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The Dynamic Impacts of Economic Growth, Financial Globalization, Fossil Fuel, Renewable Energy, and Urbanization on Load Capacity Factor in Mexico

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Abstract: This study explores the interplay among economic growth, financial globalization, urbanization, fossil fuel consumption, and renewable energy usage and their combined impact on the load capacity factor in Mexico. This research employs the load capacity factor as a unique measure of ecological health, facilitating a comprehensive ecosystem assessment by sequentially evaluating biocapacity and ecological effects. Using time series data spanning from 1971 to 2018, this study employs the Autoregressive Distributed Lag (ARDL) method to analyze both long-term and short-term dynamics and cointegration. The findings reveal that economic growth, fossil fuel usage, and urbanization reduce Mexico's load capacity factor, thereby diminishing environmental quality. In contrast, the adoption of renewable energy sources and the influence of financial globalization exhibit positive effects on the load capacity factor over the long and short term. These outcomes remain consistent even when compared with alternative estimation techniques, including dynamic ordinary least squares (DOLS), fully modified least squares (FMOLS), and canonical cointegrating regression (CCR). As a priority, Mexican policymakers should accelerate the transition to renewable energy sources, encourage sustainable urban development, and foster a more ecologically conscious economic agenda. Furthermore, promoting greener technologies can enhance the load capacity and mitigate environmental degradation. Ultimately, Mexico can establish an environment conducive to expanding sustainable investments by encouraging cross-border investments, enabling global trade in financial services, and cultivating greater integration of capital and financial markets.

Keywords: load capacity factor; fossil fuel; ecological degradation; financial globalization; renewable energy; sustainable development

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1. Introduction

Despite increased climate change awareness, emissions of greenhouse gases and other pollutants from fossil fuel use, industrial processes, transportation, and human activities persist at elevated levels. The public's better grasp of climate change has yet to reduce ecological harm [1,2]. The barrier to mitigating climate devastation partly endures due to a lack of affordable technical solutions, inadequate policy-making, and uncoordinated sustainability efforts [3,4]. In 2022, the International Energy Agency reported a record 36.8 gigatons of CO_2 emissions, up 0.9% from the prior year, driven by a growing global economy and energy demand [5,6]. Consequently, the UN Framework Convention on Climate Change emphasizes reinforcing the Paris Agreement via concerted state and collaborative efforts. Prominent nations like the UK, Brazil, France, Japan, Germany, and Mexico have pledged substantial CO_2 reduction commitments despite ongoing environmental degradation [7,8].

The nexus of globalization, ecological preservation, and economic growth is a current debate [9,10]. Expanding global trade will likely elevate energy use and greenhouse gas emissions, particularly as developing nations seek economic advancement via integration and innovation [11,12]. Dreher's globalization index [13] and Gygli et al.'s extended version [14] illuminate these dynamics, including the ecological impacts of trade and finance globalization. Dreher's [13] calculations could not differentiate between the ecological effects of global trade and global finance. In contrast, using Gygli et al.'s calculations [14] allows us to distinguish between the ecological consequences of trade and financial globalization. This study employs the financial globalization index, encompassing de facto (e.g., reserves, overseas income payments) and de jure (e.g., investment agreements) dimensions to analyze if financial globalization and urbanization aid developing nations in achieving economic prosperity without ecological harm. Amid interconnected financial globalization, fossil fuels, renewable energy, and urbanization concerns, this research offers policy insights to address ecological degradation.

Carbon emissions are under intense study, revealing threats to environmental quality in developing nations like India, Mexico, Malaysia, the BRICS, and South Asian countries due to economic growth, global trade, population increase, and non-renewable resource usage [6,15–17]. However, Akinsola et al. [18] underline that carbon output, a significant GHG component, inadequately reflects ecological damage in both advanced and developing nations [19–21]. These analyses focus primarily on ecological impact, overlooking ecosystem resources [22]. Thus, finding a superior indicator for holistic environmental assessment is paramount, as was first proposed by Rees [23]. The load capacity factor, presented by Siche et al. [24], offers a more precise ecological insight. Calculated by dividing biocapacity (supply) by ecological footprint (demand), a factor above 1 indicates stability, while below 1 implies unsustainability [3]. Unlike carbon emissions or ecological impact, the load capacity factor provides a comprehensive index. This study advances comprehensive analysis by considering the broader ecological context.

Numerous studies have explored how environmental factors impact carbon emissions and ecological footprints across countries or groups [19–21]. However, there is a research gap in investigating the dynamic interactions of environmental variables with the load capacity factor, especially concerning Mexico. Earlier studies largely concur that financial development and greater renewable energy integration curb CO_2 emissions or ecological footprint [1,2,18]. In contrast, economic growth, non-renewable energy usage, urbanization, and trade openness often correlate with elevated CO_2 levels [2,9,25]. However, few studies have examined these variables' impact on CO_2 and biocapacity, yielding a more holistic environmental quality evaluation.

Moreover, existing literature requires more conclusive insights into the effects of urbanization and financial globalization on the load capacity factor. This study aims to bridge this gap by examining the dynamic relationships between economic growth, financial globalization, fossil fuel and renewable energy use, urbanization, and the load capacity factor. Utilizing the case of Mexico, one of the world's largest emerging economies, we employ the latest econometric techniques to provide comprehensive insights.

Mexico was chosen for this study due to significant factors. As of 2019, Mexico was Latin America's second-largest economy and ranked fifteenth globally, with a GDP of USD 1.25 trillion and a per capita income of USD 10,013 [26]. Mexico draws increased foreign investments as a G-20, OECD, and WTO member. Its financial globalization index rose from 40 to 69 points between 1970 and 2020, positioning it as one of Latin America's most globalized economies. Mexico's industrial and service sectors heavily rely on fossil fuels, ranking eleventh and thirteenth in crude production and net exports. The country is among the top 17 for oil reserves and is the fourth-largest oil supplier in the Americas [27]. This fossil-fuel dependence has led to one of the region's most polluted power grids and the highest annual energy consumption in Latin America [8,16]. Mexico ranks fifteenth globally in energy consumption, with over 80% of its energy sourced from fossil fuels. In 2019, oil accounted for 45.20%, natural gas 37.84%, coal 6.44%, biofuels 5.02%, wind and solar 2.75%, nuclear 1.65%, and hydropower 1.13% of its energy supply.

In addition, urban and city areas hosted approximately 80% of Mexico's total population, growing by around 1.5% each year during the same period [26]. Rapid urbanization negatively affects Mexico's economic and social progress by driving business and residential construction, contributing to ecological degradation [8]. Accelerated urbanization threatens sustainable development via increased energy consumption and greenhouse gas emissions [28]. As the 12th largest global CO_2 emitter and the largest in Latin America, Mexico's extensive fossil fuel use generates around 1.3% of worldwide emissions [26]. Raihan and Tuspekova [27] highlighted that Mexico's rapid economic growth, urbanization, and tourism development are fueled by intensified fossil fuel energy use, causing a significant CO_2 emission rise in recent years. Despite relying on fossil fuels for over 80% of its energy, Mexico remains Latin America's most globalized nation, achieving an annual GDP growth rate of 4.7% in 2021 and setting ambitious renewable energy targets while grappling with rapid urbanization and environmental degradation.

