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Urbanization, Economic Activity, and Electricity Consumption in Jordan: Evidence from the Autoregressive Distributed Lag Approach

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ABSTRACT

This study examines the impact of urbanization on per capita electricity consumption in Jordan, while controlling for key economic and structural determinants, namely economic growth, industrial sector contribution, and population growth. Using annual time-series data for the period 2000-2022, the study employs the autoregressive distributed lag (ARDL) methodology to analyze both short-run dynamics and long-run equilibrium relationships among the variables. The results of the ARDL bounds testing procedure confirm the existence of a long-run cointegrating relationship between electricity consumption and its underlying determinants. Long-run estimates reveal that urbanization, economic growth, industrial sector contribution, and population growth all exert positive and statistically significant effects on per capita electricity consumption. These findings indicate that urban expansion and structural economic transformation are key drivers of the increasing electricity demand in Jordan. In the short run, the error correction model (ECM) reveals significant dynamic adjustments. Urbanization and industrial activity exert immediate and positive effects on electricity consumption, whereas economic growth displays mixed short-term impacts. The error correction term is negative and statistically significant, confirming the stability of the long-run equilibrium and indicating a relatively rapid adjustment process following short-term disturbances. The study concludes that accelerated urbanization and economic expansion place increasing pressure on Jordan's electricity sector. Accordingly, policymakers are encouraged to integrate energy efficiency initiatives, sustainable urban planning practices, and industrial energy management strategies to ensure long-term energy security and environmental sustainability.

Keywords: Electricity Consumption, Urbanization, Economic Growth, Industrial Sector, Population Growth, Autoregressive distributed lag
JEL Classifications: Q43, Q41, C22, R11

1. INTRODUCTION

The relationship between urbanization, economic activity, and electricity consumption has become a central issue in energy economics and public policy, particularly in developing economies. Rapid urban expansion, rising income levels, and sustained demographic growth have significantly altered consumption patterns, resulting in increased electricity demand across residential, industrial, and service sectors. Understanding these dynamics is especially important for countries facing energy constraints and a high dependence on imported energy resources, such as Jordan.

Urbanization reflects the spatial concentration of population and economic activities within cities, a process that typically leads to higher electricity demand due to changes in lifestyles, infrastructure development, and improved access to modern energy services. Simultaneously, economic growth—commonly proxied by gross domestic product (GDP)—intensifies electricity consumption through expanded production activities, higher household incomes, and increased industrial output. In addition, the industrial sector represents a key structural driver of electricity demand, while population growth places further pressure on energy systems, particularly in rapidly urbanizing environments.

In the Jordanian context, these challenges are particularly pronounced. Over recent decades, Jordan has experienced rapid urbanization, sustained population growth, and steadily rising electricity demand, alongside limited domestic energy resources and a heavy reliance on energy imports. This combination underscores the importance of examining the determinants of electricity consumption from both short-run and long-run perspectives. Against this background, the present study investigates the impact of urbanization, economic growth, industrial sector contribution, and population growth on per capita electricity consumption in Jordan using the autoregressive distributed lag (ARDL) approach.

By distinguishing between short-run dynamics and long-run equilibrium relationships, this study contributes to the energy economics literature by providing policy-relevant insights into how urbanization and economic transformation shape electricity demand. The findings are intended to support policymakers in designing sustainable urban development strategies, enhancing energy efficiency, and strengthening energy security in Jordan, in line with national energy transition objectives (Al-Bajjali and Shamayleh, 2018; Dar-Mousa et al., 2019; World Bank, 2023).

2. LITERATURE REVIEW

A substantial body of literature identifies urbanization as a major driver of energy and electricity consumption. Urban areas account for more than two-thirds of global energy use, largely due to higher population density, expanded infrastructure, and increased demand for electricity-intensive services (Seto et al., 2014; Creutzig et al., 2015). Güneralp et al. (2017) argue that, in the absence of effective energy efficiency policies, continued urban expansion will substantially increase electricity demand in buildings over the coming decades.

