE model. Ali et al. (2017) investigate the empirical inspiration of UP on CO₂ in Singapore between 1970 and 2015. Within the analysis, the ARDL method is used. They demonstrate that UP has an adverse and noteworthy influence on CO₂ in Singapore.

Liu et al. (2018), explore the influence of UP on CO₂ efficiency, which is quite complicated. They utilize the model to examine the CO₂ efficiency of ten typical Chinese from 2008-2015. Their findings reveal that the CO₂ efficiency of Chinese urban clusters has not been greatly enhanced, and the proficiency from the 'self-evaluation' technique differs notably from IPCE. Hanif (2018) utilized a system GMM on a panel of thirty-four (34) economies from 1995-2015 and found that the use of fuels for cooking, as well as the growth of metropolitan areas, contribute considerably to CO₂ on one end while driving air pollution on the other. In addition, the findings show an inverted U-shape link between GDPpc and CO₂. Lv and Xu (2019) utilized the PMG method and data of 55 economies from 1992-2012. They discover that trade has a positive impact on the environment in the short-period but a harmful impact in the long-period. Meanwhile, the findings indicate that UP has a harmful and substantial influence on CO₂, meaning that urbanization enhances environmental quality.

Yazdi and Dariani (2019) used Asian nations data from 1980-2014 using the PMG technique. They found that urbanization improve EC and CO₂. For a long time, Wang et al. (2021) used ARDL technique for estimation and found that industrialized nations tend to have the same harmful effects of UP on CO₂, notwithstanding disparities in resources. used the data of thirty-seven (37) Sub-Saharan African nations, and demonstrate that the effect coefficients of UP on CO₂ and ecological foot-print are both optimistic, indicating that UP raises environmental. Similarly, Rasool et al. (2022) focus on China from 1991 to 2015 and demonstrate a substantial unfavorable relationship between the Chinese IT industry, energy usage, urbanization, and environmental damage.

Empirical Literature about industrialization and CO₂ emissions

used data of 30 Chinese provinces from 2000-2013 utilizing panel datasets at the provincial level in an LMDI model. Their findings demonstrate that GDP is the most important driver of regional CO₂, followed by EC, and social transformation. Similarly, Pata (2018) used data of Turkey from 1974-2013. According to the results of the ARDL approach, UP and ID has a long-period optimistic effect on CO₂pc. Furthermore, the data verify the EKC hypothesis's validity for Turkey. According to Wang et al. (2018), used data of China and India from 1980 to 2014 and demonstrate that China mostly conducted a poor decoupling of economic development from CO₂, but India's decoupling status was irregular. CO₂ intensity is the most important sponsor to decoupling in China, followed by UP, GDP, and ID. In India, the most important driver of uncoupling is also the intensity of carbon emissions, followed by UP, ID, and GDP. As a result, boosting energy efficiency is the greatest policy for China and India to achieve economic development while reducing emissions. Furthermore, Dong et al. (2019) found that urbanization and income level have a strong influence on CO₂. In terms of UP, there is no link between CO₂ and UP stage. Wang and Su (2019) found that China's CO₂ and GDP appear to be significantly decoupled only in a few years between 1990-2015, with the remainder years being slightly decoupled.

Majeed and Tauqir (2020) used a panel of one hundred and fifty-six (156) nations and income categories from 1990 to 2014. Dynamic GMM, and CCEMG estimation approaches. They found that UP and ID has significant and favorable effects on CO₂ across all panel categories. According to Dong et al. (2021), Using panel data from 2002 to 2017, and found that CO₂ have a long-period negative impact on residents' health a percent increase in CO₂ emissions China. Sikder et al. (2022) examine the combined impacts of EC, ID, GDP, and urbanization on CO₂ for twenty-three (23) developing nations from 1995-2018. They use the Panel-ARDL technique for estimation. According to their findings, a 1% rise in energy usage, GDP, ID, and UP increases CO₂ by 0.230%, 0.170%, 0.540%, and 2.320%, correspondingly.

Summary of Literature and Gap

The existing empirical research on the relationship between CO₂ and other parameters is either inconclusive or mixed. For instance, discovered two paths of causation between income and CO₂ emissions for 88 nations from 1960 to 1990, confirm EKC. Apergis and Payne (2009), discovered that there were long-term correlations between real production, energy consumption, and CO₂ using panel-data from six (6) Central American countries from 1971-2004. The use of energy has a optimistic impact on CO₂. Shi (2003) discovered a optimistic link between population changes and CO₂ emissions for 93 economies from 1975 to 1996. Industrialization and commerce, according to Keho (2015) aided in the deterioration of the CO₂ in Cote d'Ivoire from 1970 to 2010. For 86 economies from 1975 to 1998, Cole and Neumayer (2004) found a promising connection between CO₂ and urbanization rate, inhabitants, family sizes, and energy-intensity. For five ASEAN nations from 1980 to 2006, Lean and Smyth (2010) naked a optimistic relationship between energy usage and CO₂, as well as a non-linear link between actual production and CO₂. For 85 economies from 1990 to 2011, Akin (2014) discovered that trade has a undesirable impact on

CO₂, with a unidirectional causation flowing from CO₂ to trade and GDP to CO₂ and energy-usage in the near term. During the period 1961–2003, Aka (2008) discovered that commerce improved but economic expansion damaged environmental quality in Sub-Saharan Africa.

