UNIVERSITY OF ZIELONA GÓRA

CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2025; 35 (2): 0063-0077
DOI: 10.59440/ceer/202239
Original Research Article

A CONFIRMATORY ANALYSIS OF DISCONNECT BETWEEN URANIUM SUPPLY AND GDP IN KAZAKHSTAN AND NAMIBIA

Stanisław HALKIEWICZ[1], Aleksandra CHEJDUK[2]
[1]Department of Applied Mathematics, AGH University of Cracow, Kraków, Poland
[2]Institute of Quantitative Methods in Social Sciences, Cracow University of Economics, Kraków, Poland

Abstract

This study showcases linear regression as a tool for studying the resource curse by examining the relationship between global uranium supply and the economic performance (measured as GDP) of Kazakhstan and Namibia, two of the world's major uranium producers. In spite of their significant contribution to global uranium production, the relationship between uranium supply and GDP in these countries remains unclear. Using simple regression analysis and statistical tools, this study assesses the extent to which fluctuations in uranium exports and global market dynamics have influenced GDP growth in Kazakhstan and Namibia. To achieve this, OLS regression models were estimated using historical uranium production values and GDP data, allowing for an empirical assessment of the statistical significance of this relationship. The results suggest that there is a limited and statistically insignificant relationship, indicating that factors other than resource extraction play a more important role in shaping the overall economic performance of these countries. This lack of significance can also lead to questions about inequity in the global uranium trade, with major suppliers not benefiting from exchanges to the same extent as they would in a fair market. This study contributes to a broader understanding of resource-rich economies and challenges the assumption that natural resource wealth directly translates into national economic prosperity.

Keywords: resource curse, stratification, uranium mining, Kazakhstan, Namibia

1. INTRODUCTION

Kazakhstan and Namibia are amongst world's largest suppliers of uranium, ranking 1st (in 2022) and 4th (and in some years even 3rd), respectively [1, 2].

Kazakh economy is heavily resource-dependent, as over 80% of its export are reliant on the resource sector, with uranium being one of the most strategically important minerals. The uranium industry in Kazakhstan is primarily operated by Kazatomprom, the country's national nuclear operator [1]. The company oversees approximately 50 known deposits and 22 operational mines. Kazakhstan is

[1]Corresponding author: Stanisław M. S. Halkiewicz, Department of Applied Mathematics, AGH University of Cracow, Czarnowiejska 70, 30-054 Kraków, Poland, email: smsh@student.agh.edu.pl, phone: +48 665 120 626

estimated to possess approximately 12% of the world's total recoverable uranium resources, making it a significant contributor to the nuclear energy sector [1, 2]. The mining process predominantly employs in-situ leaching, a method that has the dual benefit of minimising environmental impact and reducing costs in comparison to traditional mining techniques [1, 3]. Despite having not utilised its uranium reserves for domestic electricity generation since the closure of its final nuclear power plant in 1999, Kazakhstan has demonstrated a sustained commitment to nuclear industry. This has entailed the establishment of a low-enriched uranium bank, thereby further reinforcing its position within the global nuclear supply chain [3]. According to Kazatomprom approximately 64% of its uranium shipments destined for western markets were transported via the Trans-Caspian International Transport Route in 2023. However, recent sales data indicate a notable decline in exports to the U.S. and Europe, while sales to Russia and China have risen sharply. This shift has been influenced by geopolitical factors, including Russia's war on Ukraine, which has made it more challenging for Kazakhstan to supply Western markets. Additionally, Russia's state nuclear corporation, Rosatom, has sold its stakes in significant Kazakh uranium deposits to Chinese companies, further strengthening China's position in the region. These developments underscore Kazakhstan's growing role in the global nuclear supply chain and its strategic pivot towards Eastern markets.

The uranium mining sector in Namibia is characterised by the presence of substantial mineral deposits and an established infrastructure, with notable operations, such as, the Rossing Uranium Mine, which is regarded as one of the largest open-pit uranium mines globally [1]. The uranium resources found in Namibia are extracted primarily through conventional mining methods, which have been developed and refined over decades of exploration and production. Furthermore, Namibia is geographically situated in such a way as to allow it to serve as a principal provider of nuclear energy resources for the global market. In addition, the government has adopted an active approach in promoting the development of uranium resources in Namibia [4], although this has sometimes resulted in environmental costs.

1.1. Resource curse

Resource curse, also called *paradox of plenty*, is an economic theory, first posed by Richard Auty in 1993 [3], which posits that countries with abundant natural resources (e.g. oil, minerals and gas) often exhibit diminished economic growth and inferior development outcomes in comparison to their counterparts lacking such resources. The phenomenon is suspected to arise from a number of interrelated factors.

Firstly, the influx of foreign currency from resource exports can result in an appreciation of the local currency, which in turn makes other sectors, such as manufacturing, less competitive. This effect is known as the Dutch Disease [6].