Mexico, however, possesses multiple sources of green energy supported by governmental regulations. In line with its General Climate Change Law, the nation is poised to achieve its objective of producing 35% of its electricity from clean sources by 2024. Mexico's commitment to emission reduction has also intensified post-Paris Agreement. Its updated NDC outlines a more ambitious target of 35% lower GHG emissions by 2030, surpassing the previous 22% reduction goal established in 2020. Figure 1 illustrates Mexico's annual biocapacity, ecological footprint, and load capacity factor trends. Deteriorating environmental conditions contribute to diminishing biocapacity and expanding ecological footprint, leading to reduced load capacity. Hence, studying load capacity factors becomes imperative to attain ecological sustainability in Mexico and achieve its climate objectives.

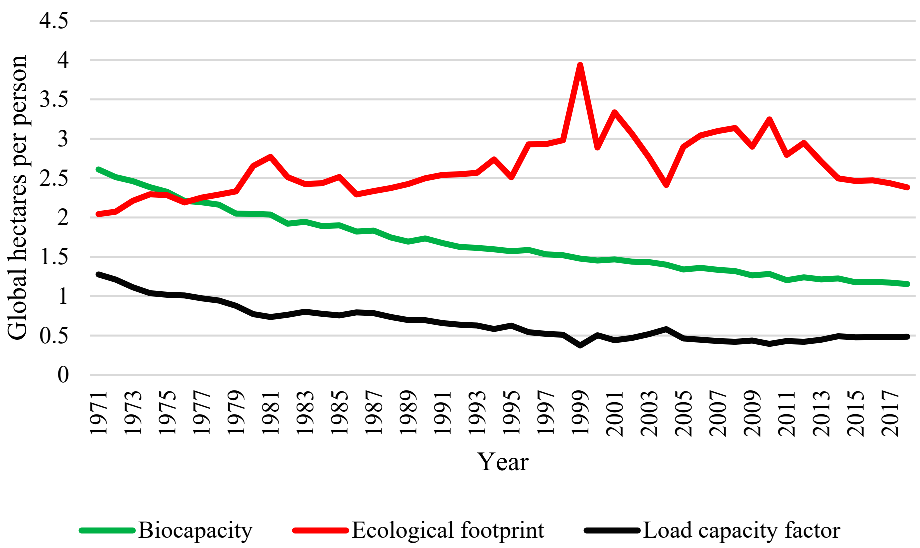

Figure 1. Biocapacity, ecological footprint, and load capacity factor in Mexico.

This research adds to the existing literature by providing much-needed context for the connection between load capacity factor and the interconnectedness of energy and economic systems, globalization, and the natural world in the context of developing countries. Second, when applied to Mexico's particular circumstances, the load capacity factor offers a nuanced perspective on the ecological balance within a nation that possesses a rich array of resources but also contends with environmental challenges stemming from fossil fuel utilization. Both supply and demand-side approaches to ecological issues are looked at in the study. Thirdly, how financial globalization, encompassing the flow of capital, investment, and financial services across international borders, intersects with ecological well-being has remained relatively obscure. The adopted measure of financial globalization takes the consideration of environmentally responsible practices to a greater depth. Fourthly, the most up-to-date and extensive data collection was used for this study; it covered the period from 1971 to 2018. Three-unit root analyses (ADF, DF-GLS, and P-P) were implemented to determine the optimal data integration sequence. Finally, DOLS, FMOLS, and CCR have been implemented to confirm the ARDL procedure predicted values on the variables.

In addition to bolstering climate change adaptation and mitigation strategies, the findings of this study could aid other developing nations in formulating effective methods for achieving sustainable development. Finally, the outcomes of this investigation offer government officials with more complete and informative verification to implement successful approaches for the sectors of the carbon-free economy as a whole, advancement of green power, practical urban planning, and enhancement of financial globalization, all of which would guarantee a boost in load capacity factor along with ecological longevity in Mexico.

Here is how the rest of the article is laid out. The research pertinent to this article's topic is discussed in the second part, "Literature review", to provide context. The data, theoretical framework, empirical model creation, and estimation techniques used in this study are all described in depth under the "Methodology" of this publication. The practical assessment of the model's performance is extensive in the article's fourth part, "Results and Discussion", along with a discussion and comparison with the results of other research that has addressed similar questions. Finally, the study's findings and policy recommendations are summarized in the fifth part.

2. Literature Review

This particular part of the present study examines the research conducted on the relationship between economic growth, fossil fuel and renewable power, financial globalization, urbanization, and ecological mortification.

2.1. Economic Growth and Environment

Various countries have extensively explored the relationship between economic growth and environmental impact. The relationship between economic growth and CO_2 emissions is typically understood to involve increased emissions with higher economic activity, particularly for emerging countries [8]. However, the scenario becomes more complex when a broader measure of environmental quality, such as the load capacity, is considered instead of solely relying on CO_2 emissions [9]. Pata and Balsalobre-Lorente [29] studied Turkey's data from 1965 to 2017, revealing a negative correlation between economic development and the load capacity factor. Khan et al. [30] analyzed G7 and E7 countries from 1997 to 2018, finding that economic development corresponded with a reduction in the load capacity factor. Awosusi et al. [31] investigated South Africa from 1980 to 2017, uncovering an adverse association between economic prosperity and the load capacity factor. Shang et al. [32] examined ASEAN countries between 1980 and 2018, observing the adverse effects of economic expansion on load capacity factors.

In India, Akadiri et al. [33] discovered a short-term positive correlation between economic growth and the load capacity factor, shifting to a negative correlation in the long run. Pata's empirical analysis [3] used the ARDL method and identified an inverse relationship between economic growth and the load capacity factor in Japan and the United States from 1982 to 2016. Pata and Isik [34] focused on China from 1981 to 2017, finding that a growing economy adversely affects the load capacity factor.

Fareed et al. [35] investigated Indonesia's data spanning 1965 to 2014, observing that increased income led to a decrease in the load capacity factor. Majeed et al. [36] employed an asymmetric procedure to study Pakistan's economy from 1971 to 2014, showing a negative impact of economic expansion on environmental performance. However, Solarin et al. [37] employed the ARDL method for Nigeria from 1977 to 2016 and found that while economic growth initially deteriorates the environment, it ultimately improved environmental quality in the long run. Examining countries with rapid economic expansion followed by significant slowdown, such as Mexico, is crucial to understanding the evolving dynamics between economic growth and environmental well-being.

2.2. Energy Use and Environment

Previous research emphasizes the significant influence of energy consumption and sources on determining the load capacity factor and its subsequent environmental consequences; however, the outcomes have demonstrated variability.

Huang et al. [38] in India, Pata and Balsalobre-Lorente [29] in Turkey, and Pata and Isik [34] in the case of China reveal that energy consumption, particularly non-renewable sources, adversely affects the load capacity factor, leading to ecological degradation. In the instances of those countries (all of which are emerging economies), the load capacity factor experienced a decline attributed to a rise in energy intensity. On the other hand, Alola et al. [9] find that a higher load capacity factor, achieved via enhanced renewable energy use, promotes ecological sustainability. Similar trends emerge as researchers examine different countries and regions. Guloglu et al. [39] in 26 OECD nations, Shang et al. [32] in Southeast Asia, Pata and Samsour [40] in 27 OECD nations, Pata [3] in the US and Japan, Zhao et al. [41] in the BRICS, and Awosusi et al. [31] in South Africa collectively suggest that the adoption of cleaner energy sources, such as green power, positively influences the load capacity factor, indicating an improvement in environmental quality.