Ly and Xu (2019) discovered that trade has beneficial effects on the CO₂ in the short-term but has a adverse impact on the CO₂ in the long run for 55 middle-income economies between 1992 and 2012. However, UP has a noteworthy and negative impact on . Yazdi and Dariani (2019) found that relationships between variables in Asian nations from 1980 to 2014. Increased urbanization leads to increased CO₂ and then energy usage, as well as a bi-directional causation between CO₂, urbanization, and output growth. From 1975 to 2017, Parveen et al. (2019) demonstrated that there is a one-way causation between CO₂ to urbanization, as well as CO₂ to GDP in Pakistan. The energy growth hypotheses were created by Odugbesan and Rjoub (2020), who found that there was one-way causation going from energy use to growth in Nigeria and Indonesia, but bi-directional causation in Turkey and Mexico. Adebayo et al. (2021) discovered that energy use, CO₂, and urbanization all have a favorable impact on output growth in Brazil from 1965 to 2019, but that there is no substantial relationship between trade openness and economic growth. According to Moutinho, Madaleno, and Elheddad (2020) production growth increases CO₂ nations, and energy usage has a negative impact on the environment; nevertheless, trade has better-quality environment in twelve OPEC nations from 1992-2015.

Few studies have been showed to examine the connection between urbanization, output growth, industrialization, trade, and , and most of them used a small sample size or a short time period, such as Saidi and Rahman (2021), who used data for five (5) OPEC countries from 1990-2014, but they overlooked the most central variables, namely trade and industrial development, which are the most noteworthy factors in CO₂. Similarly, Moutinho, Madaleno, and Bento (2020) ignored the most relevant variables, which are the most important contributors in CO₂ emissions in 12 OPEC nations from 1992 to 2015. Although there have been several research on the urbanization-environment nexus, only a few have focused on the least developed nations (Wang et al., 2022). Most previous research also overlooked the application of ARDL and granger causality methodologies in the case of Pakistan, as well as key factors. To close the gap, this study employed time series data of Pakistan, the ARDL approach, and Granger causality to produce accurate and more trustworthy conclusions that we could generalize to all developing countries.

Methodology

Model specification

This study uses secondary annually time series data for the period 1990-2020 which was collected from the World Development Indicators (WDI) (2022). This study's model is based on Kaya (1989) empirical model, which was used to investigate the relationship between CO₂ emissions and human activities. Lin et al. (2015) employed the Kaya empirical model to explore the impact of industrialization on CO₂ in Nigeria and China, respectively. This study used the following modified model is as under:

$$CO_{2t} = \alpha_0 + \alpha_1 UP_t + \alpha_2 GDP_t + \alpha_3 EC_t + \alpha_4 EXP_t + \alpha_5 ID_t + \mu_t \dots \dots \dots (1)$$

Whereas are the coefficient.

Table 1: Descriptions of the variables

Variable	Mark	Units
CO ₂ (metric tons per capita)	CO ₂	Log
Urban population	UP	Percentage
GDP growth (annual %)	GDP	Percentage
Energy consumption	EC	Log
Exports (% of GDP)	EXP	Percentage
Industry	ID	Percentage

Econometric Techniques

ARDL Technique

There are lot of technique for estimating for estimation, but the ARDL techniques developed Pesaran and Shin (1998). The ARDL technique more appropriate than other techniques due to the verity of reasons, like mixed order of integration and overcome on endogeneity. Therefore, the ARDL techniques results are more reliable, and authentic.

$$CO_{2t} = \alpha_0 + \sum_{i=1}^n \alpha_{1i} CO_{2t-1} + \sum_{i=0}^n \alpha_{2i} UP_{t-1} + \sum_{i=1}^n \alpha_{3i} GDP_{t-1} + \sum_{i=1}^n \alpha_{4i} EC_{t-1} + \sum_{i=1}^n \alpha_{5i} EXP_{t-1} + \sum_{i=1}^n \alpha_{6i} ID_{t-1} + \mu_t$$