Secondly, a reliance on the extraction of resources can foster rent-seeking behaviour and corruption, as governments may prioritise the interests of resource industries over broader economic development. This can result in an inefficient allocation of resources whereby funds are diverted from essential services such as education and healthcare into government salaries and subsidies for the resource sector. This can happen, for example, if such sector is a key player in sustaining a political regime [7]. Overreliance on one industry may also lead to unevenly distributed economic growth, which could then be a factor contributing to the regional stratification of wealth.

A third potential explanation, though seldom discussed in the literature, is the unequal bargaining power between the parties involved in the transaction. While, besides Canada and Australia, the majority of the largest uranium producers are developing economies, such as Kazakhstan, Niger and Namibia, the largest importers are some of the most robust economies globally, including the United States, China and France. This may indicate a possibility that the final price may not be solely market-driven but may also be influenced by political factors [8]. This could also be an explanation for the occurrence of exceptions to the resource curse, namely, in countries with robust institutions and an established international position, which are also abundant in natural resources e.g. Norway [3, 9]. A crucial role of institutions in reverting the resource curse was discussed in recent research by Destek et al. [10] and previously it has been described by many other researchers (according to Narh [11]).

1.2. Purpose of the study

Resource curse is a phenomenon, which has been widely researched and described in many articles, books and monographs and many case studies have been conducted in regard to this topic [3, 6, 7, 9, 10, 11]. Therefore, the main point of this article is not to repeat the same theory nor to conduct advanced economic divagations concentrated on a specific case, but to showcase an econometric approach to studying the resource curse through the example of Kazakhstan and Namibia's economies. Through statistical modelling, the analysis explores the relationship between uranium supply and GDP growth in these economies, assessing whether resource wealth translates into broader economic prosperity.

First, an overview several quantitative studies is conducted. Then, in the Methods section, Ordinary Least Squares (OLS) regression is introduced as the primary analytical tool for this study. In results, the disconnect between the GDP of Kazakhstan and Namibia and their respective uranium supply is shown by data visualisation and simple OLS model construction.

2. LITERATURE REVIEW

As noted by Cheng et al. [12], in spite of abundance of studies about resource curse, few of them use quantitative methods as a main research tool. Niftiyev [13] uses two econometric techniques: principal component analysis (PCA) and regressions, to study the resource curse doctrine in Azerbaijan. These tools are employed in order to address the complexity of the natural resource curse phenomenon with the objective of capturing the multidimensional impacts of resource wealth on institutional quality and economic performance. Principal component analysis represents a fundamental step in the analytical process, reducing the dimensionality of the data set in order to identify the key latent factors that influence Azerbaijan's economic trajectory. This approach was particularly valuable for his analysis, given the interlinking of a wide array of economic, social, and institutional variables. By isolating the most significant components, among which he recognised the *oil factor* (a component representing the state of the oil industry in the country) and *institutional quality*, Niftiyev [10] enhances the interpretability of the regression models. Furthermore, the dynamic regression analysis allows the study to account for temporal dependencies and inertia within the data, thus enabling an evaluation of the influence of historical oil revenues and institutional changes on current economic conditions. The ordinary least squares regression complements this by offering a straightforward approach to quantifying relationships between variables, thus facilitating the establishment of robust statistical correlations.

Adding to the discussion, Sharma and Pal [14] offer a multifaceted examination of the resource curse hypothesis through the utilisation of a comprehensive array of state-of-the-art heterogeneous panel cointegration techniques. The study spans 111 countries from 1996 to 2015 utilising models, such as, the Common Correlated Effects Mean Group (CCEMG), Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL), and Cross-Sectionally Augmented Distributed Lag (CS-DL). While conventional methods yielded inconclusive evidence regarding the resource curse, the CCEMG estimator offered limited support for the hypothesis in the long run. By contrast, the CS-DL and CS-

ARDL models yielded compelling evidence of the resource curse in the short term, though the long-term impacts were less pronounced. These findings underscore the temporal and methodological nuances of resource curse dynamics, indicating that resource dependence often constrains short-term economic growth, with its effects unfolding over time.

In their study, Antonakakis et al. [15] revisited the resource curse hypothesis using a Panel Vector Autoregression (PVAR) methodology, which allows for dynamic interactions among oil abundance, economic growth, and institutional quality (which corresponds with the study by Niftiyev [10]). The study spanned 76 countries over the 1980–2012 period, with categorisation by income levels, developmental stages and oil import/export status. In addressing the endogeneity issues previously identified in studies of this nature, the approach treats all variables as potentially endogenous. The study incorporated a range of measures related to oil abundance, including oil rents and oil revenue per capita, and measures of institutional quality, such as the Polity IV index. The research employed panel impulse response functions to illustrate the time dynamics of these relationships, revealing that constraints on executive power and the democratic quality of institutions significantly influence the extent to which oil wealth contributes to economic growth.

