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NATURAL RESOURCES, ENERGY USE AND ECONOMIC GROWTH UNDER THE LCC HYPOTHESIS: EVIDENCE FROM AZERBAIJAN

Abstract

This study explores the connection between economic growth and environmental sustainability in Azerbaijan through the Load Capacity Curve (LCC) hypothesis. The Load Capacity Factor (LCF) is used to represent the environmental sustainability situation by indicating the equilibrium between mankind's consumption of nature's resources and nature's capacity to regenerate them. Based on yearly statistics from 2000 to 2021, per capita GDP, international natural resource rents, the consumption of renewable energy, and 'green' innovation measured by the spending on research and development (R&D) were reviewed. Autoregressive Distributed Lag (ARDL) method was used to look at both short-run and long-run associations of the variables. The results indicate that Azerbaijan faces a persistent ecological deficit, as the ecological footprint always surpasses the biocapacity and the short-run income changes do not have a significant impact on the ecological capacity. The rents from natural resources have diverse dynamic impacts, whereas the usage of renewable energy has a positive albeit a delayed impact on ecological capacity, and the research and development spending has not yet made a contribution to environmental sustainability. In general, the results provide cautious evidence for the LCC hypothesis and underline the need for faster renewable energy transition and the necessity of making innovation policy compatible with the environmental goals.

Keywords: *load capacity factor, economic growth, natural resource rents, renewable energy, green innovation, Azerbaijan.*

INTRODUCTION

Sustainability and the "green transition" have become increasingly important on both national and international agendas over the last years. The Azerbaijani government has formulated its own strategy on issues of the development of renewable energy sources, economic diversification, and environmental protection. However, the success of these policies is dependent on the compatibility of economic development and environmental capacity. The relationship between growth dynamics and environmental constraints has become a vital theme in development planning.

The analysis of environmental sustainability cannot be done by the use of analysis tools that only consider environmental pollution. In this case, environmental sustainability is more appropriate by looking at environmental pressure and the ability of the environment to regenerate itself. Environmental sustainability analysis by looking at environmental pressure and the ability of the environment to regenerate itself is important for resource-rich countries like Azerbaijan because environmental stress is accumulated slowly and not visible to the eye.

Despite the rising importance of sustainability in policy circles, little research has been conducted on the relationship between economic development and ecological capacity in the case of Azerbaijan.

This is despite the fact that all the studies that have been conducted have been focused on economic performance, energy use, or specific aspects of the environment without looking at development in relation to ecological constraints. Against this background, this research paper intends to investigate the interrelation between economic growth and ecological capacity in Azerbaijan using the Load Capacity Curve approach. The research includes economic growth, natural resource rents, renewable energy use, and green innovation to determine their joint effect on environmental sustainability. The research covers different stages of economic growth, shocks, and energy policy changes from 2000 to 2021. The results are anticipated to contribute to policy recommendations on how Azerbaijan can pursue economic growth and strengthen its ecological sustainability.

LITERATURE REVIEW

The interaction between economic development and the environment is an area of research that has been widely studied in the literature. The earliest research on this topic was conducted on the Environmental Kuznets Curve (EKC) hypothesis, where it was suggested that the level of environmental deterioration rises in the early stages of economic growth and reverses as soon as the income level reaches a certain threshold (Grossman & Krueger, 1995). However, the result of this model is highly susceptible to the variable used to represent the environment. Most of the EKC studies focus on one type of pollutant, like carbon, thus limiting the scope of the model in analyzing the environment from the perspective of sustainability.

To overcome these issues, there has been growing interest in ecological accounting methods which seek to incorporate both environmental pressure and ecological capacity for self-recovery. The concepts of ecological footprint and biocapacity were developed by Wackernagel and Rees (1997). Based on these concepts, a new approach called Load Capacity Factor (LCF) has been used to determine how well economic systems are operating within their ecological limits and is defined as biocapacity to ecological footprint ratio. The Load Capacity Curve (LCC) approach is founded on this method and measures sustainability through direct links between economic growth and ecological capacity instead of pollution.