Empirical studies indicate that the impact of urbanization on electricity consumption varies according to the level of economic development. Poumanyvong and Kaneko (2010) find that urbanization exerts a stronger positive effect on energy consumption in developing economies than in developed ones. Similarly, Zhang and Lin (2012) demonstrate that urbanization, GDP growth, and population size jointly explain the rapid growth of energy consumption in China. These findings suggest that urbanization interacts closely with economic activity and demographic factors in shaping energy demand.

Recent empirical studies further suggest that urban dynamics, together with technological progress, influence energy consumption patterns by affecting demand structure and efficiency levels, particularly in developing and emerging economies (Cole and Neumayer, 2004; Liu and Bae, 2018; Wang et al., 2022; Liu and Zhang, 2024).

Economic growth represents another key determinant of electricity consumption. Rising income levels increase household electricity use and stimulate industrial production, thereby raising overall electricity demand. Studies such as Liddle and Lung (2010) and Sadorsky (2014) confirm that long-run economic growth has a significant and persistent impact on energy demand, particularly in emerging economies. Nevertheless, technological progress and improvements in energy efficiency may moderate this relationship, especially in advanced economies (York, 2007; Jones, 1991).

The industrial sector also plays a critical role in determining electricity consumption patterns. Industrialization increases electricity demand through energy-intensive manufacturing and production processes. Empirical evidence from developing regions suggests that expansion of the industrial sector is positively associated with electricity consumption, reflecting structural transformation toward higher energy use (Bekhet and Othman, 2017; Al-Mulali and Ozturk, 2015).

Population growth further amplifies electricity demand by increasing the number of consumers and expanding urban infrastructure requirements. Sadorsky (2014) and Rafiq et al. (2016) emphasize that population dynamics constitute an important demographic channel through which urbanization affects energy consumption, particularly in emerging and developing economies.

In the Jordanian context, previous studies confirm the relevance of these determinants. Al-Bajjali and Shamayleh (2018) identify urbanization, GDP growth, and population increases as major drivers of electricity demand in Jordan, while Dar-Mousa et al. (2019) highlight the additional pressures arising from the country's dependence on imported energy. Recent World Bank reports (2023) further emphasize that rapid urban growth and demographic expansion continue to fuel electricity demand in Jordan.

3. HYPOTHESES DEVELOPMENT

Based on the theoretical framework and the empirical evidence reviewed above, the following hypotheses are formulated in accordance with the ordering of variables in the ARDL model:

3.1. Urbanization (UR)

H_{1a} (Short run): Urbanization has a statistically significant effect on per capita electricity consumption in Jordan in the short run.

H_{1b} (Long run): Urbanization has a statistically significant effect on per capita electricity consumption in Jordan in the long run.

3.2. Economic Growth (GDP)

H_{2a} (Short run): Economic growth has a statistically significant effect on per capita electricity consumption in Jordan in the short run.

H_{2b} (Long run): Economic growth has a statistically significant effect on per capita electricity consumption in Jordan in the long run.

3.3. Industrial Sector Contribution (IND)

H_{3a} (Short run): The contribution of the industrial sector has a statistically significant effect on per capita electricity consumption in Jordan in the short run.

H_{3b} (Long run): The contribution of the industrial sector has a statistically significant effect on per capita electricity consumption in Jordan in the long run.

3.4. Population Growth (POP)

H_{4a} (Short run): Population growth has a statistically significant effect on per capita electricity consumption in Jordan in the short run.

H_{4b} (Long run): Population growth has a statistically significant effect on per capita electricity consumption in Jordan in the long run.

4. METHODOLOGY

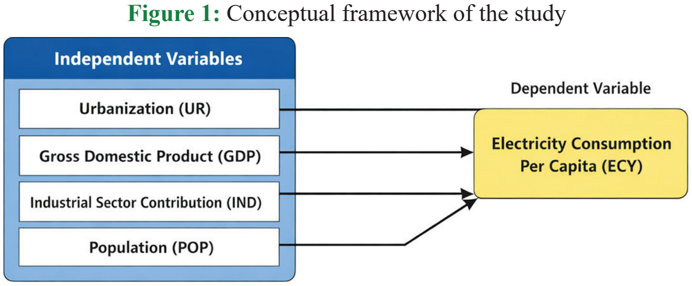
This study adopts a descriptive-analytical approach to examine the impact of urbanization, economic activity, industrial sector contribution, and population growth on per capita electricity consumption in Jordan. The selection of variables is grounded in the established energy economics literature and prior empirical studies that investigate the determinants of electricity demand in developing economies.

