Sosyoekonomi

2026, Vol. 34(68), 451-473

RESEARCH ARTICLE

ISSN: 1305-5577
DOI: 10.17233/sosyoekonomi.2026.02.19
Date Submitted: 24.04.2025
Date Revised: 16.06.2025
Date Accepted: 09.04.2026

Beyond GDP: The Impact of Economic and Social Indicators on Regional Human Development in Türkiye

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GSYİH'nın Ötesinde: Ekonomik ve Sosyal Göstergelerin Türkiye'de Bölgesel İnsanî Gelişmeye Etkisi

Abstract

This study investigates the relationship between human development and key economic indicators, per capita GDP, unemployment rate, trade volume, and income inequality, using annual data from 12 Turkish regions between 2013 and 2023. Employing PDOLS and Panel VAR Granger Causality Test, the findings reveal significant short- and long-term links. While GDP positively influences human development, unemployment negatively affects it, and trade volume positively affects it. No significant direct relationship was found between income inequality and human development. The results emphasise that sustainable human development requires economic growth and inclusive policies for health, education, and social welfare.

Keywords : Human Development Index, Regional Disparities, Economic Growth, Income Inequality, Unemployment Rate.

JEL Classification Codes : O15, E24, F14, I31.

Öz

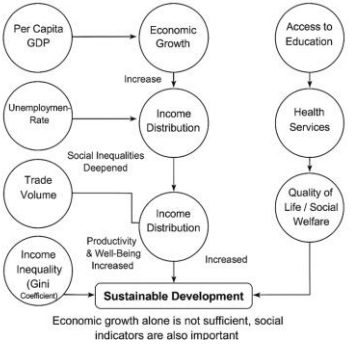
Bu çalışma, 2013-2023 yılları arasında Türkiye'nin 12 bölgesine ait yıllık veriler kullanılarak, insan gelişimi ile kişi başına düşen GSYİH, işsizlik oranı, ticaret hacmi ve gelir eşitsizliği gibi temel ekonomik göstergeler arasındaki ilişkiyi incelemektedir. Panel Dinamik En Küçük Kareler (PDOLS) ve Panel VAR Granger Nedensellik Testi yöntemleri uygulanmıştır. Bulgular, insan gelişimi ile ekonomik göstergeler arasında kısa ve uzun vadeli anlamlı ilişkiler olduğunu göstermektedir. Kişi başına düşen GSYİH insan gelişimini olumlu yönde etkilerken, işsizlik oranı olumsuz etkilemektedir; ticaret hacmi ise destekleyici bir etki sunmaktadır. Gelir eşitsizliği ile insan gelişimi arasında doğrudan anlamlı bir ilişki tespit edilmemiştir. Sonuçlar, sürdürülebilir insan gelişiminin yalnızca ekonomik büyüme ile değil, aynı zamanda kapsayıcı sağlık, eğitim ve sosyal refah politikalarıyla da mümkün olduğunu vurgulamaktadır.

Anahtar Sözcükler : İnsani Gelişme Endeksi, Bölgesel Eşitsizlikler, Ekonomik Büyüme, Gelir Eşitsizliği, İşsizlik Oranı.

1. Introduction

After World War II, development was long associated solely with economic growth, with social progress overlooked and the process defined by increases in income and production. This approach treated Gross Domestic Product (GDP) growth as the primary measure of a country's level of development, while social indicators such as individuals' quality of life, access to education, and healthcare services were relegated to a secondary position. However, over the past thirty years, criticisms of GDP as an insufficient measure of development have increased, and the view that social indicators such as health, education, and living standards significantly contribute to development has gained widespread acceptance in academic circles. Accordingly, the concept of human development, which places individuals at the centre of economic development, has come to the forefront, emphasising that development is closely linked not only to income growth but also to improvements in individuals' living standards (Taner et al., 2011: 55).

Graphics: 1
Multidimensional Interaction Model



Within this new paradigm, it is argued that evaluating development solely through an economic growth-oriented lens is inadequate; human development should be considered alongside economic indicators and factors that enhance individuals' quality of life. Human development is a multidimensional concept that aims to expand individuals' economic, social, and political opportunities. In this context, elements such as education, health, and quality of life are among the key determinants of human development. However, while investment in human capital may lead to measurable progress, it does not directly shape income distribution. In societies, healthy and educated individuals contribute to economic growth by increasing productivity and participating in the labour force (Bolat & Çilan, 2007: 224). However, the critical issue here is the extent to which economic growth translates into improvements in individuals' well-being. If income growth is not equitably distributed across society, economic growth may deepen social inequalities and negatively impact human development.

