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Regional Economic Divergence And Inequality In Mongolia: A Multidimensional Analysis With A Focus On The Gobi Region

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Abstract

This study aims to examine the dynamics of regional economic growth and income inequality in Mongolia over the period 2000-2024, using the theoretical framework of neoclassical economic growth. Employing a comprehensive dataset, the analysis integrates multiple econometric methods, including conditional β-convergence and σ-convergence tests, Markov transition matrices, kernel density estimation, and inequality measures such as the Gini coefficient and Theil index. The results indicate statistically significant evidence of β-convergence, suggesting that provinces with lower initial income levels tend to grow faster. However, σ-convergence, which measures the reduction in income dispersion over time, is not observed at the national level. The only region showing statistically significant σ-convergence is the Khangai region. In contrast, the Gobi region exhibits increasing intra-regional income disparities driven by structural differences in sectoral composition and resource concentration. Markov chain analysis reveals that high-income provinces, such as Umnugobi, maintain their economic dominance, while low-income provinces show limited upward mobility. Kernel density plots reveal a shift from an unimodal to a bimodal distribution, indicating the emergence of a dual economy. The steady rise in the Gini and Theil indices further confirms the deepening inequality, particularly linked to the expansion of the mining sector and disparities in infrastructure and institutional capacity. The findings underscore the need for a more balanced regional development strategy that focuses on diversifying the economic base, improving access to infrastructure and social services, and strengthening institutional effectiveness. Without such measures, regional disparities may continue to widen, undermining the long-term sustainability of inclusive economic growth in Mongolia.

Keywords: *Mongolia, regional inequality, economic convergence, Gobi region, convergence, Markov matrix, kernel density estimation, Gini coefficient, Theil index, regional policy*

1. INTRODUCTION

Regional disparities in development have become a significant challenge in many countries, particularly in the developing world. Economic growth is distributed unevenly across regions, resulting in growing gaps in income, infrastructure, employment, and industrial concentration. While neoclassical growth theory (Solow, 1956; Barro & Sala-i-Martin, 1992) suggests that regional income levels converge over time, empirical evidence often shows divergence due to structural, institutional, and locational differences.

In Mongolia, despite steady growth in real GDP per Capita over the past 25 years, regional disparities have intensified. For example, the Gobi region, which benefits from mining and external market access, recorded an average growth rate of 7.3%. In contrast, the Eastern and Western regions lagged with rates of around 2-4%. Mining-intensive provinces, such as Umnugobi and Dornogovi, have achieved higher income levels, while remote provinces like Zavkhan and Sükhbaatar remain in the lower-income group. In 2022, the Government of Mongolia restructured its regional policy framework into seven regions, each with defined priorities to support balanced development through spatial planning involving logistics, population distribution, resources, and industrialization. This study examines regional economic divergence and development dynamics in Mongolia between 2000 and 2024, utilizing real per capita GDP data from all 21 provinces. It applies to a range of quantitative methods, including β- and σ-convergence, Markov transition matrices, kernel density estimation, Gini and Theil indices, change-

point detection, and time-series clustering. Results show that disparities are evident not only in income levels but also in growth volatility and structural shifts. Mining-dependent regions exhibit sharp but unstable growth, whereas remote regions persist in underdevelopment. These findings underscore the need for data-driven policy strategies tailored to regional characteristics, ensuring inclusive and sustainable economic development.

2. LITERATURE REVIEW

The study of regional economic disparities has evolved into a significant strand within the broader theory of economic growth. Its theoretical foundation is rooted in the neoclassical growth model (Solow, 1956), which, based on capital accumulation and diminishing returns, posits that low-income regions grow faster and eventually converge with high-income regions in the long run, a concept known as the convergence hypothesis.

Barro and Sala-i-Martin (1992) further developed the concepts of absolute and conditional convergence. While absolute convergence assumes that all regions will converge to the same income level regardless of their characteristics, conditional convergence accounts for structural and institutional differences across regions, offering a more realistic model. Numerous empirical studies using panel data have tested these hypotheses, with many confirming the prevalence of conditional convergence (Islam, 1995; Durlauf et al., 2005).