Per capita electricity consumption (ECY) is used as the dependent variable, while the independent variables include the urbanization rate (UR), gross domestic product (GDP), industrial sector contribution (IND), and population size (POP). Together, these variables capture the economic, structural, and demographic dimensions that influence electricity demand.

Annual time-series data covering the period 2000-2022 are employed in the empirical analysis. The data are obtained from official and reliable sources, including the Central Bank of Jordan, the Ministry of Planning and International Cooperation, and the Department of Statistics. To provide a clear visual representation of the trends and interrelationships among the study variables, Figure 1 illustrates the time series of per capita electricity consumption (ECY), urbanization rate (UR), gross domestic product (GDP), industrial sector contribution (IND), and population growth (POP) over the period 2000–2022. This figure highlights the upward trajectories of electricity consumption, urbanization, economic activity, industrial expansion, and population growth, emphasizing their potential influence on energy demand in Jordan.

To analyze both short-run and long-run relationships, the study applies the autoregressive distributed lag (ARDL) modeling approach. The ARDL methodology is particularly appropriate because it allows for the inclusion of variables integrated of different orders, I(0) and I(1), provided that none of the series is integrated of order I(2).

Figure 1: Conceptual framework of the study



Prior to estimating the ARDL model, unit root tests are conducted using the Augmented Dickey-Fuller (ADF) test to determine the stationarity properties of the variables. The optimal lag length is then selected based on information criteria, with particular emphasis on the Akaike information criterion (AIC), to ensure model parsimony and robustness.

The existence of a long-run equilibrium relationship among the variables is examined using the ARDL bounds testing approach to cointegration. Once cointegration is confirmed, long-run coefficients are estimated, and an error correction model (ECM) is derived to capture short-run dynamics and the speed of adjustment toward the long-run equilibrium following short-term shocks. In addition, descriptive statistics, including means and standard deviations, are reported to provide an overview of the data characteristics. This integrated econometric framework enables a comprehensive assessment of the effects of urbanization and economic factors on electricity consumption in Jordan in both the short and long run.

Within this analytical framework, the autoregressive distributed lag (ARDL) methodology is applied to investigate the short-run dynamics and long-run equilibrium relationships among the variables under study.

5. DATA ANALYSIS

5.1. Unit Root Test for Data Stationarity

Prior to estimating the ARDL model, the stationarity properties of all variables were examined using the Augmented Dickey-Fuller (ADF) unit root test in order to determine their respective orders of integration. Testing for stationarity is a necessary precondition for applying the ARDL bounds testing approach, as the methodology requires that none of the variables be integrated of order two, I(2).

The ADF test results, summarized in Table 1, indicate that all variables are non-stationary in their levels but become stationary after first differencing. Specifically, electricity consumption per capita (ECY) is stationary at the first difference, indicating that it is integrated of order one, I(1). Similarly, urbanization (UR), gross domestic product (GDP), and industrial sector contribution (IND) achieve stationarity after first differencing, confirming that they are also integrated of order one. The population variable (POP) likewise becomes stationary in its first difference, D(POP), and is therefore classified as I(1).