At this point, it is evident that economic and human development take different approaches, particularly in developing economies. Economic development is defined by growth in per capita national income, emphasising income and consumption, while the human development approach places individuals at the centre of development, arguing that income growth alone is not sufficient. Although higher income levels contribute to individuals' ability to improve their living conditions and achieve their goals, development must be examined holistically. Thus, while income growth is an important factor in development, it cannot be considered a sufficient criterion on its own (Anand & Sen, 1994: 13).

The extent to which income growth translates into societal welfare depends on factors such as income inequality and labour market conditions. Çalışkan (2010) emphasised the importance of the Gini coefficient in understanding the impact of economic growth on individuals' well-being, highlighting how income inequality shapes long-run development. Therefore, for economic growth to be sustainable and inclusive, attention must be given not only to income growth but also to the effectiveness of social policies.

Additionally, Arodoye & Iyoha (2014: 122-124) examined the impact of trade expansion on economic development, demonstrating that increased trade volume directly influences not only economic growth but also employment levels. The expansion of trade promotes growth in production and consumption, thereby increasing economic activity. However, the effects of trade expansion on income distribution vary across countries, depending on their economic structures and the development policies they implement.

In this context, this study analyses the interaction between economic growth and human development by examining the relationship between the Human Development Index (HDI) and economic and social indicators, including the Gini coefficient, unemployment rate, GDP, and trade volume, across Türkiye's 12 NUTS-1 regions between 2013 and 2023. The study highlights the role of social indicators in the development process alongside economic growth, within the framework of sustainable development.

In conclusion, this study aims to comprehensively examine the relationship between regional and human development in Türkiye, addressing a gap in the literature on regional-level comparative analyses. Investigating the dynamics among HDI, the Gini coefficient, the unemployment rate, GDP, and trade volume yields empirical findings that inform regional development policies. The study's results demonstrate that growth-oriented development approaches alone are insufficient, emphasising the need to integrate the human development perspective more effectively into policy design processes.

2. Human Development and Regional Disparities in Türkiye

Since 1990, Türkiye has been included in the Human Development Reports (HDR) and related indices (Akçiçek, 2015: 4). The 1996 report was the first to calculate the Human Development Index (HDI) values for Turkish provinces, and subsequent years saw a

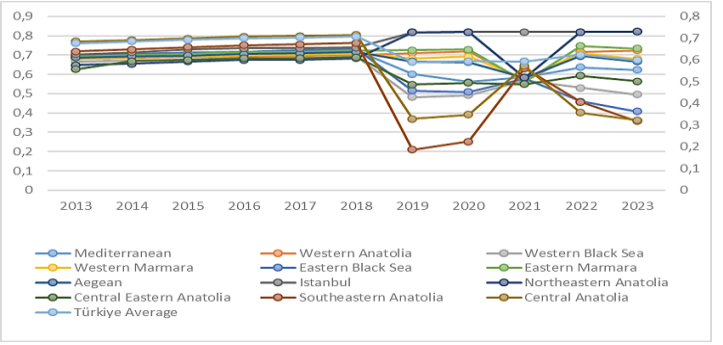
continuation of this effort. However, national reports were not published in 2000, 2002, and 2003. Consequently, HDI calculations for these years were not conducted (Tüylüoğlu & Karali, 2006: 68). Since its first inclusion in the HDR, Türkiye has been classified among countries with medium human development and has shown significant progress in HDI rankings over the years. For instance, in 2013, Türkiye ranked 69th among 187 countries and regions, and by the 2023-2024 Human Development Report, it had risen to 45th place among 193 countries. Despite this positive development, an analytical examination of the HDI's variables reveals that the relationship between economic growth and human development does not fully overlap. The disparity between Türkiye's economic growth performance and improvements in individual well-being underscores the need to analyse human development at the regional level.

Particularly when considering regional development disparities and income inequalities, it becomes evident that HDI is not distributed homogeneously across Türkiye. While some regions enjoy a more advantageous position in terms of development, others remain relatively underdeveloped. This situation indicates that economic growth does not translate evenly across all regions and that regional inequalities in human development persist. Therefore, analysing human development not only at the national level but also at the regional level is becoming increasingly important (Şeker et al., 2020: 17).