..... (2)

$$\Delta CO_{2t} = \alpha_0 + \sum_{i=1}^n \alpha_{1i} \Delta CO_{2t-1} + \sum_{i=0}^n \alpha_{2i} \Delta UP_{t-1} + \sum_{i=1}^n \alpha_{3i} \Delta GDP_{t-1} + \sum_{i=1}^n \alpha_{4i} \Delta EC_{t-1} + \sum_{i=1}^n \alpha_{5i} \Delta EXP_{t-1} + \sum_{i=1}^n \alpha_{6i} \Delta ID_{t-1} + \gamma_1 UP_t + \gamma_2 GDP_t + \gamma_3 EC_t + \gamma_4 EXP_t + \gamma_5 ID_t + \mu_t$$

..... (3)

Results and Discussion

Unit Root Tests Results

Table 2 shows the unit-root tests results, which shows that the energy consumption and GDP are stationary at level and zero (0) degree integration order, while, the series CO₂, exports, industrialization, and urbanization are stationary at first difference and has 1st degree integration order. The unit root tests result indicated that the degree integration order of variables is mixed. Therefore, this study used the ARDL technique for estimation which more suitable for mixed order.

Table 2: PP and ADF tests Results

Variables	PP Test	ADF Test	Decision
	At level	At level	1 st Difference
	1 st Difference		

	-1.4407	-1.4407	-4.9628*	1(1)
CO _{2t}	(0.5486)	(0.5486)	(0.0004)	
	-3.2469*	-3.2507*		1(0)
EC _t	(0.0273)	(0.0270)		
	-0.5266	-0.6375	-5.2167*	1(1)
EXP _t	(0.8719)	(0.8470)	(0.0002)	
	-3.7311*	-3.7325*		1(0)
GDP _t	(0.0088)	(0.0088)		
	-2.1767	-2.1767	-5.9360*	1(1)
ID _t	(0.2185)	(0.2185)	(0.0000)	
	-0.7910	-0.8273	-7.2313*	1(1)
UP _t	(0.8068)	(0.7951)	(0.0000)	

*Note: The values inside the parenthesis () are p-values and *, **, & *** indicated the significance level at 1, 5 and 10-percent.*

Regression Results

Table 3 shows the ARDL results, which shows that, in the long-run, the EC has optimistic and noteworthy effect on CO₂. A % raise in the EC will increase the CO₂ on average by 0.3683 percent. The results were matching with the finding of Acaravci and Ozturk (2010), Sharma (2011), Hwang and Yoo (2014) and Franco et al. (2017), while, the opposite results were given by Alkhathlan and Javid (2013), and Muhammad (2019). Similarly, the exports have optimistic and noteworthy effect on CO₂. A % rise in the exports will boost the carbon emissions on average by 0.0149 percent. The results are parallel with the outcome of Al-mulali and Sheau-Ting (2014), Weber et al. (2008), and Hasanov et al. (2018), while, dissimilar with the outcome of Stretesky and Lynch (2009), and Weitzel and Ma (2014).

The GDP has optimistic and noteworthy effect on CO₂. A % rise in the GDP will boost the carbon emissions on average by 0.0043 percent. The similar finding were given by Acaravci and Ozturk (2010), Halicioglu (2009), Alkhathlan and Javid (2013), Ahmed and Long (2012), Sharma (2011) and Tang and Tan (2015), while, different results were given by Liu (2005), and Acheampong (2018). Similarly, the industrialization has optimistic and noteworthy effect on carbon emission. A % increase in the ID will increase the CO₂ on average by 0.0062%. The results are in line with the outcome of Patnaik (2018), Cherniwchan (2012), and Munir and Ameer (2020), while, dissimilar with the outcome of Opoku and Aluko (2021) and Opoku and Boachie (2020). Moreover, the UP has optimistic and noteworthy effect on CO₂. A % rise in the urbanization will surge the carbon emissions on average by 0.0156 percent. The results are parallel with the outcome of Franco et al. (2017), Uttara et al. (2012), Shahbaz et al. (2014), and Rahman and Alam (2021), while, opposite finding were given by Cui et al. (2019) and Liang et al. (2019).

Similarly, in the short-term, the EC has optimistic and noteworthy effect on carbon emission. A % rise in the energy consumption will boost the CO₂ on average by 0.3204 percent. Correspondingly, the exports have optimistic and noteworthy effect on CO₂. A % raise in the exports will raise the CO₂ on average by 0.0186%. The GDP has optimistic and noteworthy effect on CO₂. A % rise in the GDP will increase the CO₂ on average by 0.0015%. Moreover, the industrialization has optimistic and noteworthy effect on CO₂. A % rise in the industrialization will increase the CO₂ on average by 0.0073%. However, the urbanization

has unimportant effect on CO₂. Furthermore, the ECM worth is found negative (-0.5369) and significant, which shows that there is 54% the speed of convergence and exist co-integration.