To assess regional inequality, scholars have applied various quantitative methods, including σ-convergence (Xala-i-Martin, 1996), kernel density estimation, the Gini coefficient, Theil index, Markov transition matrices, cluster analysis, and change-point detection. For example, Rey (2001) and Ezcurra (2007) examined income distribution, polarization, and mobility across European and Latin American regions. Their findings highlighted the importance of institutional quality, access to social services, and transportation infrastructure as key drivers of regional economic instability.

In recent years, regional economic inequality and convergence have received growing attention from international scholars. New research emphasizes that regional disparities extend beyond income and are deeply influenced by institutional capacity, infrastructure, human capital, urbanization, and innovation. For instance, Rodríguez-Pose and Ketterer (2023) identified institutional quality as a key determinant of regional growth in Europe, while Ezcurra (2021) found similar patterns in Latin America. Dijkstra et al. (2022) emphasized the roles of infrastructure and education in convergence processes, while Puga (2020) and Gennaioli et al. (2021) underscored the positive effects of agglomeration, urbanization, and innovation on sustained growth. Barro and Sala-i-Martin (2022) recently expanded their theoretical framework of conditional convergence, and Chetty et al. (2023) linked income inequality in U.S. cities to education and housing accessibility.

Major international organizations have also conducted in-depth regional analyses. Reports by the OECD (2024), World Bank (2025), and UNDP (2023) have provided policy diagnostics and strategic recommendations on regional development in emerging economies, focusing on convergence dynamics, institutional stability, and human capital development. In Mongolia, empirical studies on regional disparities remain limited. For instance, Amgalanbaatar (2020) assessed provincial economic convergence using panel data, while Ganbold (2018) analyzed regional GDP and income inequality. However, these studies did not fully address external shocks, institutional variables, or dynamic changes in income and growth patterns.

Thus, the theoretical foundation of this study draws upon neoclassical growth theory, conditional convergence models, and dynamic inequality analysis. It emphasizes spatial and institutional heterogeneity through multidimensional economic diagnostics. By applying these frameworks to real regional data in Mongolia, the study aims to identify development disparities and inform region-specific policy needs, offering both theoretical contribution and practical relevance.

3. METHODOLOGY

This study employs a multidimensional quantitative analysis to assess regional economic disparities, inequality, and development dynamics in Mongolia from 2000 to 2024. The analysis is based on real per capita GDP data for all 21 provinces and Ulaanbaatar city. The theoretical foundation lies in the neoclassical growth model, which postulates that regions tend to converge in income levels over time. Within this framework, the study examines whether regional convergence has occurred, employing both β- and σ-convergence methods.

To test conditional β-convergence, panel data regression models, including Pooled OLS, Fixed Effects, Random Effects, and Time Effects, were employed to estimate the relationship between initial income levels and subsequent growth. Standard statistical tests, such as the Hausman and F-tests, guided model selection. For σ-convergence, we computed the annual standard deviation of real per capita GDP to capture the evolution of income dispersion and regional income stability over time. To further explore the dynamics of regional income distribution, the following methods were employed:

Markov Transition Matrix: Used to evaluate the probability of income class transitions across provinces, providing insights into the persistence and mobility of regional development.

Kernel Density Estimation: Visualizes the shape and shifts in income distribution over time, including signs of polarization and income concentration.

Inequality Measures: We estimated the Gini coefficient and Theil index to quantify regional income inequality and track its changes over time.

Additionally, change-point detection was conducted to identify periods of abrupt growth shifts (defined as growth > +15% or < –15%) and to assess the impact of major external and internal shocks such as the 2009 global financial crisis and the 2020 COVID-19 pandemic on regional economic performance and vulnerability. All data processing and analysis were conducted using Python and Microsoft Excel. The real per capita GDP data were obtained from the official database of the National Statistics Office of Mongolia (www.1212.mn).