To address these inequalities, various development programs have been implemented and regional development projects launched. Within this framework, the Southeastern Anatolia Project (GAP), supported by the United Nations Development Programme (UNDP), has emerged as one of the most significant initiatives to ensure sustainable human development and expand economic opportunities in disadvantaged regions. The GAP project has particularly focused on social development goals, such as increasing girls' access to education and creating income-generating opportunities. Similarly, the 1997 National Human Development Report emphasised the relationship between sustainable development and social cohesion, highlighting the state's role in promoting development. The report advocated for targeted social programs to combat poverty. It underscored the need to support vulnerable groups, particularly those residing in Eastern and Southeastern Anatolia, including people with low incomes, women, youth, and older people. However, despite the continuation of such initiatives, regional development disparities and income inequalities remain critical issues in Türkiye (Tesev, 1998: 13).

Figure 1 illustrates the regional human development values in Türkiye, comparing HDI values in the Mediterranean, Western Marmara, Aegean, Central Anatolia, Western Anatolia, Eastern Black Sea, Istanbul, Southeastern Anatolia, Western Black Sea, Eastern Marmara, and Northeastern Anatolia regions with the national average during the period 2013-2023.

Figure: 1
Human Development Index by Regions in Türkiye (2013-2023)



During the 2013-2018 period, HDI values increased steadily across all regions. The Istanbul region consistently maintained the highest HDI values, distinctly diverging from other regions. However, after 2018, a sharp decline was observed across all regions, with Southeastern Anatolia and Central Anatolia being the most affected.

HDI is directly related to economic indicators such as the Gini coefficient, unemployment rate, GDP, and trade volume. Income inequalities can negatively impact human development by restricting individuals' access to healthcare and education services (Çalışkan, 2010: 103). Similarly, unemployment can exacerbate social opportunity disparities in regions with low human development. However, the relationship between unemployment and HDI varies across regions, depending on specific economic and social structures. The expansion of trade can promote local development; however, Arodoye & Iyoha (2014) emphasise that trade activities should not be limited solely to major cities.

A comprehensive analysis considering all these factors reveals that regional development is shaped not only by economic indicators but also by social factors. Therefore, regional development policies should incorporate social development processes alongside economic growth. While designing policies to reduce regional disparities, the unique economic and social dynamics of each region should be considered, and localised solutions should be developed accordingly.

3. Materials and Methods

This study employs quantitative data analysis methods. The study uses secondary data from the Turkish Statistical Institute (TÜİK) for the period 2013-2023. The dependent variable in the research is the Human Development Index (HDI), calculated by the author.

In this study, the Human Development Index (HDI) was computed by the author using the United Nations Development Programme (UNDP) methodology, with adjustments

for regional data availability in Türkiye. The HDI was calculated as a composite index consisting of three main dimensions:

- Health Dimension: Represented by life expectancy at birth. Regional life expectancy data were obtained from the Turkish Ministry of Health and national demographic statistics.
- Education Dimension: Represented by two indicators: mean years of schooling and expected years of schooling, sourced from the Ministry of National Education and regional education statistics provided by TÜİK.
- Income Dimension: Represented by per capita Gross Domestic Product (GDP) in Turkish Lira, adjusted to constant prices and transformed using the natural logarithm to reduce skewness and capture diminishing marginal returns of income on well-being.

To make the indicators comparable and combine them into a single index, each component was normalised using the min-max normalisation method, as follows:

$$Index_{ij} = \frac{X_{ij} - min(X_j)}{max(X_j) - \min(X_j)}$$

where Xij is the value of dimension j for region i, and the min/max values are derived from the observed dataset across all regions and years.

After normalisation, the geometric mean of the three-dimensional indices was calculated to obtain the HDI:

$$HDI_{\text{i}} = (Health_i \times Education_i \times Income_i)^{\frac{1}{3}}$$

This method ensures that no single component dominates the final index and allows for interaction among the dimensions. The use of the geometric mean also reflects the idea that high values cannot fully compensate for a low value in one dimension, even in others. The computed HDI values range between 0 and 1 and were calculated annually for each of the 12 NUTS-1 regions in Türkiye over the 2013-2023 period.

The independent variables are the Gini coefficient, unemployment rate, trade volume, and Gross Domestic Product (GDP). The scope of the study includes the Nomenclature of Territorial Units for Statistics (NUTS) Level 1 regions in Türkiye. These regions are as follows: Istanbul, Western Marmara, Aegean, Eastern Marmara, Western Anatolia, Mediterranean, Central Anatolia, Western Black Sea, Eastern Black Sea, Northeastern Anatolia, Central Eastern Anatolia, and Southeastern Anatolia.