Table 3: ARDL Results

Variables	Coefficient	Std Error	t-value	P-value
Long-Run Coefficients				
EC _t	0.3683*	0.1243	2.9638	0.0077
EXP _t	0.0149*	0.0036	4.1879	0.0005
GDP _t	0.0043*	0.0013	3.4142	0.0027
ID _t	0.0062***	0.0034	1.8321	0.0819
UP _t	0.0156**	0.0071	2.2031	0.0395
C	1.2574***	0.6345	1.9816	0.0614
Short-Run Coefficients				
D(EC _t)	0.3204***	0.1851	1.7307	0.0982
D(EXP _t)	0.0186*	0.0020	9.1772	0.0000
D(GDP _t)	0.0015**	0.0006	2.3137	0.0309
D(ID _t)	0.0073*	0.0009	7.8884	0.0000
D(UP _t)	-0.0018	0.0011	-1.6197	0.1202
D(ECM _{t-1})	-0.5369*	0.0084	-63.6486	0.0000
C	0.0117*	0.0038	3.0540	0.0060
F-Bounds Test		H ₀ : No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.244579*	10%	2.08	3
K	5	5%	2.39	3.38
		1%	3.06	4.15

Note: *, **, & *** designated the significance level at 1, 5 and 10-percent.

Granger Causality Test Results

Table 4 illustrates that there are exist two-way casualty between EC and CO₂, and UP and CO₂, while, one way causality running from GDP to CO₂ emission, EC to exports, UP to exports. However, no causality exists between exports and CO₂ emission, industrialization and CO₂, EC and GDP, EC and industrialization, EC and UP, GDP and exports, industrialization and exports, industrialization and GDP, UP and GDP, and UP and industrialization.

Table 4: Granger Causality Test Results

Variables	CO _{2t}	EC _t	EXP _t	GDP _t	ID _t	UP _t
CO _{2t}	----	2.4108***	1.1985	1.0029	0.0882	2.5349***
		(0.0895)	(0.3474)	(0.4332)	(0.9849)	(0.0783)
EC _t	4.0174**	----	2.3690***	0.1349	0.4624	1.6480
	(0.0179)		(0.0936)	(0.9673)	(0.7624)	(0.2083)
EXP _t	0.5734	0.2591	----	0.1827	1.9875	0.4113
	(0.6856)	(0.9001)		(0.9442)	(0.1422)	(0.7981)
GDP _t	2.4913***	0.9724	0.2841	-----	0.2450	0.9340

	(0.0821)	(0.4482)	(0.8842)		(0.9087)	(0.4677)
				0.5824		
	0.7848	0.0352	0.3789	(0.6796		1.1231
ID _t	(0.5506)	(0.9974)	(0.8206)	)	----	(0.3784)
				2.0265		
	3.5808**	1.8126	2.8908***	(0.1362	0.3743	
UP _t	(0.0271)	(0.1729)	(0.0539)	)	(0.8237)	----

Note: The values inside the parenthesis () are p-values and *, **, & *** indicated the connotation level at 1-, 5- and 10-percent.

Conclusion and Recommendations

The primary goal of every economy is to achieve sustainable economic growth but sustainable development is impossible to achieve without increasing environmental quality. The main aim of the study to investigate the causal nexus in industrialization, urbanization and CO₂ in Pakistan and used the data from 1990-2019. Based on the data behavior, an ARDL technique is used for estimation. This study found that the energy consumption, exports, GDP, industrialization has optimistic and noteworthy effect on CO₂. However, the urbanization has optimistic and noteworthy effect on CO₂, while, and has inconsequential effect in the short-period. Furthermore, there is 54% the speed of convergence and there is long-period cointegration among the variables. Moreover, there are exist two-way casualty between EC and CO₂ emission, and UP and CO₂, while, one-way causation from GDP to CO₂ emission, EC to exports, UP to exports. However, no causality exists between exports and CO₂ emission, industrialization and CO₂, EC and industrialization, EC and UP, GDP and exports, industrialization and exports, industrialization and GDP, UP and GDP, and UP and industrialization.

The study recommended that the minimize energy consumption, control the emission from factories and focused on those industries like tourism which has small effect on the environment degradation. This study also suggests to discourage urbanization and promote exports of goods which emission free.

References

- Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO₂ emissions and economic growth in Europe. *Energy*, 35(12), 5412-5420. doi: <https://doi.org/10.1016/j.energy.2010.07.009>
- Acheampong, A. O. (2018). Economic growth, CO₂ emissions and energy consumption: What causes what and where? *Energy Economics*, 74, 677-692. doi: <https://doi.org/10.1016/j.eneco.2018.07.022>
- Ahmad, M., & Zhao, Z.-Y. (2018). Empirics on linkages among industrialization, urbanization, energy consumption, CO₂ emissions and economic growth: a heterogeneous panel study of China. *Environmental Science and Pollution Research*, 25(30), 30617-30632. doi: <https://doi.org/10.1007/s11356-018-3054-3>
- Ahmed, K., & Long, W. (2012). Environmental Kuznets Curve and Pakistan: An Empirical Analysis. *Procedia Economics and Finance*, 1, 4-13. doi: [https://doi.org/10.1016/S2212-5671\(12\)00003-2](https://doi.org/10.1016/S2212-5671(12)00003-2)
- Aka, B. F. (2008). Effects of trade and growth on air pollution in the aggregated sub-Saharan Africa. *International Journal of Applied Econometrics and Quantitative Studies*, 5(1), 5-14.