4. RESULTS

From 2001 to 2024, real GDP per Capita in the Gobi region grew unevenly, resulting in widening intra-regional disparities. Umnugobi Province experienced exceptional growth, increasing from MNT 1,929 to MNT 25,020 (13-fold), primarily driven by mining expansion, especially in 2022–2023. In contrast, Dornogovi and Dundgovi saw moderate increases of 2.2 and 2.4 times, respectively, with Dundgovi showing signs of stagnation after 2020. Gobisumber recorded the weakest growth (1.6 times), with a declining trend in recent years. While income levels across the Gobi provinces were relatively uniform in the early 2000s, disparities have sharply increased since 2020. Umnugobi now dominates regional growth, highlighting the need for more balanced development strategies within the region.

Table 1. Real GDP per Capita in Gobi Region Provinces (2001–2024)

Province	2001 (MNT)	2024 (MNT)	Change	Key Characteristics
Gobisumber	2,469	3,982	1.6x	Slow growth; declining trend in recent years
Dornogovi	1,822	4,070	2.2x	Stable growth; supported by logistics infrastructure
Dundgovi	1,798	4,276	2.4x	Moderate growth; signs of decline since 2020
Umnugobi	1,929	25,020	13x	Sharp growth; mining-driven; highest income level

4.1. Conditional β-convergence analysis

This study applies to a conditional β-convergence model based on neoclassical growth theory, which posits that regions with lower initial income levels tend to grow faster, converging over time. However, due to structural, institutional, and locational differences across provinces, a conditional rather than

absolute convergence framework is more appropriate. The analysis uses the following panel regression specification:

$$\log\left(\frac{y_{i,t}}{y_{i,t-1}}\right) = \alpha + \beta \mathrm{Log}(y_{i,t-1}) + \gamma X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \qquad (1)$$

Here, y_i,t is the real GDP per Capita; X_i,t includes conditioning variables such as population growth and HDI; μ_i and λ_t account for individual and time-specific effects, respectively. Model selection was based on Hausman and F-tests to ensure robustness. The fixed effects model provided a better fit by controlling for unobserved heterogeneity relevant to regional development.

Table 2. Estimation Results of Conditional β-Convergence

Variable	All Regions				Gobi Region			
	Time effect		Time & indvidual		Time effect		Time & indvidual	
	coefficient	t-stat	coefficient	t-stat	coefficient	t-stat	coefficient	t-stat
Constant	0.583***	3.498	1.570***	5.635	0.739	1.281	1.482*	1.898
$\mathrm{Log}(y_{i,t-1})$	-0.347***	-13.79	-0.521***	-16.05	-0.517***	-5.803	-0.523***	-5.677
Population Growth	0.869***	2.695	0.700**	2.169			-0.779**	-2.236
Gov. Expenditure/GDP	-0.663*	-4.165	-0.711***	-4.109				
Public Debt/GDP	-0.136***	-5.25	-0.230***	-5.829	-0.096***	-2.474	-0.112**	-1.887
Students per School	0.069*	1.853	0.340***	4.428				
Human Development Index	3.211***	9.887	3.703***	9.195	5.330***	6.008	4.296***	4.192
Industrial Output per Capita	0.003***	6.530	0.003***	7.166	0.003***	3.604	0.003***	3.997
Livestock per Capita	0.003***	6.016	0.003***	3.492				
Rail Connection (Dummy)	0.057***	2.652						
Population Density			-0.002***	-3.676				
Urbanization Rate					-0.340***	-2.78		
R-squared	0.477757		0.585798		0.65816		0.703409	
S.E. of regression	0.128703		0.117131		0.134806		0.128476	
F-statistic	14.15108***		12.6485***		4.607074***		4.896295***	