In this study, the unit of analysis is the NUTS-1 level, as defined by the Turkish Statistical Institute (TÜİK), comprising 12 main regions. This selection is based on the fact that NUTS-1 regions represent the most comprehensive, consistent, and long-term data availability among the statistical classification levels in Türkiye. As part of the European

Union's harmonised statistical system, the NUTS-1 level enables macro-level regional planning, facilitates monitoring of development policies, and enables comparative analyses of economic and social indicators across regions. Therefore, this level has been widely adopted in empirical academic studies. Its selection in this research ensures the methodological robustness of regional comparisons and enhances the validity of the findings. Moreover, the NUTS-1 level is frequently referenced in national policy frameworks, further supporting its relevance in assessing regional human development.

The data consist of panel data, combining time series data from 2013 to 2023 with cross-sectional data from 12 NUTS Level 1 regions in Türkiye. EViews 12 was used to analyse the data. The definitions and data sources of the variables used in the model are presented in Table 1.

Table: 1
Descriptive Statistics of Variables

Variables	Variable Definition	Data Source	Mean	Min.	Max.	Standard Deviation
GDP	Gross Domestic Product (GDP) per capita	TÜİK	10.724	9.363	13.143	0.855
GINI	Gini Coefficient	TÜİK	0.367	0.302	0.451	0.030
UNEMP	Unemployment Rate	TÜİK	2.291	1.280	3.1091	0.323
TRADE	Trade Volume	TÜİK	16.108	12.586	19.616	1.730
HDI	Human Development Index (HDI)	TÜİK	0.651	0.186	0.821	0.116

In this study, the independent variables used include the Gini coefficient (GINI), unemployment rate (UNEMP), trade volume (TRADE), and per capita real Gross Domestic Product (GDP). The data for these variables were compiled from the Turkish Statistical Institute (TÜİK) database. The dependent variable, the Human Development Index (HDI), was calculated by the author.

The variables used in the study have also been examined in the literature and are widely utilised in empirical analyses. For instance, studies on the Gini coefficient include those by Kabakçi-Günay & Topbaş (2021), Setiawan (2023), Shah (2016), and Ghifara et al. (2022). The trade volume variable has been analysed in studies by Hamid & Amin (2013) and Sinha & Sen (2016). The unemployment rate has been included in research by Priambodo (2021), Amalia et al. (2015), and Ipmawan et al. (2022). The GDP variable has been examined in studies conducted by Rahmawati (2020) and Gulcemal (2020).

The fundamental statistical properties of the variables used in this study provide significant insights into understanding regional disparities. The Human Development Index (HDI) has an average value of 0.651, with notable regional variations (min: 0.186, max: 0.821). The standard deviation is 0.116, indicating measurable differences in HDI across regions. It is observed that more developed regions exhibit higher HDI values, while less developed regions have lower HDI values.

The Gini coefficient, which measures income inequality, has an average value of 0.367 (min: 0.302, max: 0.451). These values indicate significant disparities in income inequality across regions. The standard deviation of 0.030 suggests that while income

inequality remains relatively stable across regions, some regions experience more pronounced inequality.

The average value of per capita GDP, after natural logarithmic transformation, is 10.724 (min: 9.363, max: 13.143). These values correspond to a wide variation in real income levels across regions. When converted back to real terms, the data range from approximately 11,600 TL to 510,000 TL per capita. The relatively high standard deviation (0.855) in the logged values indicates significant disparities in regional income distribution. These differences in income levels are crucial for understanding how economic performance influences human development across Türkiye's regions.

After transforming the trade volume data using natural logarithms to reduce scale imbalances in the econometric model, the mean is 16.11. This corresponds to an approximate actual average of 34,645,000 TL, with a wide range from 292,483 TL to 330,711,064 TL across Türkiye's regions. The high standard deviation of 63,610,425 TL in real terms (or 1.73 in log scale) highlights the uneven distribution of trade activities and points to strong regional disparities in commercial development.

The unemployment rate, which reflects regional labour market disparities, has a log-transformed average value of 2.29, with a minimum of 1.28 and a maximum of 3.11. A standard deviation of 0.32 on the logarithmic scale indicates a significant variation in unemployment rates across regions. This highlights notable differences in employment opportunities and labour market conditions among Türkiye's 12 regions. Empirical findings show that regions with higher unemployment rates tend to have lower HDI values, confirming the negative impact of unemployment on human development. This also suggests that unemployment adversely affects fundamental components of human development, such as education, healthcare, and quality of life.