Researchers have highlighted the challenges countries face in enhancing the load capacity factor while striking a balance between the utilization of renewable and fossil fuel energy sources [42]. Raihan et al. [27], Shang et al. [32], and Caglar et al. [39] found that the utilization of non-renewable energy sources negatively correlated with the load capacity factor, exacerbating ecological concerns. Still, using data from 1997 to 2018, Khan et al. [30] discovered a positive interaction between renewable energy and load capacity factor in the context of the G7 and E7 countries, similar to the findings of Fareed et al. [35] in Indonesia between 1965 and 2014. Shang et al. [32] also found that between 1980 and 2018, load capacity factors in ASEAN countries improved significantly due mainly to the elevated adoption of clean power, in line with the findings of Hakkak et al. [42] In Russia, Caglar et al.'s [43] study of 10 economies validated a positive relationship between non-renewable energies and carbon output; green energy and ecological effects had a negative feedback loop. Pata [44] also discovered that clean power negatively correlated with ecological damage from 1980 to 2016 in the United States.

These findings underscore the pivotal role of energy sources in shaping the load capacity factor and the subsequent environmental impact, with overall agreement that a higher load capacity factor enhances ecological sustainability by boosting renewable energy utilization. Similarly, the use of non-renewable energy generally appears to reduce load capacity. Still, several studies found an insignificant impact of renewable energy on load capacity factor (i.e., in Japan [3]) or a decreasing (even reversing) trend in the influence of renewable power on load capacity over time (i.e., Akadiri et al. [33] in India).

2.3. Urbanization and Environment

Another common challenge experienced by major emerging countries is the environmental pressure stemming from the rapid growth of urbanization, which is often linked to a substantial increase in energy demands [2,17,19,45]. The research of Guloglu et al. [39] revealed that as cities expanded, their load capacity factors diminished in 26 OECD countries from 1980 to 2018. Between 1980 and 2017, Rafique et al. [21] found that in 10 different economies, ecological effects negatively interacted with urbanization. Nathaniel [46] employed the ARDL procedure to find that between 1971 and 2014, the carbon footprint in Indonesia increased significantly in line with urbanization. Nathaniel et al. [45] provided more support for this analysis by citing studies they conducted in South Africa between 1965 and 2014. Ahmed et al. [47] looked at the G-7 countries from 1971 to 2014 to see how urbanization influenced their ecosystems. The ecological footprint was found to be positively associated with urbanization.

However, Nathaniel and Khan [48] discovered a dissimilar conclusion regarding ASEAN economies. The researchers did not find significant evidence of the urbanization-energy-environment nexus for the developing ASEAN economies. For the time frame spanning 1977–2016, Solarin et al. [37] applied the ARDL method to the case of Nigeria. They reported that urbanization has no harmful impact on the environmental quality of Nigeria. By utilizing the data spanning 1991–2016, Ansari et al. [49] discovered a negative correlation between ecological footprint and urbanization, indicating that urbanization improves the quality of the environment in a panel of top renewable energy-consuming countries. Danish et al. [19] also found that urbanization alleviated the carbon footprint level. As highlighted by Ahmed et al. [47], urbanization can increase the ecological footprint, which suggests an enhanced capacity of the ecosystem to regenerate and provide essential resources. In this context, a larger ecological footprint can potentially mitigate the adverse impacts stemming from the heightened energy demand in urbanized regions.

2.4. Financial Globalization and Environment

Prior research on the finance–environment relationship suggests that financial development's attraction of Foreign Direct Investment (FDI) might amplify economic expansion and energy consumption, potentially harming the environment [18,20,50]. However, it is crucial to note that financial development can have a positive impact on curbing carbon emissions if FDI aligns with environmental goals. Enhanced access to financial markets can facilitate access to greener technologies, advanced expertise, and efficient energy utilization, potentially resulting in decreased CO_2 emissions. Some studies support the negative influence of FDI on CO_2 emissions via the adoption of energy-efficient technologies [20,51,52]. Nonetheless, empirical evidence on FDI's contribution to environmental quality is contradictory, with specific studies indicating that financial development correlates with reduced environmental quality [53,54]. This complexity underscores the need for further research to grasp the multifaceted interactions between finance, FDI, and environmental outcomes.

Still, the impact of financial globalization on ecological devastation is discussed relatively infrequently. Kihombo et al. [20] investigated the association between economic globalization and CO_2 emissions during the period spanning from 1970 to 2018 in India using the NARDL approach. The empirical findings suggest that a boost in financial globalization will diminish CO_2 emissions in India. Still, the release of more carbon dioxide will rise proportionately to the degree to which globalization is reduced. Ulucak et al. [51] implemented the ARDL and DOLS datasets spanning 1974 to 2016 to explore the association between rising nations' carbon footprint and globalized finance. They illustrated that globalization alleviated ecological damage. Examining 1996 to 2019, Shahzad et al. [52] determined that globalization in finance heightened ecological impacts, with financial and trade globalization amplifying pollution. Interconnections between environmental footprints, globalization, and economic complexity highlight the complicated globalization-environment nexus. Similar findings were supported by Kihombo et al. [55], who discovered that the economy in West Asia and the Middle East (WAME) region has an adverse link between economic globalization and its ecological footprint.

Nevertheless, in the case of India, Akadiri et al. [33] found that financial globalization positively influences the load capacity factor. Advocating for India's increased financial integration, Akadiri et al. [33] suggest governmental promotion of liberalization and international capital inflows, directing funds towards eco-friendly manufacturing as financial globalization positively impacts environmental quality. Ansari et al. [49] discovered a negative correlation between ecological footprint and globalization, indicating that globalization improves the quality of the environment in the top renewable energy-consuming countries. Considering these findings, it is imperative to explore whether financial globalization offers a similar avenue for Mexico to enhance its load capacity factor. The positive impact on the load capacity factor seen in India, where financial globalization was encouraged, along with the improvement in environmental quality due to globalization, as observed in top renewable energy-consuming countries, warrants a closer examination of Mexico's potential in this regard.

The research mentioned above is an indispensable foundation for the expanding environmental challenges in emerging economies like Mexico. This complex web of interactions underscores the necessity to closely examine whether these factors could present a novel opportunity for Mexico to enhance its load capacity factor. By delving into these dynamics, Mexico can ascertain if harnessing economic growth, urbanization, and financial integration could provide a pathway to elevate its load capacity factor, aligning with broader global trends towards enhanced environmental sustainability. Research has yet to be mentioned on the impact of the load capacity factor in Mexico. Consequently, this research considers these aspects necessary for environmental and long-term sustainability. The present study used the latest time series data to apply the most up-to-date estimation techniques for filling the research gap in the existing literature.

3. Methodology

3.1. Data

Using data collected from 1971 to 2018, this study examines how load capacity factors changed in response to economic development, urbanization, financial globalization, fossil fuel, and renewable power. Data on financial globalization led to the selection of a period beginning in 1971; the lack of load capacity factor data through 2018 led to the choice of a period ending in 2018. The World Development Indicators database was mined for information on growing economies, increasing urbanization, fossil fuels, and renewable energy sources. The load capacity factor was sourced directly from the GFN. Lastly, information on globalization in the financial sector came from the "Swiss Economic Institute's (KOF) database". The observed series were transformed into their natural logarithms to minimize the potential for estimating mistakes. The series descriptions are compiled in Table 1.

Table 1. Specification of the variables.

