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Investigating the Validity of the Environmental Kuznets Curve in Afghanistan

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ABSTRACT

The main aim of this study to investigate the validity of environmental Kuznets Curve (EKC) in Afghanistan. This study used the annual secondary data from 2000 to 2024 of Afghanistan and employ the GMM techniques for assessment, based on the data behavior. This study initiates that the GDPpc, Foreign Direct Investment (FDI), urbanization has optimistic effect on carbon emission (CO2). However, the inflation rate has negatively influence CO2. Therefore, the empirical outcomes confirmed the existence of EKC in Afghanistan, because there is inverted U-shape relationship between GDPpc and CO2. This study recommended that to reduce CO2, the government should prioritize increasing GDP per capita in metropolitan areas and attracting FDI. This study also faced some limitation, like not consider the energy consumption due to unavailability of data.

Background of the Study

Attaining sustainable economic growth (GDPpc) is the primary goal of every economy (Azam *et al.*, 2022; WCED, 1987). Similarly, the greatest serious challenge to global GDPpc and existence is environmental deterioration (CO_2). Natural-resources (NR) is expanding on a daily basis, putting significant strain on the eco-system and posing considerable environmental risks (Azam *et al.*, 2024; Chu & Le, 2021). There are several factors that contribute significantly to maintaining and attaining GDPpc, with energy use (EC) playing an important role that can't be ignored. A clean environment is also an important feature and unquestionably necessary for sustainable growth. The EC, industrialization (IND), urbanization (URBN), and trade-openness (TO), among other things, all have a substantial impact on environmental-quality (EnQ). Energy efficiency is helpful since it lessens work costs and CO_2 (Dincer & Rosen, 1999).

Nowadays, the relationship between EnQ and GDPpc is the most contentious question among academics and policymakers alike. Instead, CO2 upsurge faster than production growth first and slower than output growth at higher development levels. The EKC describes a systematic relationship between EnQ and GDPpc (Dinda, 2004). The primary rationale of the EKC is that pollution increases too quickly during industrialization since output development was the government's top objective, and citizens prioritized money production (Azam et al., 2023; Dasgupta et al., 2002).

This study emphases on determining the legitimacy of EKC, which describe the long-term (LR) relationship between production growth and CO_2 possessions. The expansion of NR mining impacts GDPpc during the takeoff stage. The resource collapse begins to outpace the NR regeneration, and waste creation increases in toxicity and volume. The structural change and higher GDPpc toward industries raises environmental awareness, follows environmental regulations, spends more on the environment, and uses better technology, resulting in a leveling off and gradual decrease in CO_2 (see Figure 1 (Kuznets, 1955)). EnQ begins to improve as income reaches the EKC tipping point. Thus, it represents the natural progression of economic expansion from an clean agrarian economy to a dirty economy and, lastly, an clean services sector (Arrow *et al.*, 1996).

Global warming is a significant hazard, and climate change evaluation raises obvious health and CO_2 concerns. The subsequent EC and industrial growth are thought to be the primary causes of CO2 emissions, the implications of which are obvious via phenomena such as rising temperatures, among others (Anwar *et al.* (2020). Some researchers suggest that CO2 emissions, like other pollutants, will fall as economic expansion continues. However, previous literature on EKC has not yet provided convincing proof of its presence (Joshi & Beck, 2018). Some scholars affirm the presence of EKC in general (Azam *et al.*, 2023; Destek & Sarkodie, 2019; Fayaz *et al.*, 2024; Lau *et al.*, 2014; Murshed *et al.*, 2021), while others disagree (Day & Grafton, 2003; Gergel *et al.*, 2004; Mahmood *et al.*, 2020). Further research is looked-for to study the presence of EKC and provide convincing evidence (Joshi & Beck, 2018).

The primary purpose of this research is to evaluate the presence of EKC in Afghanistan using yearly time series data. Previous research has investigated the presence of the EKC using panel, time series data, and other estimate approaches, but the outcomes are still inconclusive, and there is no restructured study in Afghanistan. They utilized data from 2000 to 2024 and estimated with GMM methods. Panel data results can't be extended to individual nations, and time-series data from one country can't be applied to another owing to differences in demographics and wealth levels. Different estimate strategies provide skewed findings owing to endogeneity difficulties. Thus, this is the first research to employ Afghanistan data as the suitable empirical approach. This work makes a substantial fourfold contribution to the literature. First, we utilized data from Afghanistan with a unique mix of independent factors to investigate the presence of EKC for each country. Second, this study used the GMM estimator to cope with the non-linear bond between CO_2 and GDPpc and overcome the data's endogeneity difficulties. Third, this analysis determines the threshold effect or tipping point for each nation. Finally, the findings of this study can help Afghanistan government authorities develop environmentally friendly policies aimed at reducing CO_2 and keeping the environment clean and green.