In their study, Sun and Cai [16] employed both linear regression and non-dynamic panel threshold models to analyse the relationship between resource abundance and economic growth, with a particular focus on the moderating role of financial development. The panel threshold model is of particular importance as it divides the data set into distinct regimes based on financial development levels, thus enabling the analysis of non-linear and context-specific effects. This approach demonstrates that resource wealth has a positive effect on growth in regions with low financial development, due to the resource endowment effect. However, as financial development progresses to intermediate levels, the resource curse becomes evident and limits economic growth. It is noteworthy that at elevated levels of financial sophistication, the resource curse dissipates and financial system performance begins to overshadow resource wealth as a driver of growth. By incorporating these threshold-based econometric tools, the authors [16] provided a well-contextualized understanding of how the interplay between financial systems and resource wealth shapes economic outcomes, thereby demonstrating the importance of advanced methodologies for exploring complex, non-linear economic phenomena.

He et al. [17] contribute another interesting perspective to the discourse on the resource curse by exploring its nonlinear dynamics, with a particular focus on the concept of a "curse threshold". The authors' analysis of panel data from 90 countries (1972–2011) identified an inverted U-shaped relationship between natural resource abundance and economic growth. This reveals that the resource curse only emerges once resource abundance surpasses a critical threshold. Furthermore, the authors highlighted how shifts in resource status, driven by global economic developments, can lower this threshold, increasing the likelihood of countries experiencing resource curse effects. This threshold-based perspective aligns with the methodology of Sun and Cai [16], while the findings correspond with those of Niftiyev [14].

The studies reviewed provide a multifaceted understanding of the resource curse, emphasising how methodological innovations have advanced the knowledge of this complex phenomenon. Quantitative tools, including regression models, panel VAR methods, and threshold analyses, have proved invaluable in analysing the dynamics of resource dependency. The studies by Sharma and Pal [14] and Sun and Cai [16] demonstrate the significant impact of financial systems and institutional contexts on the outcomes of resource abundance. Antonakakis et al. [15] illustrate the dynamic interdependence of oil wealth, institutional quality, and economic growth. Furthermore, the threshold analysis conducted by He et al. [17] emphasises the non-linear nature of the resource curse, indicating the conditions under which resource wealth transitions from a blessing to a burden. Niftiyev [13] contributes further insight by employing PCA and regressions, to research how resource wealth deteriorates institutional quality in Azerbaijan's oil-dependent economy. By situating his insights within a specific national context, Niftiyev provides a critical case study that reinforces the generalisable patterns identified in other studies.

Collectively, these works underscore that the resource curse is not an inevitable outcome of resource abundance; rather, it is mediated by factors, such as, governance quality, financial systems, and economic structures.

3. METHODS

Confirmatory Data Analysis (CDA) is a statistical approach that is employed for the purpose of testing predefined hypotheses and validating theoretical expectations. This method is based on a set of structured procedures, including the selection of specific statistical tests, significance thresholds, and analytical models, all of which are established prior to analysis. CDA is an inherently deductive process, whereby observed data are evaluated for alignment with theoretical predictions or experimental designs. By adhering to established protocols, CDA ensures the reproducibility and validity of results, serving as a critical component in hypothesis-driven research.

In contrast, Exploratory Data Analysis (EDA) is an inductive process used to identify patterns, trends, and relationships within a dataset. EDA is conducted without predefined hypotheses, emphasising flexibility and discovery. The approach typically involves descriptive statistics, visualisation techniques, and the identification of data characteristics such as distributions, outliers, and correlations. The key differentiating factor between these methods is the objective and methodological framework they employ. CDA aims to confirm or refute hypotheses through meticulous and structured testing, whereas EDA is a flexible process focused on comprehending and contextualising the data. Both approaches are mutually reinforcing; EDA often precedes CDA, providing the essential groundwork for the design of robust and targeted confirmatory analyses.

In the case of interest for this article, an explicit EDA is not necessary, as the research hypotheses can be posed based on the literature review and empirical observation.

The first set of hypotheses can be formulated for the case of Kazakhstan:

H_0: *There exists a disconnect between the amount of uranium being supplied by Kazakhstan to the global economy and its economic growth.*
H_A: *The amount of uranium being supplied by Kazakhstan to the global economy translates to its economic growth.*

The same set of hypotheses can be formulated for the Namibia's case:

H_0: *There exists a disconnect between the amount of uranium being supplied by Namibia to the global economy and its economic growth.*
H_A: *The amount of uranium being supplied by Namibia to the global economy translates to its economic growth.*

These hypotheses were examined by estimating OLS regressions.

3.1. Ordinary Least Squares

One of the principal methods for modelling and analysing data is linear regression. This enables the examination of the influence of one or more variables (called *independent variables*, often represented as a vector $\mathbb{X}$) on another variable (called *dependent variable*, often represented as Y). It functions by establishing a linear equation that best represents the data. It can be employed to ascertain the nature of the relationship between variables and to predict future outcomes.