These findings demonstrate that human development in Türkiye is closely linked to economic and social indicators. Specifically, regional disparities in GDP and trade volumes directly affect HDI. Furthermore, social indicators such as unemployment and income inequality significantly influence the level of human development.

The results highlight important indicators that should be considered in developing regional development policies and ensuring social justice. The effects of economic growth and income inequality on human development require more comprehensive analysis. The data for the variables used in this study span the period 2013-2023, with annual data being utilised. The visual representations of these annual time series are presented in Figure 2.

Figure: 2
Graphs of the Series for the Variables

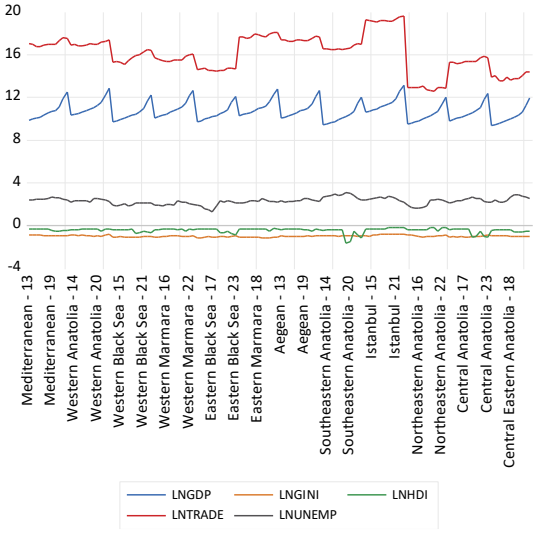


Figure 2 visualises the dynamic relationship between economic and social variables. While economic growth and trade volume exhibit an increasing trend, income inequality and unemployment demonstrate a relatively stable pattern. Moreover, the relative stability of human development indicators over time suggests that human development is a long-term process and cannot be directly linked to economic growth.

In this context, it can be concluded that regional development policies should shift from a solely economic focus to a more inclusive approach that also encompasses social development. Given that economic growth alone is insufficient to drive human development, policies to reduce income inequality, stabilise the labour market, and enhance social welfare are needed. To eliminate scale differences among the variables used in the study and to analyse their relationships more effectively, natural logarithms were used in the calculations. This analysis provides significant insights into examining regional development disparities in Türkiye and understanding how human development indicators interact with macroeconomic variables.

In the study, the Human Development Index (LNHDI) was designated as the dependent variable, and the following economic model was established:

LNHDI= f (LNGDP, LNGINI, LNUNEMP, LNTRADE)

A panel regression model was used to determine the relationship between the variables. The general mathematical representation of the model is as follows:

$$LNHDI_{it}=\beta_0+\beta_1 LNGDP_{it}+\beta_2 LNGINI_{it}+\beta_3 LNUNEMP_{it}+\beta_4 LNTRADE_{it}+u_i+\varepsilon_{it}$$

In the equation, i represents the cross-sectional unit, while t denotes time. The term β_0 is the intercept, and εit represents the error term, which is assumed to have a zero mean and constant variance. A log-linear model was used to transform variables with different measurement units into a common scale.

In this framework, the coefficients β_1, β_2, β_3 and β_4 correspond to the parameters of Gross Domestic Product (LNGDP), income inequality (LNGINI), unemployment rate (LNUNEMP), and trade volume (LNTRADE), respectively.

This model enables the analysis of the relationship between human development and economic and social indicators using the panel data method.

Although a single regression model is estimated in this study, it is based on a balanced panel dataset that includes annual observations for 12 NUTS-1 level regions of Türkiye between 2013 and 2023. Rather than estimating separate models for each region, the study utilises a unified panel regression model that combines both the cross-sectional (regional) and time-series dimensions. This approach allows the analysis to identify generalizable patterns while accounting for regional heterogeneity. Therefore, references to the 12 regions in the text reflect the data's geographical scope, not the presence of multiple distinct models.

4. Analysis Results and Findings

In this study, cross-sectional dependence among the variables was first analysed. Then, the stationarity levels of the series were tested using the Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), ADF-Fisher Chi-Square, and PP-Fisher Chi-Square unit root tests.

To determine the long-term relationship between the variables, a cointegration test was conducted, and both short- and long-term relationships were examined using the Panel Dynamic Ordinary Least Squares (PDOLS) method. In the final stage of the study, the VAR Granger Causality Test was applied to assess causal relationships among the variables and to assess the model's diagnostic validity.