Review of Literature

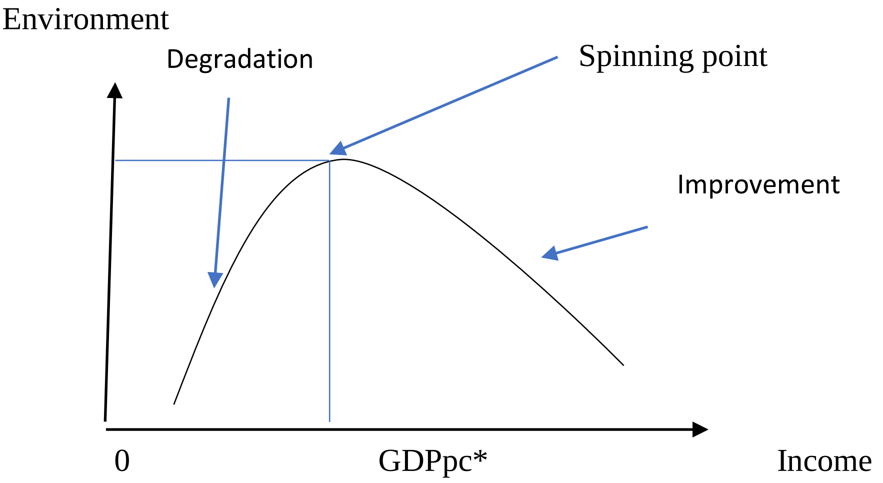
The key study of Kuznets (1955) demonstrates the connection among GDPpc and income discrepancy. Future, Grossman and Krueger (1991) constructed the EKC to evaluate the environmental impression of the NAFTA among Mexico and the US. Beckerman (1992) contends that increases in GDPpc increase pollution at the start of development, but thereafter demonstrate an inverse connection as economic activity develops and pollution decreases. Stern *et al.* (1996) disputed the EKC notion of an inverted U-shaped relationship among income per capita and CO_2, implying that economic expansion lessens the environmental impact of economic activities. The notion is based on an economic model in which environmental quality has no effect on output possibilities, and commerce has an impartial influence on environmental deterioration. The real breach of these assumptions adds to the inherent problems in determining the characteristics of an EKC. They also point out certain economic issues with analyzing the EKC after studying numerus research. The inferences from such EKC estimates that additional increases in GDPpc will reduce air pollution are based on the assumption that GDPpc is normally-distributed over the world, with the median value being less than the mean income.

The EKC dialog stems from the debate over growth-related policies. Scholars think that greater economic levels lead to increased environmental damage. In reality, increasing income levels can reduce environmental deterioration (Beckerman, 1992), hence economic expansion is required to promote environmental quality (Bhagwati, 1993). Thus, economic expansion may be an influential factor in minimizing environmental deterioration in poor nations (Panayotou, 1993). There is controversy among scholars about which growth is ultimately advantageous to the enhancement of environmental quality, such as present environmental legislation; limiting economic growth may fundamentally result in worsening EnQ (Bartlett, 1994). Since recent years, there have been debates about the relationship between environmental preservation and globalization, as well as link among GDPpc and CO_2 (Dinda, 2004). Shahbaz and Sinha (2019) perform a study of the experiential literature on EKC estimate for CO_2 between 1991-2017. They take into account research completed on both individual and group nations and predict that the figure of the EKC that demonstrates the relationship among CO_2 and GDPpc. They are unable to establish a consistent viewpoint on the legitimacy of the EKC theory.