Variables	Description	Logarithmic Forms	Measurement Units	Sources
LCF	Load capacity factor	LLCF	Global hectares per person	GFN
GDP	Economic growth	LGDP	GDP per capita (constant 2015 USD)	WDI
FFE	Fossil fuel energy use	LFFE	Percentage of total final energy use	WDI
RNE	Renewable energy use	LRNE	Percentage of total final energy use	WDI
FGL	Financial globalization	LFGL	Financial globalization index	KOF
URB	Urbanization	LURB	Urban population (% of the total population)	WDI

3.2. Conceptual Framework and Empirical Model

The environmental Kuznets curve (EKC) theory was suggested by Grossman and Krueger [56], and a reverse U-shaped connection is described between economic expansion and the environment. This relationship can be further broken down into three phases (size, composition, and technical). The size of the impact suggests that higher production levels result in environmental degradation. The compositional effect is indicative of a structural shift in the economy. While pollution rises throughout the move from agricultural to industry, it drops significantly as industries give way to services. Furthermore, the technical effect demonstrates that environmentally responsible technologies and manufacturing procedures can improve ecological conditions.

Despite being essential to economic prosperity, energy consumption is a major contributor to ecological deterioration [57]. Numerous fossil fuels exist, including coal, natural gas, and oil, used by nations worldwide to power economic development, urbanization, and industrialization, all of which negatively affect the environment [58]. Since emission levels have been rising recently, methods for reducing the buildup of these gases are urgently needed. However, there needs to be an agreement on the best strategies for preventing severe environmental damage. However, renewable energy has become a serious contender to fossil fuels recently. The widespread availability of renewable energy options that do not contribute to climate change, like fossil fuels, is a big reason for their recent surge in popularity. It has been shown that switching to renewable power can save money, boost health, clean the air, and create new jobs [59]. Clean energy like solar, wind, geothermal, and biomass can be used locally to keep the lights on and reduce expensive imports.

Consequences of other factors, which include globalization, on the mix, scale, and methodology of these effects may be more explicit than those of economic growth alone. Thus, globalization is crucial to the correlation between growing economies and worsening ecological circumstances. The financial globalization viewpoint holds that the globalization of finance exacerbates numerous ecological issues. Globalization of the financial sector via the scale effect might boost spending and the economy. In addition, globalization in the financial sector encourages international trade and investment, which in turn stimulates the manufacturing sector within a country and, in turn, exacerbates environmental degradation. Increased consumer and company confidence, increased output and consumption, and a worsening of environmental degradation are all outcomes that can be expected to follow a period of strong stock market performance.

On the other hand, globalization of the financial sector has the potential to enhance environmental quality via technical and compositional impacts. As the population grows, the demand for natural resources rises, making urbanization a major contributor to the state of the planet. Thus, unchecked urbanization may negatively influence the ecology, while sustainable urbanization may help lessen those effects. Therefore, ecological degradation may come from poorly managed urbanization. We used this data to derive the following economic function, which we implemented inside the framework of the Cobb-Douglas production function [60] at time t:

$$\mathrm{LCF_t} = f\,(\mathrm{GDP_t}; \mathrm{FFE_t}; \mathrm{RNE_t}; \mathrm{FGL_t}; \mathrm{URB_t}) \tag{1}$$

This section details the experimental framework:

$$\mathrm{LCF_t} = \tau_0 + \tau_1\mathrm{GDP_t} + \tau_2\mathrm{FFE_t} + \tau_3\mathrm{RNE_t} + \tau_4\mathrm{FGL_t} + \tau_5\mathrm{URB_t} + \varepsilon_t \tag{2}$$

where τ_0 is the intercept and ε_t is the error term at time t. In addition, τ_1, τ_2, τ_3, τ_4, and τ_5 characterize the coefficients. Moreover, $\mathrm{LCF_t}$ is the load capacity factor at time t, $\mathrm{GDP_t}$ is the economic growth at time t, $\mathrm{FFE_t}$ is fossil fuel energy use at time t, $\mathrm{RNE_t}$ is renewable energy use at time t, $\mathrm{FGL_t}$ is financial globalization at time t, and $\mathrm{URB_t}$ is urbanization at time t.

In addition, to normalize the time series data, the paper computed the natural log of every variable. Conclusions from log-linear models are more reliable and efficient than those from simple linear models in empirical studies. Here is the linear log model's enhanced multivariate production function:

$$\mathrm{LLCF_t} = \tau_0 + \tau_1\mathrm{LGDP_t} + \tau_2\mathrm{LFFE_t} + \tau_3\mathrm{LRNE_t} + \tau_4\mathrm{LFGL_t} + \tau_5\mathrm{LURB_t} + \varepsilon_t \tag{3}$$

where $\mathrm{LLCF_t}$ is the logarithm form of load capacity factor at time t, $\mathrm{GDP_t}$ is the logarithm form of economic growth at time t, $\mathrm{FFE_t}$ is the logarithm form of fossil fuel energy use at time t, $\mathrm{RNE_t}$ is the logarithm form of renewable energy use at time t, $\mathrm{FGL_t}$ is the logarithm form of financial globalization at time t, and $\mathrm{URB_t}$ is the logarithm form of urbanization at time t.

An overview of the estimating processes is shown in Figure 2.

3.3. Unit Root Test

Avoiding errors in the regression requires conducting unit root tests. In this test, we check to see if the regression variables are stable, and if they are, the paper uses equations for estimating the required stationary procedures. According to the data presented in the empirical research, identifying the integration sequence is necessary before using cointegration techniques [61]. For this reason, the unit root test is implemented to guarantee that the variables in this portion are stable. Probability distributions for mean-variance and covariance of variable shifts over time; we say that the variable is non-stationary. Due to the power disparity between the tests and sample size, many researchers have suggested using various unit root tests to establish the integration order [62]. This research deployed three different tests for detecting the occurrence of an autoregressive unit root: the "Augmented Dickey–Fuller (ADF) "test designed by Dickey and Fuller [63], the "Dickey–Fuller generalized least squares (DF-GLS)" test generated by Elliott et al. [64], and the "Phillips–Perron (P-P)" test developed by Phillips and Perron [65].

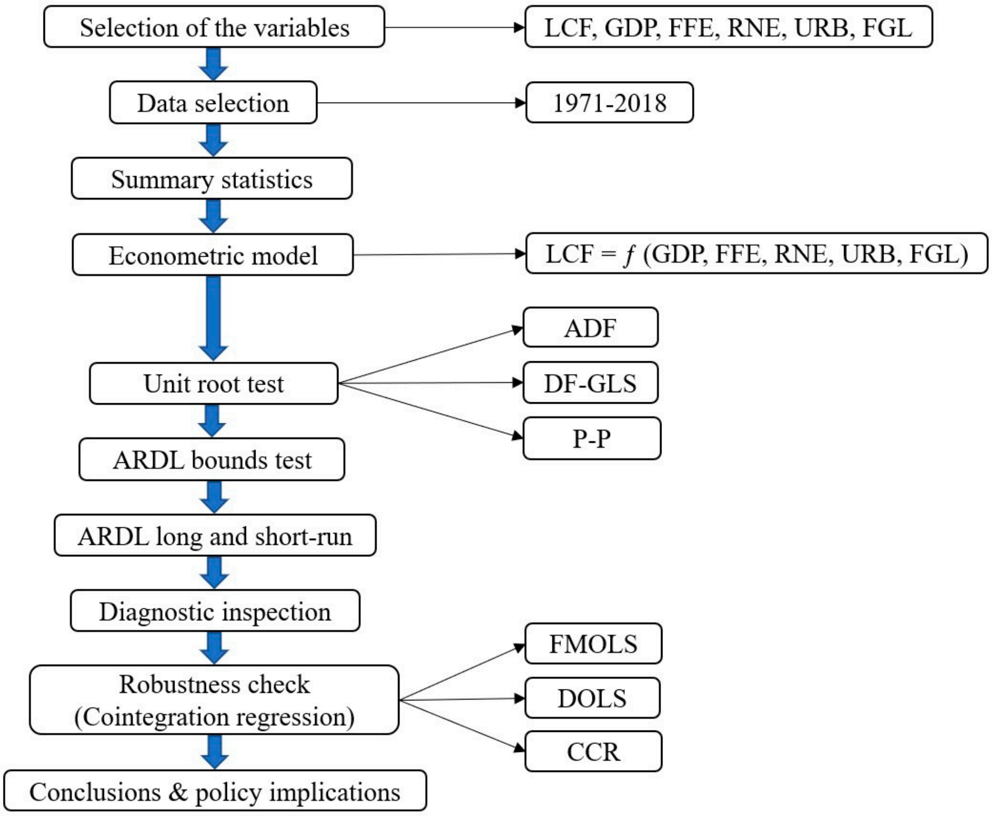

Figure 2. The methodological framework of the study.