4.1. Estimation Strategy and Diagnostic Tests

In this context, the Panel Dynamic Ordinary Least Squares (PDOLS) estimator was employed to investigate the long-run relationship between the Human Development Index and the selected explanatory variables. The PDOLS approach accounts for potential endogeneity and serial correlation by incorporating appropriate lag and lead values into the model.

In this study, the optimal number of lags and leads was determined using the Schwarz Information Criterion (SIC), given the limited time dimension (T = 11). This selection aimed to prevent model overfitting while preserving estimation efficiency.

Before estimation, the stationarity of the variables was tested using panel unit root tests, including the Levin-Lin-Chu, Im-Pesaran-Shin, and Hadri tests. Additionally, cross-sectional dependence was evaluated using the Pesaran (2004) CD test, which is particularly relevant in regional panel data settings.

Cointegration among the variables was confirmed using panel cointegration tests, thereby justifying the application of PDOLS to estimate long-run coefficients.

4.2. Homogeneity of Slope Coefficients

Before proceeding with the panel data analysis, a homogeneity test was conducted to determine whether the data were homogeneous or heterogeneous. In this context, the delta tests developed by Pesaran (2004) and Hashem Pesaran & Yamagata (2008) were used to examine the homogeneity of the variables based on the intercept and slope coefficients.

The null and alternative hypotheses evaluated in the applied test are as follows (Yücesan & Yağış, 2020):

H_0: For all β_i, $\beta_1 = \beta_2 = \ldots = \beta_n = \beta$ (The data are homogeneous).

H_1: For at least one i, $\beta_1 \neq \beta_2 \neq \ldots \neq \beta_n$ (The data are heterogeneous).

The findings provide a crucial basis for determining the appropriate panel data analysis method.

Table: 2
Homogeneity Test Results

Variable	Test Statistics	Prob
LNGDP	2.685	0.008
LNGINI	3.010	0.003
LNUNEMP	2.159	0.032
LNTRADE	4.526	0.000
LNHDI	2.365	0.042

According to the Delta test results, the null hypothesis (H_0) has been rejected for all variables, and the alternative hypothesis (H_1) has been accepted. This indicates the presence of heterogeneity in the model.

The results suggest that the analysed variables exhibit different responses across units, highlighting the need to employ panel-data methods that account for this heterogeneity.

In panel data analyses, testing for cross-sectional dependence is a crucial step (Breusch & Pagan, 1980; Pesaran, 2004). Examining whether cross-sectional dependence exists among variables should be conducted before unit root and causality tests. Otherwise, the reliability of the obtained findings may decrease.

In panel data analysis, the Breusch and Pagan (1980) LM test is commonly used to test whether a random effects model is more appropriate than pooled OLS, particularly in panels with a relatively small time dimension (Breusch & Pagan, 1980).

In panel data analysis, the Breusch and Pagan (1980) LM test is commonly used to determine whether a random effects model is more appropriate than pooled OLS, particularly in panels with a relatively small time dimension (Breusch & Pagan, 1980). Additionally, the Pesaran (2004) cross-sectional dependence (CD) test is applied to detect cross-sectional correlation, which is crucial for selecting robust estimators in panel data models (Yücesan & Yağiş, 2020: 698).

H_0: There is no cross-sectional dependence.

H_1: There is cross-sectional dependence.

The results of the cross-sectional dependence test are presented in Table 3.

Table: 3
Cross-Sectional Dependence Test Results

LM tests	Variables	Test Statistics	Prob
Breusch Pagan	LNHDI	311.803**	0.000
Pesaran	LNHDI	21.394**	0.000
Breusch Pagan	LNGDP	724.625**	0.000
Pesaran	LNGDP	57.3259**	0.000
Breusch Pagan	LNGINI	143.781**	0.000
Pesaran	LNGINI	6.769**	0.000
Breusch Pagan	LNUNEMP	305.946**	0.000
Pesaran	LNUNEMP	20.884**	0.000
Breusch Pagan	LNTRADE	426.624**	0.000
Pesaran	LNTRADE	31.388**	0.000

According to the Breusch-Pagan test, the test statistics for all variables are significantly high ($p < 0.01$). This strongly supports the presence of cross-sectional dependence in the variables LNHDI (Human Development Index), LNGDP (Gross Domestic Product), LNGINI (Income Inequality), LNUNEMP (Unemployment Rate), and LNTRADE (Trade Volume).