Furthermore, economic expansion is driven by the buildup of production influences (Lopez, 1994). Instantaneously, the demand for EnQ increases as income grows, as does the desire to pay for a clean environment. A simple comparative static study of the advantages and costs associated with the highest EnQ provides an intriguing conceptual idea of how the EKC can evolve and calculated from the junction locations of the marginal benefit and cost curves (Munasinghe, 1999). The EKC may be derived immediately from the connection of knowledge between the use of a favored item and the reduction of its negative consequences, implying that EKC is a upfront static (Andreoni & Levinson, 2001). The EKC is the result of a dynamic method in which one piece of capital is spent in the manufacturing process, causing environmental damage, and the other is employed to restore EnQ (Dinda, 2005). Rapid GDP expansion degrades EnQ, which has a adverse impression on national health (Anwar *et al.*, 2020). Figure 1 depicts an EKC in which we assess CO_2 with the vertical-line and revenue with the horizontal-line.

The research Bekhet *et al.* (2020) verifies the presence of EKC in Malaysia from 1971-2013. Beyene and Kotosz (2020) naked that the bond between CO_2 and GDPpc was U-shaped and not sustenance EKC in twelve (12) East African nations from 1990-2013. Similarly, Arnaut and Lidman (2021) analysis show a U-formed relationship between wealth and CO_2 and do not sustenance the EKC hypothesis in Greenland from 1970-2018. Similarly, Pauli (2003) originate no sign of EKC hypothesis in OECD from 1970-1998. Similarly, Boutaud *et al.* (2006) originate no sign of EKC in 131 nations. Setyari and Kusuma (2021) analysis concludes that EKC exists in a panel of 62 countries from 1992-2017, but that the structure of the EKC is unknown. Furthermore, Azam *et al.* (2023) use the ARDL approach to inspect the legitimacy of the EKC for four (4) MENA countries from 1980 to 2018, taking into account EnQ and real GDPpc. The cointegration findings show that there are LR relationships between variables of ach nation. The ARDL results suggest that the EKC is valid for Turkey and unconventional for the UAE in the LR, but it is invalid for Algeria, UAE and Egypt, in near run, as well as for Turkey and the UAE in the LR. Inclusive, evidence on the legitimacy of the EKC is equivocal. Similarly, Azam *et al.* (2024) test the validity of the EKC hypothesis for 182 nations using yearly time series data and the FMOLS model for estimate and found that EKC exists in 11 low, 15 lower-middle and 34 (thirty-four) upper-middle, and twenty-four (24) high-income nations out of 182, but the link between GDPpc and CO_2 in the other countries is inverted U-shaped. Furthermore, the effects of energy usage and population expansion on CO_2 are positive, as predicted. They find that the EKC is correct for 84 percent of the totals. Moreover, Fayaz *et al.* (2024) use 1990–2020 data and adopt ARDL and Granger causality estimate approaches. They validated the presence of the EKC with the moderating influence of energy use in China and Pakistan.

Figure 1. Environmental Kuznets Curve (EKC)



Source: (Azam *et al.*, 2024; Dinda, 2004)

Methodology

This study is quantitative in nature and used the annual secondary data from 2000 to 2024 collected from World Development Indicators (2025) of Afghanistan. Based on the data behavior, this study used the GMM techniques for estimation.

Model specification

This study used the following modified model, also used by Setyari and Kusuma (2021), Azam et al. (2023), and Azam et al. (2024).

$$CO_{2_t} = \beta_0 + \beta_1 GDPpc_t + \beta_2 GDPpc^2{}_t + \beta_3 FDI_t + \beta_4 CPI_t + \beta_5 URBN_t + \mu_t \text{.............} (1)$$

Where,

CO_{2_t} = Carbon dioxide (CO2) emissions (t CO2e/capita)

$GDPpc_t$ = GDP per capita growth (annual %)

FDI_t = FDI, net inflows (% of GDP)

CPI_t = Inflation, consumer prices (annual %)

$URBN_t$ = Urban population growth (annual %)