A further relevant stream of literature examines the impact of natural resource dependence. Research on the resource curse argues that an economy with strong natural resource dependence may face difficulties on the structural and institutional fronts (Sachs and Warner, 2001; Mehlum, Moene and Torvik, 2006; van der Ploeg, 2011). Although these studies focus on growth outcomes, their results can be generalized to environmental sustainability as well because natural resource-based growth often increases environmental stress and can hinder the shift to environmentally friendly production patterns, even if natural resource rents are often channeled to support environmental causes. Literature on energy economics highlights renewable energy as an important element in lessening environmental stress. Empirical evidence suggests a strong nexus between economic development and renewable energy consumption (Apergis & Payne, 2010; Omri & Nguyen, 2014). Though these papers do not use indicators of ecological capacity explicitly, they imply that a higher share of renewables can counterbalance adverse effects of economic development on the environment. Such inferences are found in other research papers which include renewable energy in models of economic development and environment (Sinha & Shahbaz, 2018).

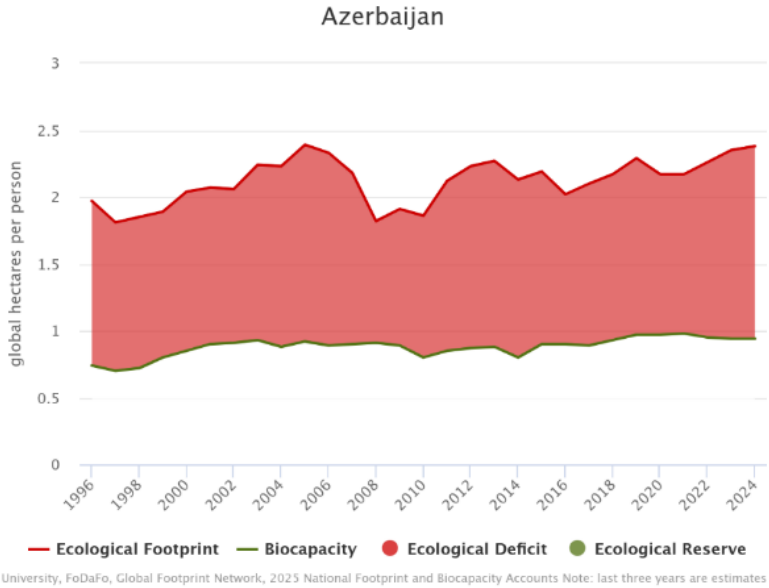
Technological change and innovation are generally considered crucial drivers of improved environmental performance, especially in terms of advances in energy efficiency and the use of clean technologies or cleaner production methods. Theoretically, innovation is driven by economic incentives and is thus an important factor in determining technological change and its environmental impact (Popp, 2002). However, in terms of environmental innovation, there are challenges in measuring this construct, especially in transition economies where there is limited information available regarding environmental patents or eco-innovation. As such, R&D spending is used as a proxy for innovation, despite its flaws, as it is indicative of overall spending in technological development and its potential impact on environmental performance.

In general, despite the fact that the literature is quite broad in its coverage of issues like economic growth, natural resources, energy consumption, and innovation, the number of studies assessing sustainability in terms of ecological capacity is relatively limited. This is especially the case in the area of resource-dependent transition economies. Azerbaijan is one country of this type, but there is limited literature in the form of country-specific evidence in the LCC framework.

RESULTS AND DISCUSSION

This paper investigates the empirical correlation between economic growth and ecological capacity in Azerbaijan using a combination of descriptive ecological data and the findings from the dynamic regression analysis conducted using the ARDL approach. The paper focuses on the Load Capacity Factor (LCF), which is a broad indicator of sustainability of the environment and its interaction with economic growth and other factors related to ecological capacity.

Figure 1 Ecological footprint and biocapacity in Azerbaijan



Note. *Data sourced from the Global Footprint Network. Ecological deficit is created when ecological footprint surpasses biocapacity.*

The above figure shows the development of ecological footprint and biocapacity in Azerbaijan during the period of observation. From this figure, it is clear that ecological footprint has always surpassed biocapacity, and this shows there has always been an ecological deficit in Azerbaijan. Ecological footprint is seen to move in cycles between 1.8 and 2.4 global hectares per capita, but biocapacity is much smaller and moves in cycles between 0.7 and less than 1.0 global hectares per capita. While it is seen that biocapacity shows some level of positive development in recent times, especially in the latter half of the 2010s, this level of development has not been enough to stem ecological demand, and Azerbaijan has remained below the ecological sustainability threshold during this period.