Overall, these findings confirm that none of the variables is integrated of order two, thereby satisfying the key requirement for employing the ARDL methodology. Accordingly, the ARDL framework is

Table 1: Results of the augmented dickey-Fuller (ADF) unit root test

Variable	Calculated value	Critical value	Lag length	Degree of stability
ECY	−4.048718	−3.788030	-	1% at 1nd difference*
UR	−4.359141	−3.788030	-	1% at 1st difference*
GDP	−3.445142	−3.788030	-	1% at 1st difference*
IND	−5.579180	−3.788030	-	1% at 1st difference*
D (POP)	−4.764858	3.808546		1% at 1st difference*

All variables are stationary at the first difference at the 1% significance level.
Sources: E-Views output

Table 2: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−667.1683	NA	4.36e+21	64.01602	64.26472	64.07000
1	−555.3436	159.7494	1.21e+18	55.74701	57.23919	56.07085
2	−512.7561	40.55952*	3.73e+17*	54.07201*	56.80767*	54.66572*

Sources: E-Views output

deemed appropriate for analyzing both the short-run dynamics and the long-run equilibrium relationships between per capita electricity consumption and the selected economic, demographic, and structural variables in Jordan over the study period.

5.2. Lag Length Selection

Table 2 reports the results of the vector autoregression (VAR) lag order selection criteria employed to determine the optimal lag length for the model. Several statistical criteria are used for this purpose, including the log-likelihood function (LogL), the sequential modified likelihood ratio (LR) test, the final prediction error (FPE), the Akaike Information Criterion (AIC), the Schwarz criterion (SC), and the Hannan-Quinn Criterion (HQ).

The results indicate that an optimal lag length of two periods (Lag = 2) is selected, as this lag order yields the minimum values for the AIC, SC, HQ, and FPE, in addition to a statistically significant LR test statistic, as indicated by the asterisk (*). These results suggest that the second lag provides the most appropriate trade-off between model goodness-of-fit and parsimony when compared with alternative lag structures.

Accordingly, a lag length of two periods is adopted in estimating the ARDL model. This selection ensures an adequate representation of the underlying dynamic interactions between per capita electricity consumption and the explanatory variables—urbanization, gross domestic product, industrial sector contribution, and population growth—thereby enhancing the robustness and reliability of both the short-run and long-run empirical results.

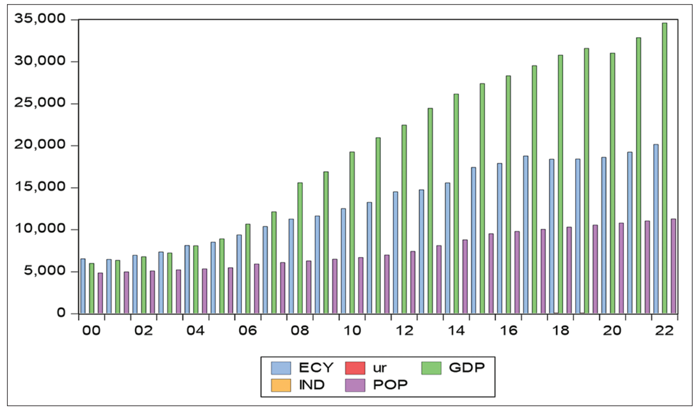
5.3. Descriptive Analysis

Figure 2 illustrates the time trends of the study variables over the sample period. A clear upward trend is observed in per capita electricity consumption (ECY), reflecting the sustained increase in electricity demand in Jordan over time. This upward trajectory can be attributed to rapid urbanization, expanding economic activity, and associated demographic changes.

With respect to urbanization (UR), the figure shows a steadily increasing and relatively stable trend, indicating a gradual shift of the population toward urban areas. This process is closely associated with rising electricity demand in residential, transportation, and public service sectors, driven by changes in lifestyle patterns and increasing population density in urban centers.

Similarly, gross domestic product (GDP) exhibits a pronounced upward trend, reflecting sustained economic expansion. Economic growth contributes to higher electricity demand through the expansion of productive and service-oriented activities, particularly in energy-intensive sectors.

Figure 2: Time trends of the study variables over the period 2000-2022



Sources: E-Views output

Regarding the industrial sector contribution (IND), the figure reveals an overall upward trend accompanied by moderate fluctuations throughout the study period. These fluctuations reflect the sensitivity of industrial activity to both domestic and external economic conditions. Nevertheless, the industrial sector remains a major driver of electricity consumption due to its intensive use of energy in production processes.

In terms of population growth (POP), a continuous upward trend is evident over the study period, exerting additional pressure on aggregate electricity demand, particularly in light of Jordan's limited domestic energy resources.