- Akin, C. S. (2014). The impact of foreign trade, energy consumption and income on CO₂ emissions. *International Journal of Energy Economics and Policy*, 4(3), 465-475.
- Al-mulali, U., & Sheau-Ting, L. (2014). Econometric analysis of trade, exports, imports, energy consumption and CO₂ emission in six regions. *Renewable and Sustainable Energy Reviews*, 33, 484-498. doi: <https://doi.org/10.1016/j.rser.2014.02.010>
- Ali, H. S., Abdul-Rahim, A. S., & Ribadu, M. B. (2017). Urbanization and carbon dioxide emissions in Singapore: evidence from the ARDL approach. *Environmental Science and Pollution Research*, 24(2), 1967-1974. doi: 10.1007/s11356-016-7935-z
- Alkhathlan, K., & Javid, M. (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. *Energy policy*, 62, 1525-1532. doi: <https://doi.org/10.1016/j.enpol.2013.07.068>
- Apergis, N., & Payne, J. E. (2009). CO₂ emissions, energy usage, and output in Central America. *Energy policy*, 37(8), 3282-3286.
- Azam, M., & Khan, A. Q. (2016). Urbanization and environmental degradation: Evidence from four SAARC countries—Bangladesh, India, Pakistan, and Sri Lanka. *Environmental progress & sustainable energy*, 35(3), 823-832.
- Blowers, A. (1997). Environmental policy: ecological modernisation or the risk society? *Urban studies*, 34(5-6), 845-871.
- Burgess, R. (2000). The compact city debate: A global perspective. In M. Jenks & R. Burgess (Eds.), *Compact cities: Sustainable urban forms for developing countries* (pp. 9-24). London and New York: Spon Press.
- Cherniwchan, J. (2012). Economic growth, industrialization, and the environment. *Resource and Energy Economics*, 34(4), 442-467. doi: <https://doi.org/10.1016/j.reseneeco.2012.04.004>
- Cole, M. A., & Neumayer, E. (2004). Examining the impact of demographic factors on air pollution. *Population and Environment*, 26(1), 5-21.
- Croitoru, L., & Sarraf, M. (2010). *The cost of environmental degradation: case studies from the Middle East and North Africa*: World Bank Publications.
- Cui, X., Fang, C., Liu, H., & Liu, X. (2019). Assessing sustainability of urbanization by a coordinated development index for an Urbanization-Resources-Environment complex system: A case study of Jing-Jin-Ji region, China. *Ecological Indicators*, 96, 383-391. doi: <https://doi.org/10.1016/j.ecolind.2018.09.009>
- Dincer, I., & Rosen, M. A. (1999). Energy, environment and sustainable development. *Applied Energy*, 64(4), 427-440.
- Dinda, S., & Coondoo, D. (2006). Income and emission: a panel data-based cointegration analysis. *Ecological economics*, 57(2), 167-181.
- Ding, Y., & Li, F. (2017). Examining the effects of urbanization and industrialization on carbon dioxide emission: Evidence from China's provincial regions. *Energy*, 125, 533-542. doi: <https://doi.org/10.1016/j.energy.2017.02.156>
- Dong, F., Wang, Y., Su, B., Hua, Y., & Zhang, Y. (2019). The process of peak CO₂ emissions in developed economies: A perspective of industrialization and urbanization. *Resources, Conservation and Recycling*, 141, 61-75. doi: <https://doi.org/10.1016/j.resconrec.2018.10.010>