In a more mathematical words, linear regression works by estimating an expected value of Y with condition on $\mathbb{X}$, written as $\mathbb{E}[Y|\mathbb{X}]$, meaning we try to calculate the average of Y knowing only that information that is stored in the vector $\mathbb{X}$. An equation comprising a single predictor variable is referred to as a simple linear regression, whereas a regression involving two or more predictor variables is designated as a multiple linear regression. The general equation for a linear regression model with n independent variables is expressed as in equations 2.1 and 2.2.:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon \tag{3.1}$$

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \tag{3.2}$$

where:

- $\hat{Y} \coloneqq \mathbb{E}[Y|\mathbb{X}]$,
- β_0 is the intercept - the predicted value of dependent variable when $\mathbb{X} = 0$,
- $\beta_1, \beta_2, \cdots, \beta_n$ are constant coefficients, indicating strength and direction of influence that the respective independent variable contributes to $\hat{Y}$,
- $X_1, X_2, \cdots, X_n \in \mathbb{X}$ are independent variables,
- $\epsilon = Y - \hat{Y}$ represents an error term

The difference between eq. 2.1. and eq. 2.2. is the presence of the error term ϵ, thanks to which we can write the exact value of Y on the left side of the equation, instead of the approximated value $\hat{Y}$.

As E.P. Box has famously written, and many researchers have later reiterated - "All models are wrong, but some are useful" [16]. Indeed, it is not feasible to construct a model that accurately represents data without any discrepancies. The objective in model construction is rather to build a model that is fit for purpose and provides the requisite information with an acceptable degree of accuracy. In order to do so, the Ordinary Least Squares (OLS) method is often employed to estimate the model's coefficients. In this method, the primary objective is to minimise the sum of squared residuals S (see eq. 2.3.):

$$S = \sum_{i=1}^{N} \left(Y_i - \hat{Y}_i\right)^2 \tag{3.3}$$

where: $Y_i, \hat{Y}_i$ are actual and predicted values of the dependent variable at time (or observation) i, respectively. In a matrix notation, S can be expressed as in the eq. 2.4.:

$$S = (\mathbb{Y} - \mathbb{X} \cdot \boldsymbol{\beta})^{\mathrm{T}} \cdot (\mathbb{Y} - \mathbb{X} \cdot \boldsymbol{\beta}) \tag{3.4}$$

where: $\mathbb{Y}$ is the vector of empirical values of the dependent variable, $\boldsymbol{\beta}$ is the vector of coefficients and the rest of the notation remains the same. To minimise S, it has to be interpreted as a function of $\boldsymbol{\beta}$. Then, $S(\boldsymbol{\beta})$ can be minimised by calculating a derivative of $S(\beta)$ with respect to $\boldsymbol{\beta}$ and setting the value to 0 (eq. 2.5):

$$\frac{\partial S(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}} = 0 \tag{3.5}$$

By solving for $\boldsymbol{\beta}$ (eq. 2.6, 2.7 and 2.8), a vector containing the model's coefficients can be obtained [19, 20]:

$$\frac{\partial S(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}} = -2 \cdot \mathbb{X}^{\mathrm{T}} \cdot (\mathbb{Y} - \mathbb{X} \cdot \boldsymbol{\beta}) = 0 \tag{3.6}$$

$$-2 \cdot \mathbb{X}^{\mathrm{T}} \cdot \mathbb{Y} = -2 \cdot \mathbb{X}^{\mathrm{T}} \cdot \mathbb{X} \cdot \boldsymbol{\beta} \tag{3.7}$$

$$\boldsymbol{\beta} = \left(\mathbb{X}^{\mathrm{T}} \cdot \mathbb{X}\right)^{-1} \cdot \mathbb{X}^{\mathrm{T}} \cdot \mathbb{Y} \tag{3.8}$$

4. RESULTS

With regard to both Namibia and Kazakhstan, uranium serves primarily as an export commodity rather than a raw material for domestic electricity generation. This is reflected in the significant export orientation of their uranium extraction industries, driven by international demand. Both countries have developed robust infrastructures to support their respective mining sectors, yet uranium's economic impact is largely confined to external trade, with minimal influence on local energy production or broader industrial applications.

In order to quantify the economic value of uranium exports, a variable representing the worth of uranium supplied by each country to the global economy was constructed. This was achieved by multiplying the market price of uranium (in the respective year) by the annual quantity mined. This metric provides a clear monetary representation of each country's contribution to the global uranium market, as detailed in Tables 1 and 2 for the period 2013 to 2021. By examining this variable, the study aimed to assess how the economic gains from uranium exports aligned or failed to align with overall GDP growth of each of the countries.

Table 1. The GDP of Kazakhstan and Namibia for the period 2013-2016

Uranium production (in milion US $)	2013	2014	2015	2016
Kazakhstan	1263	1131	910	1162
Namibia	243	159	115	122

(Source: Own calculations on data from World Nuclear Association [2] and Statista)