Overall, these descriptive trends point to a dynamic and interrelated relationship between urbanization, economic growth, industrial expansion, and population growth on the one hand, and electricity consumption on the other.

Table 3 reports the descriptive statistics of the study variables, including per capita electricity consumption (ECY), urbanization (UR), gross domestic product (GDP), industrial sector contribution (IND), and population (POP).

The results indicate that the average per capita electricity consumption (ECY) is approximately 13,319 units, with a standard deviation of 4,711, suggesting noticeable variability in electricity consumption over time. The skewness value is close to zero, indicating a nearly symmetric distribution, while the Jarque-Bera test statistic is statistically insignificant, confirming that ECY follows an approximately normal distribution.

Urbanization (UR), by contrast, exhibits a relatively low mean accompanied by a high standard deviation, reflecting substantial variation in urbanization rates over the study period. The relatively high skewness and kurtosis values, along with a statistically

Table 3: Descriptive statistics of the study variables

Descriptive statistics	ECY	UR	GDP	IND	POP
Mean	13319.17	8.690435	19921.72	25.05217	7706.478
Median	13275.00	0.870000	20962.00	24.80000	6993.000
Maximum	20161.00	91.00000	34623.00	29.60000	11302.00
Minimum	6486.000	0.780000	5998.624	21.40000	4857.000
Standard deviation	4711.232	25.97222	9986.702	2.096289	2267.072
Skewness	−0.071466	2.931742	−0.093638	0.336900	0.270232
Kurtosis	1.540921	9.595164	1.499637	2.767232	1.518512
Jarque-Bera	2.059785	74.63178	2.190905	0.487013	2.383287
Probability	0.357045	0.000000	0.334388	0.783874	0.303722
Sum	306341.0	199.8800	458199.5	576.2000	177249.0
Sum Sq. deviation	4.88E+08	14840.24	2.19E+09	96.67739	1.13E+08
Observations	23	23	23	23	23

Sources: E-Views output

significant Jarque-Bera statistic, suggest that the distribution of this variable deviates from normality.

For gross domestic product (GDP), the mean value is approximately 19,922, with a relatively high standard deviation, indicating considerable fluctuations in economic activity. The skewness coefficient is close to zero, and the Jarque-Bera test is statistically insignificant, implying that GDP is approximately normally distributed.

With regard to the industrial sector contribution (IND), the descriptive statistics reveal an average value that reflects the growing role of the industrial sector in the Jordanian economy, accompanied by a noticeable standard deviation. This variability indicates fluctuations in industrial activity, which help explain variations in electricity consumption associated with the sector.

Finally, the population variable (POP) records an average value of about 7,706, with a standard deviation of 2,267, reflecting a gradual and sustained increase in population over the study period. The skewness and kurtosis values suggest a distribution close to normality, which is further supported by the statistically insignificant Jarque-Bera test results.

6. HYPOTHESES TESTING

6.1. Long-Run Hypotheses Testing

The results of the ARDL bounds testing procedure reported in Table 4 indicate that the calculated F-statistic (5.2598) exceeds the upper critical bound I(1) at all conventional significance levels (10%, 5%, 2.5%, and 1%). Accordingly, the null hypothesis of no long-run relationship is rejected.

This finding provides strong empirical evidence of a long-run cointegrating relationship between per capita electricity consumption (ECY) and the explanatory variables, namely urbanization (UR), gross domestic product (GDP), industrial sector contribution (IND), and population growth (POP). The presence of cointegration implies that these variables move together in the long run, despite potential short-run deviations.

These results confirm the suitability of the ARDL methodology, which allows for the simultaneous estimation of long-run equilibrium relationships and short-run dynamics within a unified framework.

Table 4: F-Bounds test results for the existence of a long-run equilibrium relationship

Statistic	Calculated value	Significance level (%)	I (0) Bound	I (1) Bound
F-statistic	5.2598	10	1.90	3.01
		5	2.26	3.48
		2.5	2.62	3.90
		1	3.07	4.44

Number of independent variables (k) = 4. Actual sample size=19. Sources: E-Views output

Moreover, the existence of cointegration justifies the estimation of an error correction model (ECM) to analyze short-run adjustments and the speed at which electricity consumption converges back to its long-run equilibrium following temporary economic shocks.