- Dong, H., Xue, M., Xiao, Y., & Liu, Y. (2021). Do carbon emissions impact the health of residents? Considering China's industrialization and urbanization. *Science of The Total Environment*, 758, 143688. doi: <https://doi.org/10.1016/j.scitotenv.2020.143688>
- Ehigiamusoe, K. U., Lean, H. H., Babalola, S. J., & Poon, W. C. (2022). The roles of financial development and urbanization in degrading environment in Africa: Unravelling non-linear and moderating impacts. *Energy Reports*, 8, 1665-1677. doi: <https://doi.org/10.1016/j.egyr.2021.12.048>
- Elliott, J. R., & Clement, M. T. (2014). Urbanization and carbon emissions: a nationwide study of local countervailing effects in the United States. *Social Science Quarterly*, 95(3), 795-816.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.
- Franco, S., Mandla, V. R., & Ram Mohan Rao, K. (2017). Urbanization, energy consumption and emissions in the Indian context A review. *Renewable and Sustainable Energy Reviews*, 71, 898-907. doi: <https://doi.org/10.1016/j.rser.2016.12.117>
- Ghauri, B., Lodhi, A., & Mansha, M. (2007). Development of baseline (air quality) data in Pakistan. *Environmental monitoring and assessment*, 127(1-3), 237-252.
- Gul, A., Xiumin, W., Chandio, A. A., Rehman, A., Siyal, S. A., & Asare, I. (2022). Tracking the effect of climatic and non-climatic elements on rice production in Pakistan using the ARDL approach. *Environmental Science and Pollution Research*, 29(21), 31886-31900. doi: 10.1007/s11356-022-18541-3
- Hajer, M. A. (1995). The politics of environmental discourse: ecological modernization and the policy process. *Oxford University Press, New York.*, 1-16. doi: https://www.amazon.co.jp/Politics-Environmental-Discourse-Ecological-Modernization/dp/019829333X/ref=ntt_at_ep_dpt_1
- Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. *Energy policy*, 37(3), 1156-1164. doi: <https://doi.org/10.1016/j.enpol.2008.11.012>
- Hanif, I. (2018). Impact of economic growth, nonrenewable and renewable energy consumption, and urbanization on carbon emissions in Sub-Saharan Africa. *Environmental Science and Pollution Research*, 25(15), 15057-15067. doi: 10.1007/s11356-018-1753-4
- Hasanov, F. J., Liddle, B., & Mikayilov, J. I. (2018). The impact of international trade on CO2 emissions in oil exporting countries: Territory vs consumption emissions accounting. *Energy Economics*, 74, 343-350. doi: <https://doi.org/10.1016/j.eneco.2018.06.004>
- Hwang, J.-H., & Yoo, S.-H. (2014). Energy consumption, CO2 emissions, and economic growth: evidence from Indonesia. *Quality & Quantity*, 48(1), 63-73. doi: 10.1007/s11135-012-9749-5
- Janssens-Maenhout, G., Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E., Olivier, J. G. J., . . . Schure, K. M. (2017). EDGAR - Emissions Database for Global Atmospheric Research. from https://edgar.jrc.ec.europa.eu/booklet/Fossil_CO2andGHG_emissions_of_all_world_countries_booklet_2017report.pdf

- Jiang, J., Zhu, S., Wang, W., Li, Y., & Li, N. (2022). Coupling coordination between new urbanisation and carbon emissions in China. *Science of The Total Environment*, 850, 158076. doi: <https://doi.org/10.1016/j.scitotenv.2022.158076>
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration--with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.
- Kaya, Y. (1989). Impact of carbon dioxide emission control on GNP growth: interpretation of proposed scenarios. *Intergovernmental Panel on Climate Change / Response Strategies Working Group, May*. doi: <https://ci.nii.ac.jp/naid/10021966297/>
- Keho, Y. (2015). An Econometric study of the long-run determinants of CO2 emissions in Cote d'Ivoire. *Journal of Finance and Economics*, 3(2), 11-21.
- Khan, M. A., & Ozturk, I. (2020). Examining foreign direct investment and environmental pollution linkage in Asia. *Environmental Science and Pollution Research*, 27(7), 7244-7255.
- Le, T.-H., Chang, Y., & Park, D. (2016). Trade openness and environmental quality: International evidence. *Energy policy*, 92, 45-55.
- Lean, H. H., & Smyth, R. (2010). CO2 emissions, electricity consumption and output in ASEAN. *Applied Energy*, 87(6), 1858-1864.
- Liang, L., Wang, Z., & Li, J. (2019). The effect of urbanization on environmental pollution in rapidly developing urban agglomerations. *Journal of cleaner production*, 237, 117649. doi: <https://doi.org/10.1016/j.jclepro.2019.117649>
- Lin, B., Omoju, O. E., & Okonkwo, J. U. (2015). Impact of industrialisation on CO2 emissions in Nigeria. *Renewable and Sustainable Energy Reviews*, 52, 1228-1239.
- Liu, B., Tian, C., Li, Y., Song, H., & Ma, Z. (2018). Research on the effects of urbanization on carbon emissions efficiency of urban agglomerations in China. *Journal of cleaner production*, 197, 1374-1381. doi: <https://doi.org/10.1016/j.jclepro.2018.06.295>
- Liu, X. (2005). Explaining the relationship between CO2 emissions and national income—The role of energy consumption. *Economics Letters*, 87(3), 325-328. doi: <https://doi.org/10.1016/j.econlet.2004.09.015>
- Liu, X., & Bae, J. (2018). Urbanization and industrialization impact of CO2 emissions in China. *Journal of cleaner production*, 172, 178-186.
- Lv, Z., & Xu, T. (2019). Trade openness, urbanization and CO2 emissions: dynamic panel data analysis of middle-income countries. *The Journal of International Trade & Economic Development*, 28(3), 317-330.
- Majeed, M. T., & Mumtaz, S. (2017). Happiness and environmental degradation: A global analysis. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, 11(3), 753-772.
- Majeed, M. T., & Tauqir, A. (2020). Effects of urbanization, industrialization, economic growth, energy consumption, financial development on carbon emissions: an extended STIRPAT model for heterogeneous income groups. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, 14(3), 652-681.
- Marcotullio, P., & Lee, Y.-S. (2003). Urban environmental transitions and urban transportation systems: A comparison of the North American and Asian experiences. *International Development Planning Review*, 25, 325-354. doi: 10.3828/idpr.25.4.2
- Martínez-Zarzoso, I., & Maruotti, A. (2011). The impact of urbanization on CO2 emissions: Evidence from developing countries. *Ecological Economics*, 70(7), 1344-1353. doi: <https://doi.org/10.1016/j.ecolecon.2011.02.009>