Figure 2. ARDL estimation results for the load capacity factor

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCF(-1)	0.375935	0.225888	1.664253	0.1471
GDP_PER_CAPITA	-0.041228	0.038533	-1.069943	0.3258
GDP_PER_CAPITA_SQR	0.001300	0.003041	0.427302	0.6841
GDP_PER_CAPITA_SQR(-1)	0.002419	0.001428	1.694282	0.1411
GDP_PER_CAPITA_SQR(-2)	-0.001613	0.001017	-1.585388	0.1640
OIL_RENTS___OF_GDP	0.001873	0.001579	1.186663	0.2802
OIL_RENTS___OF_GDP(-1)	-0.007503	0.002422	-3.097108	0.0212
OIL_RENTS___OF_GDP(-2)	0.005599	0.001268	4.415460	0.0045
RENEWABLE_ENERGY_CONSUMPTI...	-0.022681	0.010867	-2.087107	0.0819
RENEWABLE_ENERGY_CONSUMPTI...	0.026013	0.010361	2.510566	0.0459
R_D_EXPENDITURE___OF_GDP	-0.102695	0.417615	-0.245907	0.8139
R_D_EXPENDITURE___OF_GDP_(-1)	-0.695328	0.308360	-2.254920	0.0650
R_D_EXPENDITURE___OF_GDP_(-2)	-0.355023	0.231576	-1.533077	0.1761
C	0.643320	0.222304	2.893878	0.0276
R-squared	0.938074	Mean dependent var		0.420866
Adjusted R-squared	0.803900	S.D. dependent var		0.031855
S.E. of regression	0.014106	Akaike info criterion		-5.488339
Sum squared resid	0.001194	Schwarz criterion		-4.791326
Log likelihood	68.88339	Hannan-Quinn criter.		-5.352275
F-statistic	6.991500	Durbin-Watson stat		2.063700
Prob(F-statistic)	0.012651			

Note. *Data are obtained from the World Bank; estimation results are generated using EViews.*

The interaction between ecological capacity and its determinants is modelled through the ARDL (1,0,2,2,1,2) approach. The results, as shown in Figure 2, indicate the overall goodness of fit of the model to the data, as the R-squared is 0.94 and the adjusted R-squared is 0.80, indicating the dominant role of the variables selected in explaining the variation in the Load Capacity Factor. The F-statistic is meaningful, and the value of the Durbin-Watson statistic of about 2.06 indicates the lack of any serious problem of serial correlation in the data, thus confirming the suitability of the model in studying the dynamics of ecological capacity in Azerbaijan. In the short run, the effect of per capita GDP on ecological capacity is not statistically significant. The coefficient of per capita GDP is negatively set at -0.041, and the square of income is positively set at 0.0013, but both are not statistically different from zero. This means that in the short run, changes in income are not directly reflected in the changes in ecological capacity, supporting the contention that the effect of economic changes on the environment takes time to manifest and is more influenced by the accumulation of structural factors than the growth process.

Natural resource rents have a more complex form of dynamics. Although the contemporaneous multiplier is insignificant, the first lag is negative and significant (-0.0075), implying that an increase in natural resource rents worsens ecological pressure in the short term. However, the second lag turns positive and significant (0.0056), implying that there is partial adjustment in the longer term. The result likely captures the dual effects of natural resources in Azerbaijan, whereby natural resource extraction has adverse environmental effects in the short term but can generate funds for compensatory actions in the longer term to alleviate ecological pressure. In contrast, renewable energy consumption has a positive but lagged effect on ecological capacity. Although it has an insignificant contemporaneous multiplier, the positive and significant first lag (0.026) implies that an increase in renewable energy consumption enhances LCF in the longer term. The result implies that environmental benefits will materialize only after renewable energy infrastructure has been sufficiently developed to integrate into the energy structure.

Green innovation, measured by R&D expenditure, lacks a positive contribution to ecological capacity. The negative and significant first lag of R&D expenditure is -0.695, while the remaining terms are insignificant, indicating innovation effort in Azerbaijan has not yet been sufficiently oriented toward environmentally effective technologies and may instead reflect transitional adjustment costs within a resource-based economic structure. Taken together, these findings of the regression analysis correspond to the descriptive statistics shown in Figure 1 above. The fact that the ecological deficit has been stable

over time reflects resource-driven growth and limited ecological capacity, while the lagged positive effect of renewable energy represents a possible path to sustainability. Though not statistically significant over the short term, the nonlinear income effects have the correct signs to correspond to the Load Capacity Curve model, which suggests economic growth negatively impacts ecological capacity but potentially less so over time due to changes brought about by economic transformation and energy transition. In sum, these findings suggest Azerbaijan operates beneath its level of ecological sustainability. Progress can be made particularly in terms of renewable energy, but more ambitious action is required for economic growth to be compatible with ecological capacity.