Urbanization (UR) - Hypothesis H_{1b} the results reported in Table 5 show that the long-run coefficient of urbanization is positive and statistically significant, indicating that urban expansion leads to a sustained increase in per capita electricity consumption in Jordan. This effect reflects the structural transformations associated with urbanization, including the expansion of urban infrastructure and the rising demand for electricity-intensive residential and commercial services.

Accordingly, Hypothesis H_{1b} is accepted.

Economic growth (GDP) - Hypothesis H_{2b} the long-run estimates presented in Table 5 reveal a positive and statistically significant impact of economic growth on per capita electricity consumption. This finding underscores the pivotal role of economic expansion in driving structural electricity demand through increased productive activity, service-sector growth, and rising income levels.

Accordingly, Hypothesis H_{2b} is accepted.

Industrial sector contribution (IND) - Hypothesis H_{3b} As shown in Table 5, the contribution of the industrial sector exerts a positive and statistically significant long-run effect on electricity consumption per capita. This result confirms that industrial activity is among the most electricity-intensive components of the economy and that its expansion imposes sustained pressure on electricity demand.

Accordingly, Hypothesis H_{3b} is accepted.

Table 5: RDL long-run form and bounds test dependent variable: Δ(ECY)

Variable	Lag structure	Coefficient	t-statistic	Probability (Prob.)	Effect direction	Significance
Urbanization (UR)	UR(−1), Δ^2	11.19791	2.7767	0.0391	Positive	Significant
Gross domestic product (GDP)	GDP(−2)	0.796953	3.9592	0.0108	Positive	Significant
Industrial sector contribution (IND)	IND(−1)	620.5192	2.9488	0.0319	Positive	Significant
Population (POP)	POP(−2), Δ^2	4.097949	2.9475	0.0320	Positive	Significant

Sources: E-Views output

Table 6: Short-Run ARDL results

Dependent variable: Electricity consumption per capita						
Independent variable	**Lag**	**Coefficient**	**t-statistic**	**Prob.**	**Effect direction**	**Statistical significance**
Urbanization (UR)	Current	10.15930	4.7677	0.0050	Positive	Significant at 1%
Urbanization (UR)	(−1)	11.19791	4.9864	0.0042	Positive	Significant at 1%
Gross domestic product (GDP)	Current	−0.711884	−4.8049	0.0049	Negative	Significant at 1%
Gross domestic product (GDP)	(−1)	0.335143	4.0803	0.0095	Positive	Significant at 1%
Gross domestic product (GDP)	(−2)	0.796953	6.4869	0.0013	Positive	Significant at 1%
Industrial sector contribution (IND)	Current	328.1304	5.2573	0.0033	Positive	Significant at 1%
Population (POP)	(−2)	4.097949	8.3867	0.0004	Positive	Significant at 1%
Error correction term CointEq(−1)	(−1)	−0.000602	−6.8803	0.0010	Negative	Significant at 1%

Sources: E-Views output

Population Growth (POP) - Hypothesis H_{4b} the results reported in Table 5 indicate that population growth has a positive and statistically significant long-run impact on per capita electricity consumption. This finding reflects the cumulative effect of population increases on residential, commercial, and public service-related electricity demand.

Accordingly, Hypothesis H_{4b} is accepted.

6.2. Short-Run Hypotheses Testing

The error correction model (ECM) results presented in Table 6 illustrate the short-run dynamics among the study variables. The error correction term (ECT) is negative and statistically significant, confirming the presence of an adjustment mechanism that restores per capita electricity consumption to its long-run equilibrium path following temporary deviations.

Urbanization (UR) - Hypothesis H_{1a} The results in Table 6 indicate that urbanization exerts a positive and statistically significant short-run effect, both contemporaneously and with lagged terms. This finding suggests a rapid response of electricity consumption to urban expansion, reflecting the immediate increase in energy demand associated with urban areas.