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

To identify the key determinants of real GDP per Capita, this study employed panel data regression using Pooled OLS, Fixed Effects (FE), and Random Effects (RE) models. The results were based on

statistical significance and model fit. The Pooled OLS model, which ignores individual heterogeneity, showed low explanatory power (R^2) and statistically insignificant coefficients, indicating limited suitability for this context. The Fixed Effects model outperformed the others, with higher R^2 and statistically significant coefficients for most explanatory variables. The F-test confirmed the presence of province-specific fixed effects ($p < 0.05$). Key drivers of income growth were associated with structural and developmental differences, particularly mining-related variables, which had a substantial positive impact in Umnugobi province. These findings suggest that natural resource exploitation contributes significantly to intra-regional income divergence in the Gobi region. Although the RE model showed a moderate fit in some specifications, both the Breusch–Pagan Lagrange multiplier (LM) test and the Hausman test ($p < 0.05$) rejected the RE assumption, validating the preference for the FE model. Overall, the Fixed Effects model was found to be the most appropriate, effectively controlling unobserved heterogeneity across provinces. The findings underscore the growing disparities in regional development and highlight the importance of structural transformation and policy support in shaping income dynamics.

4.2. σ convergence analysis

Within the neoclassical growth framework, σ-convergence examines whether income disparities across regions decline over time. It focuses on the dispersion of per capita income typically measured by the standard deviation, coefficient of variation, or Gini index. The core idea, as proposed by Barro and Sala-i-Martin (1992), is that if regions are converging economically, the dispersion of income levels should decrease over time. The standard deviation of the log of real GDP per Capita is calculated as follows:

$$\sigma_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N} \left(\log\left(y_{i,t}\right) - \mu_t\right)^2}$$

Where $y_{i,t}$ denotes the real GDP per capita of region i at time t, μ_t is the average log-income across all regions at time t, and N is the number of observations.

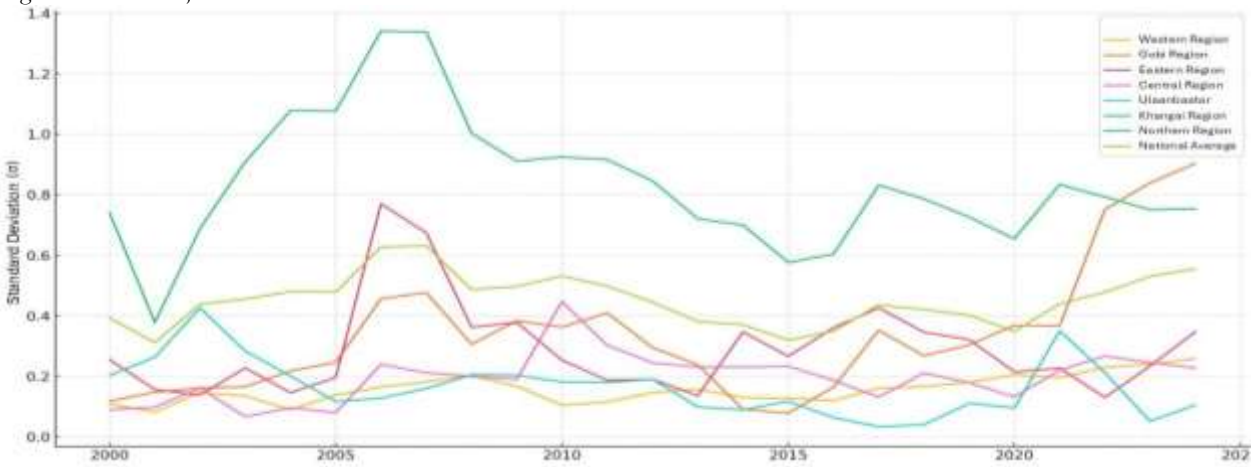


Figure 1. σ-Convergence of Regional Real GDP per Capita, 2000–2024

An analysis of σ-convergence based on real GDP per Capita reveals notable regional disparities and uneven development trajectories. At the national level, the standard deviation exhibited a slight downward trend, but the change was not statistically significant, indicating no firm evidence of σ-convergence across Mongolia. At the regional level, only the Khangai region showed a statistically significant decline in income dispersion ($p = 0.014$), suggesting internal convergence and more balanced development. It may reflect effective policy alignment with natural and geographic conditions, sustainable resource use, and support for traditional livelihoods. Conversely, the Gobi, Western, and

Central regions exhibited increasing dispersion, with the Gobi region displaying a particularly sharp upward trend in σ, indicating a deepening of intra-regional inequality. In this context, policy interventions such as establishing a resource stabilization fund, promoting value-added agriculture and industry, and improving transport and logistics infrastructure are warranted. For the Western region, enhancing market access, border trade, tourism, and local processing of animal products is essential. In contrast, the Eastern and Northern regions showed no significant σ trend, suggesting persistent inequality. These areas would benefit from investments in light agro-industry, education, healthcare access, and broader regional economic integration.