- Moutinho, V., Madaleno, M., & Bento, J. P. (2020). Cointegration and causality: considering Iberian economic activity sectors to test the environmental Kuznets curve hypothesis. *Environmental and Ecological Statistics*, 27(2), 363-413.
- Moutinho, V., Madaleno, M., & Elheddad, M. (2020). Determinants of the Environmental Kuznets Curve considering economic activity sector diversification in the OPEC countries. *Journal of cleaner production*, 271(20), 1-37.
- Muhammad, B. (2019). Energy consumption, CO2 emissions and economic growth in developed, emerging and Middle East and North Africa countries. *Energy*, 179, 232-245. doi: <https://doi.org/10.1016/j.energy.2019.03.126>
- Munir, K., & Ameer, A. (2020). Nonlinear effect of FDI, economic growth, and industrialization on environmental quality. *Management of Environmental Quality: An International Journal*, 31(1), 223-234. doi: 10.1108/MEQ-10-2018-0186
- Nasreen, S., Saidi, S., & Ozturk, I. (2018). Assessing links between energy consumption, freight transport, and economic growth: evidence from dynamic simultaneous equation models. *Environmental Science and Pollution Research*, 25(17), 16825-16841. doi: <https://link.springer.com/article/10.1007/s11356-018-1760-5>
- Odugbesan, J. A., & Rjoub, H. (2020). Relationship Among Economic Growth, Energy Consumption, CO2 Emission, and Urbanization: Evidence From MINT Countries. *SAGE Open*, 10(2), 1-15. doi: <https://doi.org/10.1177/21582440209146>
- Opoku, E. E. O., & Aluko, O. A. (2021). Heterogeneous effects of industrialization on the environment: Evidence from panel quantile regression. *Structural Change and Economic Dynamics*, 59, 174-184. doi: <https://doi.org/10.1016/j.strueco.2021.08.015>
- Opoku, E. E. O., & Boachie, M. K. (2020). The environmental impact of industrialization and foreign direct investment. *Energy policy*, 137, 111178. doi: <https://doi.org/10.1016/j.enpol.2019.111178>
- Parveen, S., Khan, A. Q., & Farooq, S. (2019). The Causal Nexus of Urbanization, Industrialization, Economic Growth and Environmental Degradation: Evidence From Pakistan. *Review of Economics and Development Studies*, 5(4), 721-730. doi: 10.26710/reads.v5i4.883
- Pata, U. K. (2018). The effect of urbanization and industrialization on carbon emissions in Turkey: evidence from ARDL bounds testing procedure. *Environmental Science and Pollution Research*, 25(8), 7740-7747. doi: 10.1007/s11356-017-1088-6
- Patnaik, R. (2018). Impact of Industrialization on Environment and Sustainable Solutions – Reflections from a South Indian Region. *IOP Conference Series: Earth and Environmental Science*, 120(1), 012016. doi: 10.1088/1755-1315/120/1/012016
- Pesaran, M. H., & Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs*, 31, 371-413.
- Rahman, M. M., & Alam, K. (2021). Clean energy, population density, urbanization and environmental pollution nexus: Evidence from Bangladesh. *Renewable Energy*, 172, 1063-1072. doi: <https://doi.org/10.1016/j.renene.2021.03.103>
- Rasool, S. F., Zaman, S., Jehan, N., Chin, T., Khan, S., & Zaman, Q. u. (2022). Investigating the role of the tech industry, renewable energy, and urbanization in sustainable environment: Policy directions in the context of developing economies. *Technological Forecasting and Social Change*, 183, 121935. doi: <https://doi.org/10.1016/j.techfore.2022.121935>