Accordingly, Hypothesis H_{1a} is accepted.

Economic Growth (GDP) - Hypothesis H_{2a} Table 6 shows that the short-run impact of economic growth is mixed, with an initial negative effect followed by delayed positive effects. This pattern indicates a gradual adjustment process in which economic activity influences electricity consumption over time.

Accordingly, Hypothesis H_{2a} is partially accepted.

Industrial sector contribution (IND) - Hypothesis H_{3a} the ECM results confirm a positive and statistically significant short-run effect of industrial sector contribution, indicating that industrial expansion is immediately associated with increased electricity demand.

Accordingly, Hypothesis H_{3a} is accepted.

Population growth (POP) - Hypothesis H_{4a} The short-run impact of population growth appears primarily through lagged terms, suggesting that the effect of population increases on electricity consumption is not immediate but materializes gradually.

Accordingly, Hypothesis H_{4a} is partially accepted.

Overall, the results in Tables 5 and 6 confirm that urbanization, economic growth, industrial expansion, and population growth are key determinants of per capita electricity consumption in Jordan. The timing and magnitude of these effects differ between the short and long run, highlighting the dynamic nature of electricity demand. These findings align with contemporary energy economics literature and provide an empirical foundation for designing more sustainable urban development, industrial planning, and energy policy interventions.

7. DISCUSSION

This study investigates the impact of urbanization, economic growth, industrial sector contribution, and population growth on per capita electricity consumption in Jordan over the period 2000-2022 using the ARDL approach. The ARDL framework allows for a clear distinction between short-run dynamics and long-run equilibrium relationships, providing a comprehensive understanding of electricity consumption behavior in the Jordanian economy.

Long-Run Relationships The results of the Bounds testing procedure confirm the existence of a long-run equilibrium relationship between per capita electricity consumption and its key determinants. The calculated F-statistic (5.26) exceeds the upper critical bounds at the 1% significance level, indicating cointegration among electricity consumption, urbanization, economic growth, industrial activity, and population growth. This finding validates the use of the ARDL methodology and suggests that these variables move together in the long run, despite short-term fluctuations.

Long-run coefficient estimates reveal that urbanization (UR) has a positive and statistically significant effect on per capita electricity consumption. The lagged urbanization variable indicates that sustained urban expansion leads to higher long-term electricity demand, reflecting structural shifts in consumption patterns associated with urban living, including increased reliance on electricity-intensive housing, transportation systems, and public services. This result aligns with prior studies, including Sadorsky (2014) and Shahbaz et al. (2016), which documented a strong long-run linkage between urbanization and energy consumption in developing economies.

Similarly, economic growth (GDP) exhibits a positive and statistically significant long-run impact on electricity consumption, particularly through its lagged effects. Sustained economic expansion increases electricity demand via higher industrial output, growth in the services sector, and rising household incomes. This finding is consistent with the energy–growth nexus literature (Apergis and Payne, 2010; Lean and Smyth, 2010), emphasizing the long-term dependence of energy consumption on economic activity.

The industrial sector contribution (IND) also shows a positive and significant long-run relationship with electricity consumption, highlighting the energy-intensive nature of industrial production in Jordan. Expansion in manufacturing and industrial activities directly translates into higher structural electricity demand. This outcome corroborates findings by Wolde-Rufael (2006) and Al-Mulali and Ozturk (2015), which underscore industrialization as a central driver of long-term energy consumption.

Finally, population growth (POP) exerts a positive and statistically significant long-run effect on per capita electricity consumption. The lagged population effect indicates that demographic pressures gradually translate into higher electricity demand over time, reflecting increased household formation, urban expansion, and infrastructure needs. These results are in line with Narayan and Smyth (2009) and Ozturk and Acaravci (2010), who identify population growth as a key long-term determinant of energy demand.

Short-Run Dynamics In the short run, the error correction model (ECM) reveals important dynamic adjustments in electricity consumption. Urbanization maintains a positive and statistically significant effect in both current and lagged periods, indicating that rapid urban expansion immediately increases electricity demand. This highlights the responsiveness of electricity consumption to short-term changes in urban development and settlement patterns.