μ_t = Error term

Estimation Technique

The first step in presenting GMM is to understand how the technique of moments works and how GMM adapts to handle more broad cases. In all situations, the formulation starts with a moment condition derived from economic theory. given example, given the first moment of a random-variable X with population mean μ, the succeeding moment condition applies:

$$E(x) - \mu = 0 \quad \text{......} \quad (2)$$

In turn, given a sample $x_1, x_2, \dots \dots \dots, x_T$, and write the equation (1) through its corresponding item:

$$\sum_{t=1}^{T} \frac{x_t}{T} - \mu = 0 \quad \text{......} \quad (3)$$

Hence, the moment method estimator for μ is obtained by:

$$\hat{\mu}_{MM} = \sum_{t=1}^{T} \frac{x_t}{T} \quad \text{......} \quad (4)$$

Furthermore, $y = x'\beta + \mu$ and $\mu = y - x'\beta$

$$E(\mu x) = 0 \quad \text{......} \quad (5)$$

$$E[x(y - x'\beta)] = 0 \quad \text{......} \quad (6)$$

$$\frac{1}{N} \sum_{i=1}^{N} x(y - x'\beta) = 0 \quad \text{......} \quad (7)$$

$$\hat{\beta}_{MM} = \left(\sum_i x_i x'_i\right)^{-1} \sum_i x_i y_i \quad \text{......} \quad (8)$$

Represent the linear method using instrumental variables. It is difficult to identify how many moments should be included in the specification. Hall (2003) suggests that for small samples of up to 100, to estimate.

Results and Discussions

Table 1 depicted that GDP per capita square has the highest and CO_2 has the lowest means and standard deviation. Furthermore, only the series CO_2, GDPpc and URBN are normally distributed. Moreover, the GDPpc and URBN has positively while, $GDPpc^2$, FDI, and CPI has negatively correlated with CO_2. Furthermore, $GDPpc^2$, FDI, and URBN has positively, while CPI negatively correlated with GDPpc. However, the rest of variables are positively correlated.

Table 1: Correlation Matrix and Descriptive Statistics

	CO_{2t}	$GDPpc_t$	$GDPpc^2_t$	FDI_t	CPI_t	$URBN_t$
Mean	0.1751	1.2086	75.7010	0.8904	5.5022	3.9122
Median	0.2036	0.1100	4.6148	0.2930	5.1332	3.9951
Maximum	0.3887	22.0202	510.0588	4.3687	26.4187	6.5576
Minimum	0.0379	-22.5845	0.0113	0.0048	-6.8112	1.1733
Std. Dev.	0.0984	8.7940	143.2537	1.2013	6.9365	1.1436
Skewness	-0.0005	-0.0248	2.2374	1.8033	0.6984	-0.2863

Kurtosis	2.1888	4.5096	6.8245	5.0903	4.8615	3.8151
Jarque-Bera	0.6854	2.3765	36.0949*	18.1008*	5.6418***	1.0336
Probability	0.7098	0.3047	0.0000	0.0001	0.0596	0.5964
CO_{2t}	1					
$GDPpc_t$	0.1107	1				
$GDPpc^2_t$	-0.1366	0.1352	1			
FDI_t	-0.5463	0.2828	0.0304	1		
CPI_t	-0.2139	-0.1408	0.0671	0.1615	1	
$URBN_t$	0.0949	0.4004	0.1033	0.3136	0.1460	1

*Note: *,**,&*** shows the significance level at 1, 5 and 10%.*

Table 2 depicted the ADF results, shows that CO_2 and FDI are stationary at first difference (1(1)) while the rest of variables are stationary at level (1(0)). Therefore, the data behavior of the variables is recommending the use of GMM test for estimation.

Table 2: Unit Root test Results

Variables	**At level**		**Δ**		**Order of Integration 1(0) or 1(1)**
	t-Statistic	**Prob.***	**t-Statistic**	**Prob.***	
CO_{2t}	-1.7770	0.3817	-3.1693**	0.0353	1(1)
$GDPpc_t$	-4.0575*	0.0048	----	---	1(0)
FDI_t	-1.7078	0.4148	-3.6424**	0.0128	1(1)
CPI_t	-4.886*	0.0007	----	---	1(0)
$URBN_t$	-4.1837*	0.0042	----	---	1(0)

*Note: *, **, &*** shows the significance level at 1, 5 and 10%.*

Table 3 depicted the GMM techniques outcomes, shows that the GDPpc has optimistic effect on CO_2. A % increase in the GDPpc will leads to upsurge the CO_2 by 0.007%. The similar results were given by Wang and Liu (2017), Liu and Bae (2018) and He *et al.* (2017) while contradict with Ali *et al.* (2017), Day and Grafton (2003) and Mahmood *et al.* (2020). However, the $GDPpc^2$ has negative effect on CO_2. A % increase in the $GDPpc^2$ will leads to decrease the CO_2 by 0.001%. Therefore, the empirical results confirmed the existence of EKC in Afghanistan. The similar results were given by Hameed *et al.* (2024) in Afghanistan. Moreover, similar with Ali *et al.* (2021), Fayaz *et al.* (2024) and Khan (2021) while, contradict with Murshed and Dao (2020), Day and Grafton (2003) and Mahmood *et al.* (2020). However, FDI has positive effect on CO_2. A % increase in the FDI will leads to increase the CO_2 by 0.09 percent. Outcomes are in line with Ali *et al.* (2021), and Lin *et al.* (2022) while, contradict with Haug and Ucal (2019), Khan *et al.* (2023), and Fauzel (2017).