- Sadorsky, P. (2013). Do urbanization and industrialization affect energy intensity in developing countries? *Energy Economics*, 37, 52-59. doi: <https://doi.org/10.1016/j.eneco.2013.01.009>
- Saidi, K., & Rahman, M. M. (2021). The link between environmental quality, economic growth, and energy use: new evidence from five OPEC countries. *Environment Systems and Decisions*, 41(1), 3-20.
- Shahbaz, M., Sbiba, R., Hamdi, H., & Ozturk, I. (2014). Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. *Ecological Indicators*, 45, 622-631. doi: <https://doi.org/10.1016/j.ecolind.2014.05.022>
- Sharma, S. S. (2011). Determinants of carbon dioxide emissions: Empirical evidence from 69 countries. *Applied Energy*, 88(1), 376-382. doi: <https://doi.org/10.1016/j.apenergy.2010.07.022>
- Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: evidence from pooled cross-country data. *Ecological economics*, 44(1), 29-42.
- Sikder, M., Wang, C., Yao, X., Huai, X., Wu, L., KwameYeboah, F., . . . Dou, X. (2022). The integrated impact of GDP growth, industrialization, energy use, and urbanization on CO2 emissions in developing countries: Evidence from the panel ARDL approach. *Science of The Total Environment*, 837, 155795. doi: <https://doi.org/10.1016/j.scitotenv.2022.155795>
- Stretesky, P. B., & Lynch, M. J. (2009). A cross-national study of the association between per capita carbon dioxide emissions and exports to the United States. *Social Science Research*, 38(1), 239-250. doi: <https://doi.org/10.1016/j.ssresearch.2008.08.004>
- Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy*, 79, 447-454. doi: <https://doi.org/10.1016/j.energy.2014.11.033>
- Temurshoev, U. (2006). Pollution haven hypothesis or factor endowment hypothesis: theory and empirical examination for the US and China. *Center for Economic Research and Graduate Education and Economics Institute (CERGE-EI)(Working Paper 292)*, 1-57. doi: <http://www.cerge-ei.cz/pdf/wp/Wp292.pdf>
- Uttara, S., Bhuvandas, N., & Aggarwal, V. (2012). Impacts of urbanization on environment. *International Journal of Research in Engineering and Applied Sciences*, 2(2), 1637-1645.
- Wang, Q., & Su, M. (2019). The effects of urbanization and industrialization on decoupling economic growth from carbon emission – A case study of China. *Sustainable Cities and Society*, 51, 101758. doi: <https://doi.org/10.1016/j.scs.2019.101758>
- Wang, Q., Su, M., & Li, R. (2018). Toward to economic growth without emission growth: The role of urbanization and industrialization in China and India. *Journal of cleaner production*, 205, 499-511. doi: <https://doi.org/10.1016/j.jclepro.2018.09.034>
- Wang, Q., Wang, X., & Li, R. (2022). Does official development assistance alleviate the environmental pressures during the urbanization of recipient countries? Evidence from the sub-Saharan Africa countries. *Environmental Impact Assessment Review*, 95, 106787. doi: <https://doi.org/10.1016/j.eiar.2022.106787>

- Wang, W.-Z., Liu, L.-C., Liao, H., & Wei, Y.-M. (2021). Impacts of urbanization on carbon emissions: An empirical analysis from OECD countries. *Energy policy*, 151, 112171. doi: <https://doi.org/10.1016/j.enpol.2021.112171>
- Wang, Y., Zhang, X., Kubota, J., Zhu, X., & Lu, G. (2015). A semi-parametric panel data analysis on the urbanization-carbon emissions nexus for OECD countries. *Renewable and Sustainable Energy Reviews*, 48, 704-709. doi: <https://doi.org/10.1016/j.rser.2015.04.046>
- WCED. (1987). Report of the World Commission on Environment and Development: Our common future. London: UN Documents Cooperation Circles.
- Weber, C. L., Peters, G. P., Guan, D., & Hubacek, K. (2008). The contribution of Chinese exports to climate change. *Energy policy*, 36(9), 3572-3577. doi: <https://doi.org/10.1016/j.enpol.2008.06.009>
- Weitzel, M., & Ma, T. (2014). Emissions embodied in Chinese exports taking into account the special export structure of China. *Energy Economics*, 45, 45-52. doi: <https://doi.org/10.1016/j.eneco.2014.06.012>
- World Bank. (2020). *World development report 2018: Learning to realize education's promise*: The World Bank.
- World Development Indicators (WDI). (2022). The World Bank. doi: <https://databank.worldbank.org/source/world-development-indicators#>
- Wu, Y., Shen, J., Zhang, X., Skitmore, M., & Lu, W. (2016). The impact of urbanization on carbon emissions in developing countries: a Chinese study based on the U-Kaya method. *Journal of cleaner production*, 135, 589-603.
- Yazdi, S. K., & Dariani, A. G. (2019). CO 2 emissions, urbanisation and economic growth: Evidence from Asian countries. *Economic research-Ekonomska istraživanja*, 32(1), 510-530.
- Zhang, N., Yu, K., & Chen, Z. (2017). How does urbanization affect carbon dioxide emissions? A cross-country panel data analysis. *Energy policy*, 107, 678-687. doi: <https://doi.org/10.1016/j.enpol.2017.03.072>