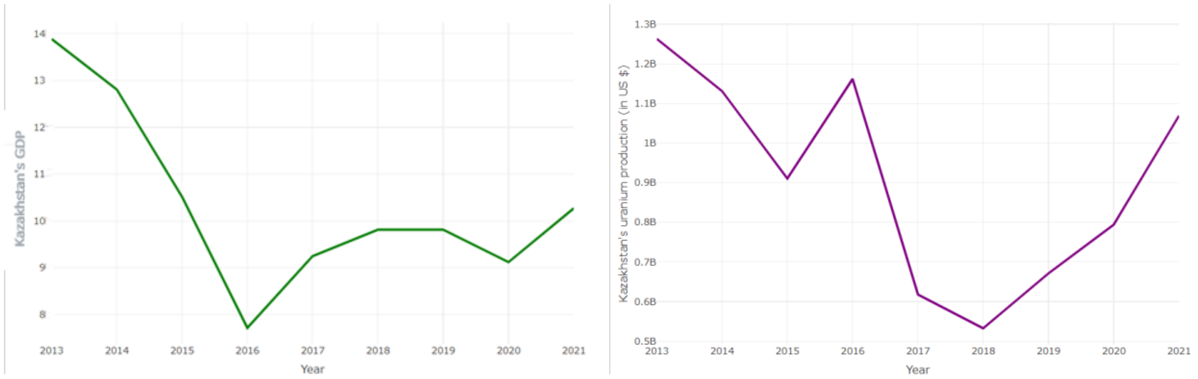
Table 2. The GDP of Kazakhstan and Namibia for the period 2017-2021

Uranium production (in milion US $)	2017	2018	2019	2020	2021
Kazakhstan	618	533	671	795	1069
Namibia	112	136	161	221	282

(Source: Own calculations on data from World Nuclear Association [2] and Statista)

4.1. Preliminary analysis of uranium production and GDP trends

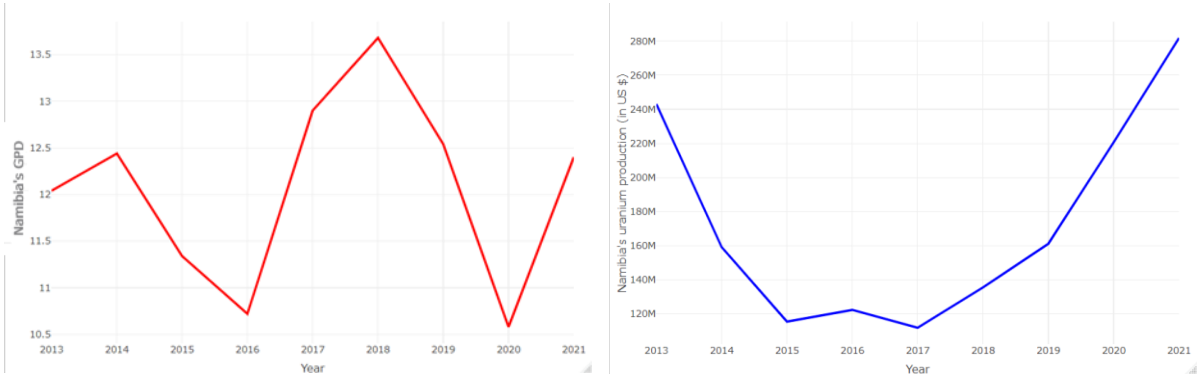
Figures 1 and 2 depict the value of uranium mined in Kazakhstan and Namibia alongside their respective GDPs. While it might be expected that these variables would exhibit parallel trends, the charts reveal that, in certain years, the relationship was notably inverse. Moreover, the overall trajectories of uranium value and GDP demonstrate a lack of clear alignment, suggesting that the economic impact of uranium mining does not straightforwardly translate into proportional changes in national economic performance.



(a) (b)

Fig. 1. The charts showing a) Kazakhstan's GDP (in ten billion US $) b) Kazakhstan's uranium production (in US $)

(Source: Own calculations in R on data from World Nuclear Association [2] and Statista)



(a) **(b)**

Fig. 2. The charts showing a) Namibia's GDP (in billion US $) b) Namibia's uranium production (in US $)

(Source: Own calculations in R on data from World Nuclear Association [2] and Statista)

The graphs presented in Fig. 2 reveal an intriguing inverse relationship. The highest GDP figures for Namibia were recorded between 2017 and 2019, with the peak being reached in 2018. However, during the same period, the value of extracted uranium reached its lowest point in 2017, reflecting a notable disparity between economic performance and resource production. Following 2017, uranium production began a steady recovery, demonstrating an upward trajectory through to 2021, while Namibia's GDP exhibited a precipitous decline after 2019. This inverse correlation indicates that the value derived from uranium production had a limited, if any, direct impact on Namibia's overall economic performance. The discrepancy between the trends highlights the disconnect between resource extraction and GDP, reinforcing the idea that resource wealth alone does not guarantee proportional economic prosperity.

Fig. 1 demonstrates a similarly inconsistent relationship. While Kazakhstan's GDP experienced a pronounced decline between 2013 and 2016, subsequently stabilising at reduced levels from 2017 to 2020, the trend in uranium production value was marked by a contrasting trajectory. It exhibited fluctuations, including a marked decline in 2016, followed by a recovery in subsequent years. By 2021, uranium production value demonstrated a significant upward trajectory, whereas GDP only began to show modest improvement. This lack of alignment between the trends suggests, as in Namibia's case, a disconnect between uranium extraction activities and their apparent contribution to the broader economy.