CONCLUSION

This research focused on the relationship between economic growth and ecological capacity in Azerbaijan based on the Load Capacity Curve Hypothesis, using the Load Capacity Factor as an integrated measure of environmental sustainability. From the empirical analysis, it is found that there is an ecological deficit during the period of study, with the ecological footprint being larger than biocapacity all the time. This indicates that economic growth during the past has occurred at the expense of ecological capacity, which is largely driven by resource and energy-dependent growth strategies. From the econometric analysis, it is found that the impact of short-run changes in income on ecological capacity is not significant, which indicates that environmental responses to economic activities are largely slow and cumulative. Natural resource rents have both adverse and compensatory impacts on ecological pressure due to their dual role as both an environmental stress and an environmental mitigation factor.

At the same time, the findings suggest that renewable energy installations will lead economic development to be less harmful to the environment in the long run. The lag in the positive impact of renewable energy use on environmental capacity means that the region's investment in renewable energy might be a slow but sure way of reducing the soil's inability to support living things in the area, even if that area relies on the resource for its living. But, green innovation (as per R&D spending) still does not positively impact the ecosystem much reflecting the innovation efforts in Azerbaijan which are not aimed at environmental goals in terms of being limited by the scope and quality. Overall, the outcomes provide cautious support for the Load Capacity Curve hypothesis, suggesting that although economic development at first puts a lot of pressure on ecological capacity, it can be made more compatible with sustainability if there are structural transformation, energy transition, and innovative policies. The policy implications are such that these findings underline the need for reducing excessive reliance on extractive growth, quickening up the process of getting renewable energy on the market, and changing the focus of innovation policy to environmentally effective technologies so that Azerbaijan will be able to walk on a more sustainable long-term development path.

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LCC hipotezi çərçivəsində təbii ehtiyatlar, enerji istifadəsi və iqtisadi artım: Azərbaycan təcrübəsi

Xülasə

Bu tədqiqat, Yük Tutumluluğu Əyrisi (YTƏ) hipotezi vasitəsilə Azərbaycanda iqtisadi artım və ətraf mühitin dayanıqlılığı arasındakı əlaqəni araşdırır. Yük Tutumluluğu Faktoru (YTƏ), bəşəriyyətin təbiət ehtiyatlarından istifadə etməsi ilə təbiətin onları bərpa etmək qabiliyyəti arasındakı tarazlığı göstərməklə ətraf mühitin dayanıqlılığı vəziyyətini təmsil etmək üçün istifadə olunur. 2000-ci ildən 2021-ci ilə qədər olan illik statistikaya əsasən, adambaşına düşən ÜDM, beynəlxalq təbii ehtiyatların icarəsi, bərpa olunan enerji istehlakı və tədqiqat və inkişafa (R&İ) xərclərlə ölçülən "yaşıl" innovasiya nəzərdən keçirilmişdir. Dəyişənlərin həm qısa, həm də uzunmüddətli əlaqələrini araşdırmaq üçün Avtoreqressiv Paylanmış Gecikmə (ARDL) metodundan istifadə edilmişdir. Nəticələr göstərir ki, ekoloji iz həmişə biotutumun üstündən keçir və qısamüddətli gəlir dəyişiklikləri ekoloji tutuma əhəmiyyətli təsir göstərmir, çünki Azərbaycan davamlı ekoloji kəsirlə üzləşir. Təbii ehtiyatlardan əldə edilən icarələr müxtəlif dinamik təsirlərə malikdir, bərpa olunan enerjidən istifadə isə ekoloji tutuma müsbət, lakin gecikmiş təsir göstərir və tədqiqat və inkişaf xərcləri hələ də ətraf mühitin dayanıqlılığına töhfə verməyib. Ümumiyyətlə, nəticələr LCC hipotezi üçün tərəddüdlü dəstək təklif edir və daha sürətli bərpa olunan enerji keçidinə ehtiyacı və innovasiya siyasətinin ətraf mühit məqsədlərinə uyğunlaşdırılmasının zəruriliyini vurğulayır.

Açar sözlər: *load capacity factor, iqtisadi artım, təbii ehtiyat gəlirləri, bərpa olunan enerji, yaşıl innovasiya, Azərbaycan.*