This study employed the unit root test to confirm that no variable exceeded the order of integration required to verify the cointegration regressions (ARDL, DOLS, FMOLS, and CCR). A unit root test in statistics determines if a time series variable is non-stationary and has a unit root. The purpose of the test is to ascertain whether or not the stochastic component has a unit root or is stationary. The null hypothesis is characterized as the presence of a unit root, while the alternative hypothesis is either stationarity, trend stationarity, or explosive root, depending on the test employed. In general, the method of unit root testing implicitly presupposes that the to-be-tested time series (Y_t) can be expressed as follows:

$$Y_t = D_t + Z_t + \varepsilon_t \tag{4}$$

where D_t represents the deterministic (trend, seasonal component, etc.) component, Z_t represents the stochastic component, and ε_t describes the stationary error process.

3.4. ARDL Approach

This study implemented the ARDL-bound procedure Pesaran et al. [66] developed to determine the variables' integration. Comparing this strategy to earlier cointegration techniques offers several benefits [67]. The integration feature of a series had required being established before using prior cointegration methods, but this technique does not call for such testing. The ARDL model can adjust for endogeneity while considering the variable's lag length. Second, it is appropriate in all situations involving the integration of investigative series. Even with few observations, the ARDL model continues to be viable. Employing the econometric framework depicted in Equation (5), the ARDL bound testing strategy might be designed.

$$\begin{aligned}\Delta LLCF_t = {} & \tau_0 + \tau_1 LLCF_{t-1} + \tau_2 LGDP_{t-1} + \tau_3 LFFE_{t-1} + \tau_4 LRNE_{t-1} + \tau_5 LFGL_{t-1} + \tau_6 LURB_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LLCF_{t-i} \\ & + \sum_{i=1}^{q} \gamma_2 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LFFE_{t-i} + \sum_{i=1}^{q} \gamma_4 \Delta LRNE_{t-i} + \sum_{i=1}^{q} \gamma_5 \Delta LFGL_{t-i} \\ & + \sum_{i=1}^{q} \gamma_6 \Delta LURB_{t-i} + \varepsilon_t\end{aligned} \tag{5}$$

where q embodies the lag length of the series and Δ indicates the first difference operator.

Starting with Equation (5), we estimate the lagged variables' joint significance using OLS and the F-test. The goal of this method is to observe long-run cointegration. Where no long-run interactions among the variables are considered null hypotheses, upper and lower limits may be used as critical values against which comparison of F-statistics is feasible [66]. If the F-statistics are larger than the maximum critical value for rejecting the null hypothesis, then it can be concluded that the variables are linked over the long term. The null hypothesis is accepted if the F-statistic is less than the minimum acceptable value. The test is inconclusive if the F-statistics are seen to fall between the minimum and maximum thresholds.

Moreover, Pesaran et al. [66] described the ARDL procedure as promising for predicting the short and long-term associations among the model's variables after establishing their unit roots and cointegration. After establishing cointegration between the study's variables, the investigation used Equation (5) to predict an ARDL procedure of the long-run coefficient. Following the identification of the long-term connections, to look into the short-term behavior of the independent variables and the short-term adjustment rate toward the long-term rate, this study evaluated the error correction model (ECM). The ECM is integrated into the ARDL structure to accomplish this goal [68], illustrated in Equation (6), where θ is the ECM's coefficient. The equation shows how the series are linked across time and how error-correction dynamics work.

$$\begin{aligned}\Delta LLCF_t = {} & \tau_0 + \tau_1 LLCF_{t-1} + \tau_2 LGDP_{t-1} + \tau_3 LFFE_{t-1} + \tau_4 LRNE_{t-1} + \tau_5 LFGL_{t-1} + \tau_6 LURB_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LLCF_{t-i} \\ & + \sum_{i=1}^{q} \gamma_2 \Delta LGDP_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LFFE_{t-i} + \sum_{i=1}^{q} \gamma_4 \Delta LRNE_{t-i} + \sum_{i=1}^{q} \gamma_5 \Delta LFGL_{t-i} + \sum_{i=1}^{q} \gamma_6 \Delta LURB_{t-i} \\ & + \theta ECM_{t-1} + \varepsilon_t\end{aligned} \tag{6}$$

3.5. Robustness Check

Considering Equation (6), this study assessed the reliability of the ARDL conclusions by applying the DOLS test offered by Stock and Watson [69], the FMOLS test that was suggested by Phillips and Hansen [70], and the CCR test proposed by Park [71]. These approaches are used to estimate the long-run association by using a single cointegrating vector. Two major difficulties prompted the deployment of these solutions. FMOLS, DOLS, and CCR can be employed once the cointegration conditions among the I(1) parameters are met. Second, these techniques give consistent parameters even in the small sample size, overcome the problems of endogeneity, serial correlation, omitted variable bias, and measurement errors [72], and allow for heterogeneity in the long-run parameters. Therefore, the results it produces are asymptotically efficient.

4. Results and Discussion

4.1. Descriptive Statistics

Before performing the actual assessment (using methods like unit root, cointegration, and other analysis methods), it is necessary to determine the dataset's descriptive properties, particularly its normality. Table 2 lists the dataset's defining characteristics across its 48 years. The outcomes demonstrate that the means of the variables are typically distributed, demonstrating the absence of outliers in the data set. According to the calculated standard deviation values, the findings for the examined parameters indicate an appropriate amount of volatility so far. Moreover, all the applied parameters' anticipated skewness between +1 and −1. The load capacity factor and renewable power data are positively skewed, while financial globalization, urbanization, economic growth, and fossil fuel energy utilization are negatively skewed. Nature is platykurtic, as evidenced by all observable series having kurtosis values below 3. Since the Jarque–Bera test and the probability value for each series agree that the data follows a normal distribution, we may conclude that all observed series follow a normal distribution. The confirmation of data normality led us to the next step of the analysis, which is the unit root test for data stationarity.

Table 2. Descriptive statistics of the variables.