These initial observations are preliminary and based on visual trends. They will be further investigated through more formal testing and econometric modelling to validate these patterns and uncover the underlying dynamics influencing both countries' economic trajectory.

4.2. Econometric modelling

Following the initial observation of reverse trends in uranium production and GDP in both Kazakhstan and Namibia, it became apparent that further investigation using formal econometric models was necessary. OLS regressions were employed to analyse the relationship between the economic value of uranium production and GDP, with a particular focus on the potential impact of variations in uranium production on the economic performance of the countries under review.

In both models, the independent variable was the value of uranium supplied to the global economy by each country while the dependent variable was the country's GDP. The results are summarised in the Table 3.

Table 3. Summary of OLS models

Coefficients:				
Model.1	Estimate	std. error	t-stat.	Pr(>|t|)
(Intercept)	7.263e+03	2.242e+03	3.239	0.0143
Kazakhstan's uranium production (in US $)	3.414e-06	2.387e-06	1.430	0.1957
Model.2	Estimate	std. error	t-stat.	Pr(>|t|)
(Intercept)	1.235e+01	1.133e+00	10.899	1.21e-05
Namibia's uranium production (in US $)	-1.597e-09	6.228e-09	-0.256	0.805

(Source: Own calculations in R on data from World Nuclear Association [2] and Statista)

The t-test is a fundamental statistical tool used to determine whether an independent variable significantly contributes to explaining changes in a dependent variable. By calculating the ratio of the estimated coefficient to its standard error, the t-test evaluates the strength of the relationship between variables [19, 20, 21]. A p-value is derived from the t-test statistic, which measures the probability of observing the estimated coefficient if the true effect is zero. A p-value below the commonly accepted threshold of 0.05 indicates a statistically significant relationship, while a higher value suggests that the variable does not meaningfully influence the dependent variable [19, 20, 21, 22]. In this study, the t-test is of crucial importance in assessing whether uranium production significantly impacts GDP in Kazakhstan and Namibia. By applying this statistical method, we can obtain clear evidence to either confirm or reject the hypothesized relationship.

The results of the regressions (Tab. 3) highlight a lack of significant relationship between uranium production and GDP in Kazakhstan and Namibia. For Kazakhstan, the coefficient for uranium supply is $3.414 \cdot 10^{-6}$, with a standard error of $2.387 \cdot 10^{-6}$, t-statistic of 1.430, and a p-value of 0.1957. These results indicate that uranium production is not statistically significant in explaining changes in Kazakhstan's GDP, as the p-value corresponding to the t-test exceeds the 0.05 significance level.

Similarly, Namibia's model yields a coefficient of $-1.597 \cdot 10^{-9}$, with a standard error of $6.228 \cdot 10^{-9}$, a t-statistic of -0.256, and a p-value of 0.805. This again suggests no statistically significant relationship between uranium production and Namibia's GDP.

Furthermore, the results of both models indicate a statistically significant intercept, with a p-value of 0.0143 for Kazakhstan and $1.21 \cdot 10^{-5}$ for Namibia. This suggests that factors beyond uranium production are influencing GDP of both countries. This reinforces the argument for diversified economic policies and stronger institutional frameworks to maximise the broader economic benefits of natural resources, as suggested by the previously discussed literature [10, 11, 13, 14, 15, 16].

As detailed in the Methods section, the reported R^2 values from the regression models provide a measure of the extent to which variance in GDP can be explained by uranium supply in Kazakhstan and Namibia. In the case of Kazakhstan, the R^2 value is approximately 0.226, which indicates that 22.6% of the variation in the country's GDP can be attributed to the value of its uranium supply. This indicates a limited explanatory capacity, although it is not sufficient to assert a robust relationship between the two variables. In contrast, the model for Namibia exhibits an R^2 of just 0.009, indicating that only 0.9% of the GDP variation is explained by uranium supply. This result serves to reinforce the weak link between uranium supply and economic performance in Namibia.

Further insight can be gained from additional statistics provided by the regression output. The standard error of the estimate, which represents the average discrepancy between observed and predicted GDP values, is notably higher for Kazakhstan (approximately 1785.9) than for Namibia (approximately 1.085). This discrepancy can be attributed to the differing magnitudes and degrees of variability observed in GDP across these two countries.

Furthermore, the F-statistic for the Kazakhstan model is 2.046, with a p-value of 0.196. This indicates that the overall model is not statistically significant at the 5% level, which aligns with the earlier findings of an insignificant t-test for uranium supply. Similarly, the F-statistic for the Namibia model is 0.0658, with a p-value of 0.805, which reaffirms the minimal explanatory power of the model. These results suggest that, while there is some degree of association between uranium supply and GDP in Kazakhstan, it is weak and statistically insignificant. In Namibia, the relationship is almost negligible.