Similarly, the Pesaran test results confirm the presence of cross-sectional dependence for all variables, as indicated by high test statistics. At the 1% significance level, the alternative hypothesis is accepted, and the null hypothesis (H_0) is rejected.

This finding indicates that economic variables across regions are interconnected, suggesting that economic changes occurring in one region may also affect others. Economic indicators from Türkiye's 12 regions exhibit a regionally dependent structure with respect

to the Human Development Index. The results highlight that while these variables influence the level of human development, they also interact across regions, demonstrating that regional development dynamics cannot be evaluated independently of one another.

4.3. Panel Unit Root Test

After analysing cross-sectional dependence, a panel unit root test was conducted to determine the stationarity levels of the series. In this context, the Levin, Lin, and Chu, Im, Pesaran, and Shin, ADF-Fisher Chi, and PP-Fisher Chi tests were used to examine whether the series were stationary. The results of the panel unit root test are presented in Table 4.

Table: 4
Panel Unit Root Test Results

	LNHDI			
	t statistic	**t probability**	**t statistic**	**t probability**
Levin, Lin & Chut	-1.358	0.087	-5.139	0.000
Im, Pesaran, and Shin W-stat	-0.024	0.490	-3.452	0.000
ADF- Fisher Chi-square	21.939	0.582	57.799	0.000
PP- Fisher Chi-square	47.846	0.002	138.151	0.000
	LNGDP			
Levin, Lin & Chut	15.147	1.0000	-6.578	0.000
Im, Pesaran, and Shin W-stat	9.147	1.0000	-2.344	0.009
ADF- Fisher Chi-square	0.050	1.0000	55.149	0.000
PP- Fisher Chi-square	0.001	1.0000	46.871	0.003
	LNGINI			
Levin, Lin & Chut	-0.713	0.237	-2.790	0.002
Im, Pesaran, and Shin W-stat	0.631	0.736	-2.669	0.003
ADF- Fisher Chi-square	23.793	0.473	52.498	0.000
PP- Fisher Chi-square	19.046	0.749	188.429	0.000
	LNUNEMP			
Levin, Lin & Chut	-0.931	0.175	-4.389	0.000
Im, Pesaran, and Shin W-stat	-0.034	0.486	-2.576	0.005
ADF- Fisher Chi-square	18.005	0.802	48.525	0.002
PP- Fisher Chi-square	14.998	0.920	144.643	0.000
	LNTRADE			
Levin, Lin & Chut	1.223	0.889	-9.727	0.000
Im, Pesaran, and Shin W-stat	1.486	0.931	-4.662	0.000
ADF- Fisher Chi-square	10.109	0.994	72.561	0.000
PP- Fisher Chi-square	7.062	0.999	103.361	0.000

Table 4 presents the results of the panel unit root test conducted using the Levin, Lin & Chu (LLC), Im, Pesaran & Shin (IPS), ADF-Fisher Chi-square, and PP-Fisher Chi-square tests.

The unit root test results indicate that the variables LNHDI (Human Development Index), LNGDP (Gross Domestic Product), LNGINI (Income Inequality), LNUNEMP (Unemployment Rate), and LNTRADE (Trade Volume) are not stationary at their level values. According to the test results, all variables exhibit unit roots at their levels, meaning that the stationarity condition is not satisfied.

Therefore, appropriate transformations were applied to ensure the series was stationary. After the transformation processes, all variables were observed to become stationary. These findings highlight the importance of ensuring stationarity in time series to establish a valid panel data model.

After applying the panel unit root test, panel cointegration tests were conducted to determine the existence of a long-term relationship among the variables. The obtained results are presented in Table 5.

Table: 5
Panel Cointegration Test Results

Variables	Statistical Value	Probability Value	Statistical Value	Probability Value
Panel v	1.04	0.0000	2.210	0.001
Panel rho	3.59	0.003	4.240	0.004
Panel PP	8.28	0.000	7.024	0.000
Panel ADF	4.69	0.000	5.108	0.000

** LNHDI shown as the dependent variable.*

According to Table 5, the statistical and probability values obtained for the Panel v, Panel rho, Panel PP, and Panel ADF tests indicate a significant long-term relationship among the variables.

The test findings reveal that the variables move together in the long run and that there is a stable equilibrium relationship among non-stationary series. Based on the probability values, the null hypothesis (H_0: No cointegration) has been rejected, and the alternative hypothesis (H_1: Cointegration among the variables) has been accepted. These results confirm the existence of a long-term relationship among the variables included in the model.