However, the inflation rate has negatively influence CO_2. A percent increase in the CPI will leads to decrease the CO_2 by 0.004 percent. The results are in line with Grolleau and Weber (2024), and Ünsal (2025) while, contradict with Musarat *et al.* (2021). However, urbanization has positive effect on CO_2. A percent increase in the URBN will leads to upsurge the CO_2 by 0.05%. Outcomes are similar with Ullah *et al.* (2020), Ali *et al.* (2019) and Liu and Bae (2018) while, contradict with Sadorsky (2014), Dong *et al.* (2019), and Martínez-Zarzoso and Maruotti (2011). Moreover, the turning point of EKC is $GDPpc = -{}^{\beta_1}/_{2\beta_2} = -\frac{0.0067}{2(-0.0013)} = 2.5769 \cong \$1316\ US$, if the GDPpc reach to \$13.16 US then the CO_2 will start declining.

Table 3: GMM Techniques Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$GDPpc_t$	0.0067***	0.0038	1.7727	0.0932
$GDPpc^2_t$	-0.0013*	0.0001	-12.7243	0.0000
FDI_t	0.0858*	0.0037	23.0648	0.0000
CPI_t	-0.0036**	0.0015	-2.4043	0.0272
$URBN_t$	0.0450**	0.0186	2.4154	0.0266
C	0.5561*	0.0880	6.3207	0.0000

*Note: *, **, &*** shows the consequence level at 1, 5 and 10%.*

Table 4 displays the Johansen-Cointegration test findings, indicating that there is cointegration up to the 4th cointegrating equation shows by both tests. As a result, the Johansen Cointegration test detects LR cointegration between variables.

Table 4: Johansen Cointegration Techniques Results

a) Unrestricted Cointegration Rank Test (Trace)				
H_0 **At most**		**Trace**	**0.05**	**p-value**
No. of CE(s)	**Eigenvalue**	**Statistic**	**CV**	**CV**
None *	0.9873*	233.8344	95.754	0.0000
1 *	0.9385*	133.3877	69.819	0.0000
2 *	0.7461*	69.22942	47.856	0.0002
3 *	0.6416*	37.70376	29.797	0.0050
4	0.4122	14.10061	15.495	0.0802
5	0.0784	1.877579	3.8415	0.1706
b) Unrestricted Cointegration Rank Test (Max-eigenvalue)				
H_0 **At most**		Max-Eigen	0.05	Prob.**
No. of CE(s)	Eigenvalue	Statistic	CV	CV
None *	0.9873*	100.4467	40.078	0.0000
1 *	0.9385*	64.15827	33.877	0.0000
2 *	0.7461*	31.52566	27.584	0.0147
3 *	0.6416*	23.60315	21.132	0.0220
4	0.4122	12.22303	14.265	0.1025
5	0.0784	1.877579	3.8415	0.1706

Note: i) Max-eigenvalue test designates 4 cointegrating equation(s) at the 0.05 level

*ii) * denotes denial of the H_0 and CV for critical values.*

Conclusion and Recommendations

The main aim of this study to investigate the validity of EKC in Afghanistan. This study used the annual secondary data from 2000 to 2024 of Afghanistan and employ the GMM techniques for estimation, based on the data behavior. This study found that the GDPpc, FDI, urbanization has positive effect on CO_2. However, the inflation rate has negatively influence CO_2. Therefore, the empirical results confirmed the existence of EKC in Afghanistan, because there is inverted U-shape relationship between GDPpc and CO_2. This study recommended that to reduce CO_2, the government should prioritize increasing GDP per capita in metropolitan areas and attracting FDI. This study also faced some limitation, like not consider the energy consumption due to unavailability of data.

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