Table. Results of σ (Sigma) Convergence Analysis

Region	slope	t-Statistic	p-value	R^2
Western	0.004359	4.678775***	0.000104	0.487647
Gobi	0.017234	3.454137***	0.002156	0.34156
Eastern	-0.00054	-0.12132	0.904493	0.000639
Central	0.004377	2.038663*	0.053139	0.153046
Khangai	-0.00628	-2.65578**	0.014124	0.234689
Northern	-0.00794	-1.33806	0.193957	0.072221
National Avg.	-0.00056	-0.23228	0.818376	0.00234

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.
The σ-convergence results show that regional income disparities in Mongolia persist and are widening in some areas, notably the Gobi region. It highlights the need for integrated development policies that combine infrastructure, human capital, and institutional reforms to reduce inequality.

4.3. Markov Transition Matrix

To assess income mobility and regional development stability over time, a Markov transition matrix was constructed based on real GDP per Capita classifications. This method estimates the probability of provinces shifting between income categories across periods, providing insights into persistence, upward mobility, or potential divergence within and across regions

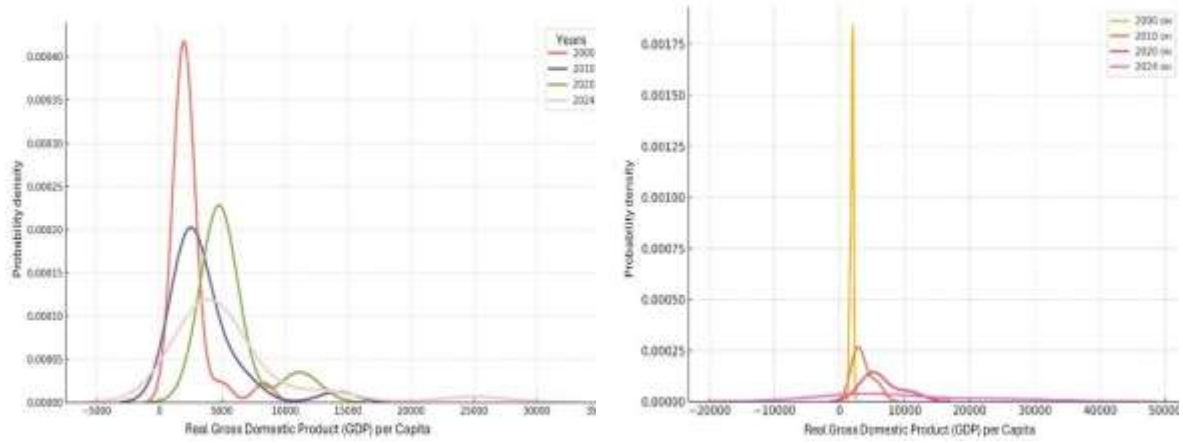
Figure. Markov Transition Heatmap for the Gobi Region

Markov transition analysis shows that income mobility within the Gobi region has declined over time. During 2000-2009, economic transitions were more dynamic: Umnugobi rapidly advanced to high-income status due to mining growth, while Dornogovi showed moderate gains from trade and logistics. Dundgovi remained low-income due to structural constraints, and Gobisumber exhibited volatility linked to its small economic base. In 2010-2019, mobility decreased. Umnugobi sustained its high-income position, while other provinces experienced modest, less stable improvements. Disparities remained evident. By 2020-2024, income levels across provinces stabilized. Umnugobi retained its lead;

Dornogovi held a mid-to-high income status; Dundgovi and Gobisumber showed minimal change. Overall, intra-regional inequality slightly eased, though structural imbalances persisted.