Variables	LLCF	LGDP	LFFE	LRNE	LFGL	LURB
Mean	−0.471092	8.987041	4.482117	2.417434	3.927990	4.272897
Median	−0.504034	8.993692	4.485016	2.413601	3.946589	4.292871
Maximum	0.244597	9.222305	4.511486	2.821840	4.193552	4.383975
Minimum	−0.979550	8.602729	4.421154	2.193886	3.676873	4.090654
Std. Dev.	0.330707	0.153684	0.021005	0.165563	0.176163	0.082632
Skewness	0.424271	−0.642277	−0.712863	0.484865	−0.054002	−0.601856
Kurtosis	2.077219	2.753942	2.830229	2.190244	1.519375	2.293941
Jarque–Bera	3.143097	3.421245	3.406817	3.192163	3.407829	3.894889
Probability	0.207723	0.180753	0.130791	0.202689	0.110370	0.142638
Observations	48	48	48	48	48	48

4.2. Findings of Unit Root Tests

Before using cointegration, unit root testing should be performed often to ensure that the variables are stationary, and then use descriptive statistics to check that the data is normally distributed. This is a crucial stage since it determines whether the applied variable is stationary and helps researchers choose the most appropriate test. In this investigation, we employed the utilization of the ADF, DF-GLS, and P-P unit root testing techniques. As shown in Table 3, all relevant metrics are constant after the initial difference. Therefore, the ARDL estimator and cointegration are viable options for these data.

Table 3. The outcomes of unit root tests.

Logarithmic Form of the Variables	ADF		DF-GLS		P-P	
	Log Levels	Log First Difference	Log Levels	Log First Difference	Log Levels	Log First Difference
LLCF	2.286	−9.520 ***	−0.186	−9.391 ***	−2.120	−9.492 ***
LGDP	−2.256	−5.705 ***	0.397	−4.831 ***	−2.211	−5.650 ***
LFFE	−3.076 **	−6.687 ***	−0.673	−4.111 ***	−2.971 **	−6.727 ***
LRNE	−2.503	−7.385 ***	−0.851	−3.662 ***	−2.520	−7.367 ***
LFGL	−0.971	−6.324 ***	−0.234	−6.348 ***	−0.414	−11.611 ***
LURB	−1.253	−3.518 ***	0.650	−3.171 ***	−2.477	−12.497 ***

*** and ** signify 1% and 5% significance, correspondingly.

4.3. The ARDL Bounds Analysis Outcomes

After validating stationarity characteristics, this research then estimated the ARDL framework. This investigation was selected using the Akaike Information Criterion (AIC) minimum values to calculate an F-statistic and then perform an ARDL bounds test; this requires a suitable lag time for the AIC for cointegration assessment. Table 4 shows the conclusions obtained from examining the ARDL bounds to establish whether the variables integrate. The existence of a long-term interaction within the variables may be inferred if the value that the F-test predicts is more than both of the threshold values, then the test is significant. The projected F-statistic value (9.193444), which shows a long-run association between related factors, is more than the 10%, 5%, 2.5%, and 1% of the crucial upper limit in the I(0) and I(1).

Table 4. ARDL bounds test results.

F-Bounds Test		Null Hypothesis: No Degrees of Relationship		
Test Statistic	**Estimate**	**Significance**	**I(0)**	**I(1)**
F-statistic	9.193444	At 10%	2.08	3.00
K	5	At 5%	2.39	3.38
		At 2.5%	2.70	3.73
		At 1%	3.06	4.15

4.4. Conclusions Drawn from ARDL's Short-Run and Long-Run Analyses

Given the apparent cointegration relationship, the ARDL method assessed these regressors' long- and short-term effects on load capacity. The computed values are shown in Table 5. The expansion of the Mexican economy is projected to reduce the country's load capacity factor. The short- and long-term data indicated that economic prosperity negatively correlates with the load capacity factor. A one percent increase in GDP would reduce load capacity by 0.63% in the long term and 0.23% in the short term. Consequently, economic prosperity degrades the character of the ecology over time. The finding is realistic from the theoretical point of view as the developing economies are heavily dependent on fossil fuels that lead to environmental degradation. Several studies reported a detrimental relationship between economic development and load capacity factor, consistent with the present study's finding. For example, Xu et al. [2] for Brazil; Pata and Balsalobre-Lorente [29] for Turkey; Khan et al. [30] in the context of G7 and E7 countries; Awosusi et al. [31] for South Africa; Shang et al. [32] for ASEAN countries; Akadiri et al. [33] for India; Pata [3] in Japan and the United States; Pata and Isik [34] for China; Fareed et al. [35] for Indonesia; and Majeed et al. [36] for Pakistan. However, the present study's findings contradict Solarin et al. [37], who reported that urbanization has no harmful impact on the environmental quality of Nigeria.

Table 5. ARDL long and short-run findings.

Variables	Long-Run			Short-Run		
	Coefficient	**t-Statistic**	***p*-Value**	**Coefficient**	**t-Statistic**	***p*-Value**
LGDP	−0.628 ***	−3.932	0.004	−0.234 ***	−3.773	0.006
LFFE	−6.779 ***	−5.311	0.001	−1.381 ***	−4.784	0.003
LRNE	1.026 ***	7.184	0.000	0.178 ***	3.947	0.001
LFGL	0.130 ***	5.686	0.000	0.009 ***	3.580	0.000
LURB	−2.314 ***	−5.195	0.001	−1.252 ***	−3.546	0.002
C	35.711	5.807	0.156	-	-	-
ECM (−1)	-	-	-	−0.541 ***	−3.953	0.000
R^2	0.9259					
Adjusted R^2	0.9190					

*** designates 1% significance, correspondingly.

The fact that Mexico is presently at the scale phase demonstrates that the nation is working toward achieving its pro-growth goals. Mexico's economic growth results from ecological issues like land, sea, and air pollution. As a developing economy, Mexico draws on a significant quantity of its resources and depends on forms of energy that produce much carbon to promote its economy [8]. To no one's surprise, ecological problems have arisen due to Mexico's rapid economic growth, driven by intensive on-resources manufacturing that has now achieved export saturation. Therefore, the growth of Mexico's economy, especially after the turn of the century, has contributed to the acceleration of environmental degradation. This highlights that an increase in income per person is not necessarily a good predictor of ecological sustainability; consequently, the government of Mexico needs to enact ecological regulations around energy use.

This study discovered that fossil fuel energy has a detrimental and statistically significant relationship with Mexico's load capacity factor in both the short and long term. A one percent boost in fossil power would reduce the load capacity factor by 6.78% in the long run and 1.38% in the short run. In Brazil, Xu et al. [2] observed that the rising demand for fossil fuels detrimentally impacts the LCF. Comparable outcomes were highlighted for Turkey by Pata and Balsalobre-Lorente [29] and South Africa, as indicated by Awosusi et al. [31]. Developing Asian countries exhibited analogous adverse connections between non-renewable energy consumption and LCF, as noted in Pata and Isik [30], Fareed et al. [35] for Indonesia, and Huang et al. [34] for China. However, our findings diverge from Alola et al. [9], who suggested that non-renewable energy efficiency advances environmental sustainability by elevating the load capacity factor.

The present study's result is not surprising as about 90 percent of Mexico's energy bundle comprises fossil fuels [26], the economic engines driving manufacturing, and output. Since the energy policy of Mexico includes the production of oil, natural gas, and coal that promotes economic growth based on fossil fuels is unavoidable. Therefore, industrial production and domestic business substantially impact the environment. An additional cause for concern is that overusing fossil power will inevitably lead to their depletion, and economies that rely only on them will eventually collapse. Mexico's extensive reliance on fossil power causes pollution and contributes to the country's mounting ecological issues by contaminating the atmosphere, reducing soil quality, and poisoning aquatic organisms. Hence, the foremost strategic imperative is to build a robust and advanced renewable energy infrastructure, ultimately phasing out the reliance on fossil fuels [73]. Mexico has been developing green power sources for decades while maintaining a fossil fuel-based power generation system.