Economic growth exhibits a mixed short-run effect, with a negative contemporaneous coefficient followed by positive lagged coefficients. This pattern suggests that short-term economic shocks may temporarily reduce electricity consumption due to adjustment costs or efficiency improvements, while lagged effects reflect increased electricity demand as economic activities stabilize. These dynamics are consistent with short-run adjustment mechanisms discussed by Narayan and Prasad (2008).

The industrial sector exerts a strong and positive short-run impact, confirming that fluctuations in industrial output immediately affect electricity demand. This underscores the industrial sector as a key short-term driver of electricity consumption in Jordan.

Population growth shows a positive but lagged short-run effect, indicating that demographic changes influence electricity demand with a delay rather than instantaneously. This reflects the gradual adjustment of residential and service-related electricity needs following population increases.

The error correction term is negative and statistically significant, confirming the presence of a stable adjustment mechanism toward the long-run equilibrium. The magnitude of the coefficient suggests that deviations from long-run equilibrium are corrected at a moderate pace, reflecting the relative flexibility of electricity demand in responding to structural and economic changes.

Policy Implications Overall, the findings demonstrate that urbanization, economic growth, industrial activity, and population growth are fundamental determinants of per capita electricity consumption in Jordan, in both the short and long run. These results underscore the need for integrated energy and urban planning policies that address rapid urban expansion, demographic pressures, and structural economic changes. Promoting energy efficiency, expanding renewable energy capacity, and encouraging sustainable urban development are essential strategies to ensure energy security and manage long-term electricity demand in Jordan.

8. CONCLUSION, RECOMMENDATIONS, AND LIMITATIONS

This study highlights the significant impact of urbanization on per capita electricity consumption in Jordan, alongside economic growth, industrial sector contribution, and population growth, over the period 2000-2022. The findings indicate that rapid urban expansion drives higher electricity demand due to structural changes in housing, transportation, and public infrastructure, reflecting the lifestyle and economic transformations associated with urban growth. These results underscore the importance of integrating urban planning with energy policies to manage electricity demand sustainably amid ongoing demographic and economic changes.

The theoretical significance of this study lies in demonstrating the role of urbanization as a structural determinant of electricity consumption. By employing the ARDL approach, the analysis provides robust evidence that urban expansion, together with economic and demographic factors, exerts both immediate and long-term effects on electricity demand. This emphasizes the necessity of incorporating urbanization dynamics in energy economics research and policy formulation.

From a practical perspective, the study offers actionable insights for policymakers, urban planners, and relevant stakeholders. To mitigate the impact of rapid urban growth on electricity consumption, it is recommended to:

Implement sustainable urban planning strategies that include energy-efficient infrastructure, green buildings, and smart-city technologies.

Promote energy-saving practices across residential, commercial, and industrial sectors.

Encourage industries to adopt renewable energy sources and energy-efficient production processes.

Explore alternative financing mechanisms, such as public-private partnerships, green bonds, or Islamic bonds, to support investment in energy-efficient urban projects.

Coordinate demographic and urban policies to balance electricity demand across regions and ensure long-term energy security.

However, the study has several limitations. First, it primarily focuses on urbanization, economic growth, industrial activity, and population growth, while other determinants, such as electricity prices, technological innovation, or policy interventions, were not included. Second, the use of annual time-series data may overlook seasonal or high-frequency fluctuations in electricity consumption. Third, although the ARDL model identifies long-run and short-run relationships, it does not establish strict causality. Finally, the findings are context-specific to Jordan and may not directly generalize to countries with different urbanization patterns, energy infrastructures, or policy frameworks.

For future research, studies could examine the integration of renewable energy, smart-grid technologies, and innovative urban planning to mitigate electricity demand growth. Investigating alternative financing options for sustainable urban infrastructure, as well as assessing the long-term effects of urbanization policies on electricity consumption and environmental sustainability, would provide valuable guidance for policymakers and contribute to the global literature on energy and urban development.

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