4.4. Kernel Density Estimation (KDE)

Kernel density estimation of real GDP per capita from 2000 to 2024 reveals evolving patterns of regional inequality. In 2000, the distribution was unimodal, concentrated, and symmetric, suggesting limited income disparity, with most provinces clustered at low-income levels. By 2010, the distribution widened, indicating early divergence as some provinces began transitioning to higher income tiers. In 2020, the distribution became bimodal, reflecting the emergence of a dual economy driven by rapid mining-led growth in provinces like Umnugobi, while others remained stagnant. By 2024, the distribution returned to a stretched unimodal form with a long right tail, showing rising inequality as a few provinces concentrated most economic gains.



National Gobi Region

Figure. Kernel Density of Real GDP per Capita Across Provinces (2000–2024)

In the Gobi region, income distribution was initially narrow and uniform but progressively widened over time. Umnugobi emerged as a high-income outlier due to mining, while provinces such as Dundgovi and Gobisumber remained in lower-income clusters. These shifts indicate increasing intra-regional polarization, underscoring the need for more balanced development strategies.

4.5. Gini Coefficient and Theil Index

Analysis of the Gini coefficient shows that income inequality in the Gobi region remained relatively low and volatile between 2000 and 2008 but has exhibited a consistent upward trend since 2009.

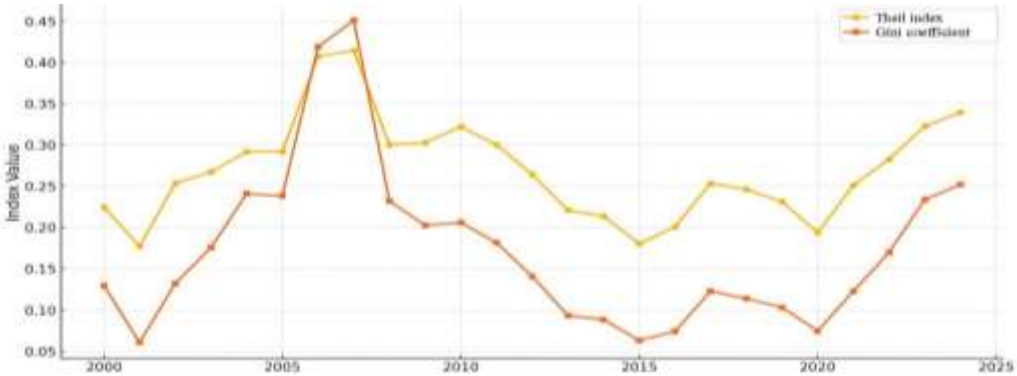
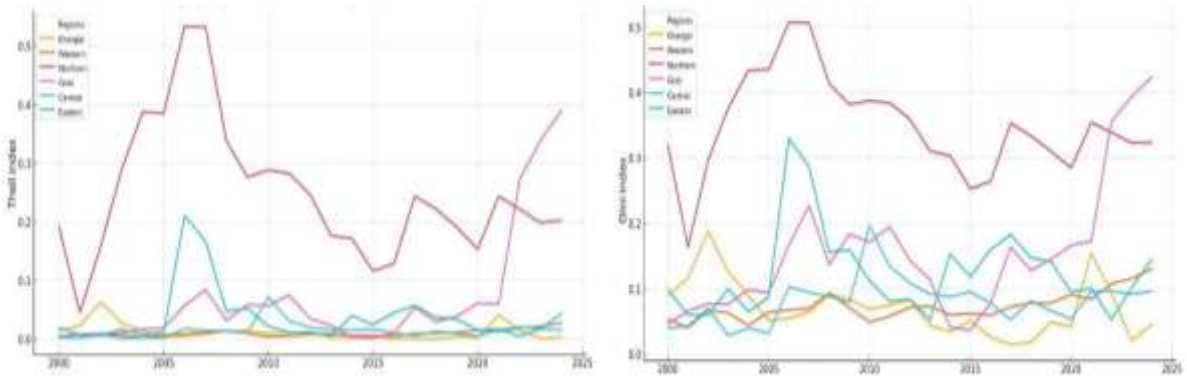


Figure. Income Inequality Indices (Gini and Theil) for Gobi Region Provinces, 2000–2024

This rise coincides with the post-2008 mining boom and concentrated investment, particularly benefiting provinces like Umnugobi and Dornogovi, which have since emerged as high-income leaders in the region.