However, this research showed that renewable power has a positive and statistically strong correlation with the load capacity factor throughout the entire load life cycle. The outcomes suggest using green energy could benefit Mexico's load capacity factor. The load capacity factor would rise by 1.03% over the long run and 0.18% over the short term, with a 1% boost in green power. Evidence from developed countries supports a positive correlation between the proportion of green power in total energy usage and the load capacity factor, as demonstrated in Pata [3] in Japan and the United States; Khan et al. [30] in the context of the G7; and Pata and Samsour [40] and Guloglu et al. [39] for OECD nations. Furthermore, comparable effects are observed within emerging economies, particularly in Asia, as highlighted by Shang et al. [32] in the Southeast Asia region, Fareed et al. [35] for Indonesia, Alola et al. [9] for India, and Zhao et al. [41] for BRICS-T nations. All observed a correlation between the ratio of green power to total energy usage and the load capacity factor; therefore, our findings align with theirs. However, our results oppose Akadiri et al. [33], who found that using renewable power sources temporarily lowers the load capacity factor in India.

The findings of this study hold both theoretical and practical validity, as the shift from fossil fuels to renewable and green energy sources could alleviate Mexico's environmental impact. Likewise, these findings are likely relevant to other developing nations grappling with environmental challenges. Using renewable energies for electricity generation is crucial to forestall potentially catastrophic climate change and guarantee ecologically sound growth. Increased energy accessibility, improved power, and utilizing locally available energy sources are just some of the many economic benefits of renewable energy [74,75]. Be-cause of rising global environmental consciousness, Mexico must shift its energy spending toward renewables to facilitate the development of a green economy.

Mexico is on track to produce 35% of its electricity from clean energy sources by 2024, as the country's General Climate Change Law mandates. Diversifying Mexico's energy supply into clean power, including wind, solar, biofuel, geothermal, hydropower, and nuclear power, might bring in vast investment. Investment in Mexico's renewable energy sector could increase if current market circumstances persist. However, natural coupling and utilization of these deposits are hindered by a wide range of specialized terminology and organizational, social, political, and economic limitations. Mexico requires an all-encompassing plan to boost the electricity it generates from green power to reach ecological sustainability.

In addition to the impact of renewables, this research found a positive correlation between financial globalization and load capacity factor, with a 1% rise in financial globalization predicted to enhance load capacity factor by 0.13% in the long run and 0.01% in the short run. Therefore, globalization of the financial sector is essential to the long-term changes and fluctuations of Mexico's ecosystems. Xu et al. [2] and Akadiri et al. [33] revealed a positive association between financial globalization and load capacity factor in Brazil and India, respectively, lending further credence to this assessment. This result is sound, as foreign investment can introduce advanced technology that enhances productivity even in resource-constrained environments. From a theoretical perspective, financial globalization signifies the advancement of a nation's financial sector, where a well-developed financial system would prioritize investments for environmental sustainability rather than pursuing a developmental trajectory that harms the environment. The availability of funds also facilitates the promotion of green energy initiatives, leading to improved sustainable development.

In addition, this study found that the load capacity factor is negatively related to urbanization. The results showed that for every 1% increase in urban population, the load capacity factor dropped by 2.31 percent in the longer term and 1.25 percent in the shorter term. The finding aligns with both a theoretical and practical standpoint, as the rise in urban population contributes to environmental deterioration via intensified energy consumption, waste production, water utilization, electricity usage, air and noise pollution, deforestation, soil erosion, and alterations in land use. The present study's result agrees with Guloglu et al. [39] for OECD nations, Zhao et al. [41] for Indonesia, and Pata [44] for E-7 countries, who found that urbanization adversely interacts with the load capacity factor leads to more degradation of the environment. This finding explains why Mexico's rapid urbanization due to rural-to-urban migration constitutes a risk to the country's environment. The findings point to a rise in GHG emissions from the usage of electrical devices, the construction of homes and factories, and the operation of automobiles due to Mexico's rapid urbanization. Economic growth, which urbanization facilitates, can lead to environmental degradation [76]. As a result, Mexico's urbanization can only be maintained for a little while, calling for adopting a strategy for such growth.

However, our results contradict Solarin et al.'s [37] theory that non-renewable energy efficiency promotes environmental sustainability by increasing load capacity. Similarly, our results contrast with Danish et al.'s [19] argument that urbanization reduces the ecological footprint of BRICS countries. These studies [19,37,61] argue that these major emerging nations could reduce emissions by prioritizing sustainable energy use, responsible natural resource management, increasing the share of renewable energy, managing urbanization, and aligning these efforts with income growth. Thus, Mexico must promote a more rapid transition to cleaner energy alongside income growth to enable the adoption of cleaner technologies and sustainable urban investments.

The error correction coefficient suggests that the model's short-term equilibrium deviations will cancel out over the long run. The calculated coefficient value of 0.611 demonstrated that the rate of change from short-run stability to long-term stability is 61% per year, which is steady. Furthermore, the proposed regression model fits the data well, as shown by the long-run estimation R^2 of 0.9259 and the corrected R^2 of 0.9190. This indicated that the independent variable could explain the changes in the dependent variable caused in 92% of cases.

4.5. Diagnostic Inspection

This investigation employed the ARDL test outcomes that need to be confirmed by various diagnostic tools before they can be considered reliable. Table 6 displays the results of applying the Breusch–Godfrey Langrage Multiplier (LM) to investigate the possibility of serial correlation. The findings suggest no sequential relationship. Heteroscedasticity was tested using the Breusch-Pagan-Godfrey statistic, and it was found that the data were not heteroscedastic. The Jarque–Bera Normality test examined the series' potential for normality. The p-value and Jarque–Bera statistic both pointed to a normally distributed residual. The "cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests" are applied to the recursive residuals to assess the consistency of the short-run beta coefficients in the ARDL technique. Figure 3 shows that according to the outcomes of the CUSUM and CUSUM square tests, the paper finds no evidence of a fundamental inconsistency (at the 5% level) within GHG emissions and independent variables. The testing validated the reliability of the model.

Table 6. The outcome of diagnostic tests.

Diagnostic Tests	Coefficient	*p*-Value	Decision
Jarque-Bera test	2.715821	0.2572	Residuals are normally distributed
Breusch-Godfrey LM test	2.657845	0.1028	No serial correlation exits
Breusch-Pagan-Godfrey test	0.574111	0.9016	No heteroscedasticity exists
Ramsey RESET test	1.254856	0.2276	The model is specified correctly

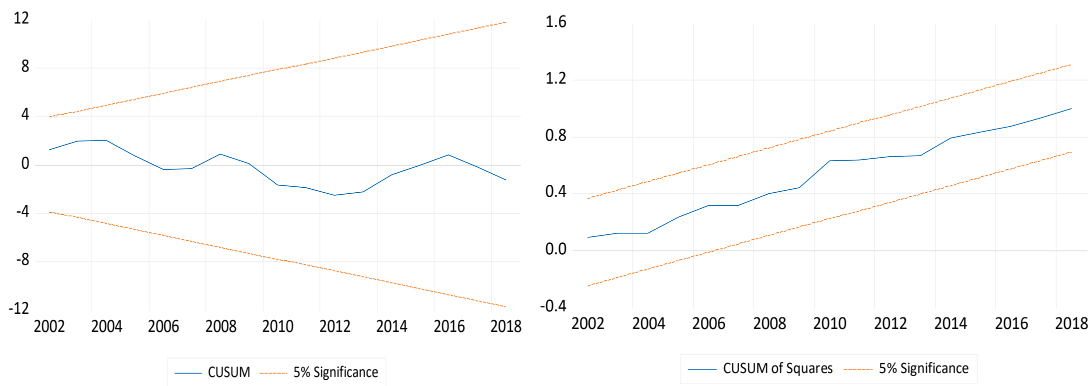

Figure 3. The plots of CUSUM and CUSUMQ tests.