5. CONCLUSIONS AND DISCUSSION

5.1. Summary of the study

This study tested the following hypotheses for Kazakhstan and Namibia:

- Kazakhstan:

H_0: *There exists a disconnect between the amount of uranium being supplied by Kazakhstan to the global economy and its economic growth.*

H_A: *The amount of uranium being supplied by Kazakhstan to the global economy translates to its economic growth.*

- Namibia:

H_0: *There exists a disconnect between the amount of uranium being supplied by Namibia to the global economy and its economic growth.*

$\mathrm{H_A}$: *The amount of uranium being supplied by Namibia to the global economy translates to its economic growth.*

The results of the regression analyses provide substantial support for the null hypothesis (H_0) in both countries, while simultaneously refuting the alternative hypothesis (H_A). In both cases, the effect of uranium supply on GDP was not found to be statistically significant. The R^2 value for the Kazakhstan model was 0.226, indicating that only 22.6% of the variation in GDP could be explained by uranium supply. The R^2 value for Namibia's model was 0.009, indicating an almost negligible association. Moreover, the t-tests for the coefficients of uranium supply yielded p-values that exceeded the 0.05 threshold, and the F-statistics demonstrated that the incorporation of uranium supply as a variable did not markedly enhance the model's capacity to elucidate GDP fluctuations. Nevertheless, the intercepts in both models were markedly significant, indicating that additional factors, not encompassed within the models, exert a predominant influence on GDP trends.

It should be noted that the models presented in the Results section were not the only ones constructed during the research phase of this article. The researchers tested additional models, including those with lagged values and other variables related to the uranium industry. However, all of the tested models yielded similar results, and thus, the simplest one was selected for presentation and description.

5.2. Comparison to existing literature in context of the Resource curse

The results of this study are in close alignment with those of existing literature on the resource curse, which emphasises the limited capacity of natural resource wealth to directly enhance economic growth in resource-dependent countries.

The findings of studies, such as those by Sharma and Pal [14] and Cheng et al. [12], indicate that resource dependence can often act as a constraint on short-term economic growth, particularly in countries where the institutional framework is underdeveloped or where there is a lack of economic diversification. This is consistent with the current findings, which indicate that uranium supply has a negligible impact on GDP, thereby reinforcing the hypothesis that resource extraction alone does not drive economic prosperity. Furthermore, Niftiyev's research on Azerbaijan demonstrates how resource wealth can lead to a deterioration in institutional quality, a challenge that may similarly affect Kazakhstan and Namibia [13]. The importance of institutional quality in mitigating the resource curse is further underscored by multiple studies [10, 11, 15, 16]. Destek et al. [10] highlight how robust institutions can reverse the resource curse by ensuring better management of resource revenues, while Antonakakis et al. [15] and He et al. [17] explore the dynamic interactions between resource wealth, governance, and economic growth. Without strong institutional frameworks, as seen in resource-rich economies like Norway, revenues often fail to deliver equitable and sustainable growth. This lack of robust institutions may explain why Kazakhstan and Namibia have not fully leveraged their uranium wealth for broader economic benefits.

The Dutch Disease effect, where resource reliance reduces the competitiveness of other sectors like manufacturing or agriculture, may also contribute to the observed disconnect [12, 14]. Furthermore, the dynamics of the global uranium market, characterized by pricing volatility and unequal bargaining power, may limit the economic benefits for producers like Kazakhstan and Namibia [8]. Unlike exporters with advanced institutional mechanisms, both countries focus heavily on uranium as an export commodity rather than integrating it into domestic economic activities, further limiting its impact on GDP.

By contextualizing the results within the resource curse framework and existing studies, this analysis contributes to a growing body of evidence that resource dependence alone is insufficient for economic growth.

5.3. Implications of the findings

The findings of this study highlight the intricate and frequently indirect influence of uranium supply on economic growth, particularly in resource-dependent economies such as those of Kazakhstan and Namibia. Notwithstanding their considerable contributions to the global uranium market, neither country exhibits a robust statistical correlation between uranium supply and GDP. This result serves to reinforce the broader conclusion that resource wealth, when not effectively integrated into the domestic economy or supported by strong institutions, fails to directly enhance economic performance. This discrepancy is consistent with the predictions of resource curse theories, which raise important questions about the economic strategies of nations that rely on natural resources. The absence of integration of uranium revenues into diversified economic sectors indicates that both Kazakhstan and Namibia are at risk of remaining overly reliant on external demand for their primary export. In the absence of substantial domestic utilisation of uranium resources, such as for energy production or value-added processes, the broader economic impact remains constrained.

Furthermore, the lack of statistical significance of uranium supply in explaining GDP highlights inefficiencies in the management of resource revenues. This finding indicates that the resource wealth is not being effectively leveraged to stimulate broader economic growth. The consistently significant intercepts in both models indicate the presence of other unexamined factors driving GDP, such as institutional frameworks, trade policies, or investments in other sectors.

The results of the study also prompt a re-evaluation of the manner in which global market conditions influence resource-exporting nations. The uranium market's pricing dynamics, coupled with the unequal bargaining power between exporting and importing countries, likely constrains the economic returns for Kazakhstan and, even more plausibly, Namibia.