Theil index Gini index

Figure. Trends in Regional Inequality Indices (Gini and Theil), 2000–2024

The Theil index also shows a marked increase from 2005 onward, with particularly steep growth between 2010 and 2020. It suggests intensifying inequality not only between provinces but also within them. The divergence may be attributed to uneven development between urban centers and remote rural areas, with certain aimags such as Uvs, Zavkhan, and Khuvsgul experiencing internal disparities due to limited access to infrastructure and services in their more peripheral soums. Moreover, both the Gini and Theil indices peaked after 2020, reflecting the economic volatility and heightened regional vulnerability associated with the COVID-19 pandemic.

4. CONCLUSION

This study analyzed the dynamics of regional economic growth and inequality in Mongolia from 2000 to 2024, grounded in the neoclassical growth framework, with a focused case on the Gobi region. The results show evidence of conditional β-convergence, indicating that lower-income provinces tended to grow faster. However, σ-convergence was not observed at the national or regional level, suggesting persistent and widening disparities, particularly within the Gobi region, driven by structural, locational, and sectoral differences.

The Markov transition analysis revealed that high-income provinces, such as Umnugobi, maintained their positions, while low-income provinces showed limited upward mobility, reflecting a dual economic structure. The kernel density analysis demonstrated a shift from unimodal to bimodal income distributions, supporting the emergence of internal divergence. The consistent rise in the Gini coefficient and Theil index further confirms the growing inequality, which is linked to mining concentration, infrastructure gaps, and institutional disparities.

Within the Gobi region, Umnugobi emerged as the dominant province due to mining-driven growth, while Dornogovi showed stable improvement through logistics development. In contrast, Dundgovi and Gobisumber experienced slower growth due to limited diversification and weaker structural foundations. The findings highlight that regional inequality is shaped not only by income differences but also by deeper variations in economic structure, institutional capacity, and access to infrastructure and services.

To address these challenges, regional development policies should reduce overdependence on mining, promote economic diversification, and improve access to education, healthcare, and infrastructure. Strengthening local institutions and establishing data-driven monitoring systems are also critical to identifying and addressing disparities early. Such integrated efforts are essential for ensuring that the benefits of Mongolia's economic growth are more equitably and sustainably distributed across regions.

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APPENDIX

Appendix 1. Description of Variables Used in the Study

No.	Abbreviation	Variable Name	Description
1	PRGDP	Real GDP per Capita	Core indicator of income level and a primary measure of regional development.

2	POPG	Population Growth	Growth in working-age population, influencing economic dependency.
3	LFPR	Labor Force Participation Rate	Proportion of economically active population; reflects development efficiency.
4	GEGDP	Government Expenditure to GDP Ratio	Indicates public service accessibility and government support for development.
5	DTGDP	Public Debt to GDP Ratio	Reflects financial burden and debt sustainability.
6	TEMP	Average Temperature	Climatic condition affecting livelihoods and productivity.
7	SPSCH	Students per School (per 1,000)	Indicator of educational accessibility and human capital quality.
8	HDO	Human Development Index (HDI)	Proxy for institutional capacity and inequality.
9	URBR	Urbanization Rate (provincial center/total)	Reflects infrastructure and service concentration.
10	ISPC	Industrial Output per Capita (mln MNT)	Indicator of industrialization and manufacturing concentration.
11	LSPC	Local Budget Support per Capita (ths MNT)	Measures fiscal support from the central government for regional development.
12	PLS	Livestock per Capita (in sheep unit)	Reflects rural livelihoods and economic dependence on agriculture.
13	RAILC	Rail Connection (Yes/No)	Indicates logistical connectivity and regional accessibility.
14	POPD	Population Density (per km^2)	Reflects spatial distribution and intensity of economic activity.