4.6. Results of Robustness Check

Longitudinal evaluations employing the DOLS, FMOLS, and CCR assessments were also performed on the ARDL procedure conclusions. The anticipated outcomes from using DOLS, FMOLS, and CCR are shown in Table 7. Conclusions from DOLS, FMOLS, and CCR were all demonstrated to be consistent and reliable. The outcomes showed that Mexico's load capacity factor drops as economic expansion, fossil power, and urbanization boost but rises with renewable energy and financial globalization. These findings are comparable with those from the ARDL simulations, with some minor differences statistically and in terms of the size of the coefficients. Given these results, it seems reasonable to determine that the ARDL analysis's findings are credible and consistent.

Table 7. The results of the robustness check.

Variables	DOLS		FMOLS		CCR	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
LGDP	−0.639 ***	−3.387	−0.665 ***	−3.418	−0.631 ***	−3.329
LFFE	−5.531 **	−2.670	−6.671 **	−2.688	−6.995 **	−2.762
LRNE	0.497 ***	3.409	0.650 ***	3.534	0.707 ***	3.507
LFGL	0.145 ***	3.709	0.085 **	2.320	0.139 ***	3.482
LURB	−2.119 ***	−3.765	−3.029 **	−2.511	−3.168 **	−2.448
C	13.719	0.846	13.365	0.877	14.874	0.924
R^2	0.9267		0.9159		0.9146	
Adjusted R^2	0.9180		0.9057		0.9041	

*** and ** denote significance at 1% and 5% levels, respectively.

5. Conclusions and Policy Implications

5.1. Conclusions

The rapid growth of Mexico's economy has made it a developing country with severe ecological problems. Carbon emissions, ecological footprint, and greenhouse gas emissions are the most often used measures to compare environmental degradation in rich and developing nations. The "Sustainable Development Goals (SDGs)" and mitigating ecological concerns depend on a broader and more comprehensive ecological evaluation. Therefore, the load capacity factor was used as an independent proxy for environmental deterioration and offered a comprehensive evaluative measurement of the environment by simultaneously contrasting biocapacity and ecological footprint. The load capacity factor also gives the integrated environmental demand and supply features.

Focusing on Mexico, this study looked at load capacity from 1971 to 2018 to see how economic growth, urbanization, financial globalization, and fossil and renewable power usage influenced it. These connections were uncovered using an array of techniques. The "ADF, DF-GLS, and P-P unit root tests" were conducted to examine the stability and stationarity of each variable. The variables were shown to be cointegrated across long periods; ARDL-bound test outcomes point in this direction. Economic growth, fossil fuel, and urbanization negatively influence Mexico's load capacity factor, based on the ARDL method's findings, while using renewable power sources and financial globalization have a favorable effect. The utilization of DOLS, FMOLS, or CCR methods robustly confirms that the estimated results remain unaffected.

5.2. Policy Implications

Given the negative coefficients within GDP and the load capacity factor, policymakers in Mexico should focus on promoting sustainable and resource-efficient economic growth. Instead of solely pursuing traditional economic indicators, the emphasis should be on inclusive development, prioritizing energy efficiency and clean technologies. Encouraging investments in green sectors, fostering innovation, and supporting businesses adopting sustainable practices can maximize the load capacity factor while achieving robust GDP growth. Additionally, targeted policies that stimulate research and development in renewable energy and sustainable infrastructure can further enhance the country's economic performance while reducing its energy intensity and environmental impact.

Based on the negative coefficients between fossil fuel consumption and the load capacity factor, Mexico should prioritize policies to reduce reliance on fossil fuels for energy consumption. Implementing measures to transition towards cleaner and renewable energy sources will mitigate environmental impacts, enhance energy security, and reduce the strain on the electricity grid. Policymakers can consider incentivizing the adoption of renewable power knowledge, setting targets for clean power integration in the energy mix, and phasing out subsidies for fossil fuels. Additionally, promoting energy conservation and efficiency initiatives across industries and the transportation sector will further support efforts to minimize the load capacity factor and move Mexico towards enhanced energy security and sustainability.

With the positive coefficients observed in both renewable power and the load capacity factor, Mexico's priority should be formulating policies to accelerate the implementation and integration of renewable energy sources. Policymakers can introduce supportive measures like feed-in tariffs, tax incentives, and grants, fostering investments in clean power projects. Streamlining the approval process for renewable energy initiatives and bolstering grid infrastructure to accommodate higher levels of renewable energy penetration become crucial steps in maximizing the load capacity factor. Additionally, initiatives focused on public awareness and knowledge dissemination can play a vital role in encouraging the utilization of green power among individuals and businesses, thereby fostering the adoption of clean energy technologies and enhancing the overall dependability and sustainability of Mexico's energy infrastructure.

Mexico can leverage the strong coefficients connecting financial globalization and the load capacity factor. This presents an opportunity to bolster its energy infrastructure and capacity. Prioritizing the attraction of FDI in the power sector, particularly in projects promoting renewable energy and energy efficiency, becomes crucial. Facilitating cross-border capital flows and nurturing international partnerships will expedite the adoption of advanced technologies and energy management best practices. Establishing comprehensive regulatory frameworks is essential to ensure sustainable and fair benefits from financial globalization, guarding against instability. Achieving equilibrium between open global financial interactions and effective regulations enables Mexico to tap into the potential of financial globalization. This approach will maximize the load capacity factor, driving Mexico's energy transition objectives.

Given the negative coefficients between urbanization and the load capacity factor, policymakers in Mexico should prioritize sustainable and smart urban planning to mitigate the strain on the electricity grid. Encouraging compact and well-connected urban development and promoting green spaces and public transportation can reduce energy demand and enhance energy efficiency in cities. Implementing energy-efficient building codes and standards, and incentivizing the implementation of green power technologies in urban infrastructure can further support the goal of minimizing the load capacity factor. Additionally, integrating urban planning with energy management strategies and considering the environmental impacts of urbanization will be essential in ensuring a balanced approach to sustainable urban development and a more resilient energy future for Mexico.

5.3. Future Research Directions and Study Limitations

This study analyzes the varied effects of economic expansion, fossil power, clean power, financial globalization, and urbanization on load capacity factors in Mexico, which have several notable limitations. Firstly, the study's reliance on available data sources may have restricted the depth of analysis and precision of results. To overcome this, more in-depth data should be collected in the future, and up-to-date data to enhance the accuracy of findings. Additionally, the research may have been constrained by the complexities and interdependencies of the factors under investigation. Future studies could employ advanced econometric models and causal analysis techniques to better discern the causal relationships among these variables. Moreover, the impact of external factors, such as government policies and technological advancements, could have been overlooked in this study. Future research might delve into the drive of these external factors on load capacity factor and its interaction with the studied variables. Furthermore, considering Mexico's geographical diversity and regional disparities, future research could adopt a more granular approach to explore how load capacity factors vary across different states or cities. Lastly, the study primarily focused on the quantifiable aspects of energy and economic factors, leaving scope for future investigations into the ecological and societal implications of pursuing renewable power and urbanization. By addressing these limitations and pursuing more comprehensive research, policymakers and stakeholders can make better-informed decisions to facilitate sustainable energy development and efficient energy utilization in Mexico.

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