5.4. Broader contributions

This study aimed to demonstrate the value of quantitative econometric techniques in analysing resource dependence and economic performance. The application of OLS regressions enables the testing of predefined hypotheses, which is of particular value in the context of resource curse research, where findings are often contingent on the presence of nuanced, case-specific variables. Furthermore, the study contributes to the existing literature by employing straightforward yet efficacious regression techniques to investigate the dynamics of uranium-exporting economies, a subject that has been comparatively less extensively examined than oil or gas-producing nations.

As evidenced in the literature review, there is a scarcity of studies on resource curse phenomena that employ econometric models as their primary analytical tool [12]. This is exemplified by studies such as those conducted by Niftiyev [13] and Sharma and Pal [14]. By situating this study within that methodological tradition, it is demonstrated that there is a need for empirical rigour in order to unravel complex economic relationships.

Moreover, this study illustrates the value of integrating econometric analysis with theoretical insights, aligning findings with broader concepts such as the Dutch Disease, institutional inefficiency, and market dynamics. It demonstrates how statistical tools, including R^2, t-tests, and F-statistics, can be employed not only to confirm or reject hypotheses but also to contextualise results within a larger theoretical framework.

5.5. Limitations of the study

While this study offers valuable insights into the discrepancy between uranium supply and GDP in Kazakhstan and Namibia, it is important to acknowledge the limitations of the research.

A significant challenge arises from the inconsistency of data regarding uranium prices and supply. The reliability, consistency and granularity of the data are of the essence for robust econometric analysis; however, the datasets identified during the preparation phase of this study were frequently in contradiction with one another. The variability in reported figures for uranium production, coupled with the lack of standardised global uranium price indices, introduces the potential for measurement errors that could affect the precision of the regression models. These data deficiencies are particularly evident in long-term analyses, where historical records may be scarce or unreliable.

Another potential limitation of this study, stemming from data inconsistency, is the use of Statista as one of the data sources, which has been pointed out as potentially not reliable enough for scientific research. The authors acknowledge this concern; however, the availability of comprehensive datasets for uranium production and GDP trends was limited. To construct a workable dataset, data had to be patched together from multiple sources, with the World Nuclear Association and Statista providing two of the most complete datasets. While recognizing Statista’s limitations, the authors carefully validated its figures by cross-checking them against overlapping data from more established sources to ensure consistency. Furthermore, it is important to note that the primary objective of this study was not to conduct an exhaustive empirical analysis of the dependencies between uranium supply and economic performance, but rather to illustrate how linear regression can be employed as a methodological tool for studying the resource curse. Therefore, while data constraints exist, they do not undermine the study’s core contribution, which is methodological rather than purely empirical.

The additional limitation is posed by the economic complexity of developing countries such as Kazakhstan and Namibia. The economies of developing countries that are dependent on natural resources are shaped by a multitude of factors, including geopolitical influences, institutional weaknesses, and informal economic activities. These factors are challenging to quantify and incorporate into econometric models. This complexity may result in omitted variable bias, as the analysis is unable to fully account for all determinants of GDP beyond uranium supply. Furthermore, the models assume linear relationships between uranium supply and GDP, which may oversimplify the interactions within these economies.

Ultimately, the study's narrow focus on a single resource (uranium) and two countries limits the generalisability of its findings. While the results provide valuable insights for Kazakhstan and Namibia, it is imperative to exercise caution in extrapolating these conclusions to other resource-dependent economies or different types of resources.

5.6. Further directions of the studies

Future research should address a number of areas in order to enhance the findings of this study and to identify any shortcomings in the research design. Firstly, it is imperative that improvements are made to the quality and scope of the data. The discrepancies in the data pertaining to uranium prices and supplies underscore the necessity for the development of more standardised and comprehensive datasets. Enhanced data collection practices could facilitate a more nuanced understanding of production dynamics and pricing trends, thereby providing a more robust foundation for econometric analysis. Furthermore, the incorporation of regional or sub-national data could facilitate the revelation of localised effects of resource dependence, thereby offering insights that extend beyond the scope of national-level analyses. The incorporation of additional variables into future models would assist in addressing the complexities inherent to developing economies.

Adding variables, such as those pertaining to institutional quality, trade policies, foreign direct investment, and social indicators like income inequality, may prove beneficial in better capturing the multifaceted influences on GDP and resource management. A comparative analysis of resources such as oil, gas, or rare earth elements across different regions may facilitate the identification of broader patterns or exceptions to the resource curse.

From a methodological perspective, the investigation of non-linear and dynamic models may prove an effective means of enhancing understanding of the phenomenon of resource dependence. The utilisation of techniques such as panel data analysis, vector autoregression, or threshold regression models may facilitate a more comprehensive account of temporal dependencies and complex interactions, which may otherwise be overlooked in the context of simple linear models. However, it may also be valuable to employ other novel models and frameworks that have emerged in recent years as a consequence of the evolution of Data Science.

ACKNOWLEDGMENTS

No external funding was acquired for this research. The DeepL technology has been used to translate parts of the work into English.

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