Following the cointegration test, a panel cointegration analysis was conducted to determine the direction and magnitude of the long-term relationship between the variables. The results of the analysis are presented in Table 6.

Table: 6
Panel Cointegration Analysis Results

Variables	Coefficients	t-Statistic	Prob.
LNGDP	2.153341	2.095	0.007
LNGINI	1.127006	1.524	0.002
LNUNEMP	0.976423	4.113	0.030
LNTRADE	0.155952	0.655	0.000
C	29.33869	2.551	0.012
R-squared		0.688	
Adjusted R-squared		0.578	

According to Table 6, the coefficients and t-statistics for the independent variables LNGDP, LNGINI, LNUNEMP, and LNTRADE indicate that these variables have a significant long-term impact on the dependent variable LNHDI. The statistical significance levels of the coefficients support the existence of a long-term relationship among the variables.

The R-squared value of the model is calculated as 0.688, while the adjusted R-squared value is 0.578. These findings indicate that the model has high explanatory power and that the long-term relationship between the variables is statistically significant.

4.4. Panel Regression Estimation Method (PDOLS)

The results of the cointegration analysis confirm the presence of a long-term relationship among the variables, indicating that the Panel Dynamic Ordinary Least Squares (PDOLS) method can be used to estimate long-term panel coefficients. Accordingly, the PDOLS method has been employed to estimate the long-term panel coefficients.

PDOLS was developed by Pedroni (2001) to estimate long-term panel coefficients. Compared to within-group panel DOLS estimation techniques, the group-mean panel DOLS estimation technique offers several advantages. Among its most significant advantages are its lower sensitivity to scale distortions and its ability to provide more accurate estimates when cointegration vectors exhibit a heterogeneous structure (Ecevit et al., 2018: 328).

For the PDOLS method, the null and alternative hypotheses are defined as follows:

H_0: $\beta_i = \beta_0$ is valid for all i units.

H_1: $\beta_i \neq \beta_0$ is valid for at least one i unit.

Within the framework of these hypotheses, the following cointegrated panel system is considered:

A cointegrated panel system is considered as follows:

$$Y_{it} = \alpha_i \beta_i X_{it} \mu_{it} \qquad X_{it} = X_{it} - {}_1\varepsilon_{it}$$

The extended cointegration equation for the Panel DOLS estimation can be expressed as follows:

$$Y_{it} = \alpha_i + \beta_i + X_{it} + \sum_{i=-K_i}^{K_i} Y_{ik} X_{it-k} + \mu_{it}$$

The estimated β coefficient is determined as follows:

$$\hat{\beta}\ {}_{*GD} = \left[N^{-1}\left(\sum_{i=-1}^{N} Z_{ik} Z_{it}\right)\left(\sum_{i=1}^{N} [\![Z_{ik} Y_{it}^{*}]\!]\right)\right]$$

In this context, $Z_{it} = (X_{it-}\bar{X}_i, \Delta X_{it-k},\ldots,\Delta X_{it+k})(K+1)\times 1$ represents a regressor vector with dimensions of $(K+1)\times 1$ $(K+1)\times 1$ (Pedroni, 2001: 729).

The Panel Dynamic Ordinary Least Squares (PDOLS) method was applied, and the panel regression estimation results are presented in Table 7.

Table: 7
Panel Regression Estimation Results (PDOLS)

Variables	Coefficients	t-Statistic	Prob.
LNGDP	0.130	3.909	0.000
LNGINI	1.040	4.389	0.000
LNUNEMP	0.197	2.126	0.035
LNTRADE	0.158	7.736	0.000
R-squared		0.713	
Adjusted R-squared		0.689	

The PDOLS analysis results presented in Table 7 illustrate the relationship between the dependent variable, the Human Development Index (LNHDI), and the selected independent variables. According to the findings, all independent variables were statistically significant.

Based on the PDOLS analysis, the panel regression equation is expressed as follows:

$$LNHDI=0.130LNGDP+1.040LNGINI+0.197LNUNEMP+0.158LNTRADE$$

The coefficient of the LNGDP variable is 0.130 and is statistically significant at the 1% significance level ($p = 0.000$). This result indicates that an increase in per capita real income positively affects human development. This finding supports the positive impact of economic growth on living standards. The coefficient for the LNGINI variable is 1.040 and is statistically significant at the 1% level ($p = 0.000$). The positive association between the Gini coefficient and human development suggests that income inequality increased alongside economic growth during the examined period. This finding differs from the expected negative relationship in the literature and may be attributed to regional disparities or specific characteristics of the analysed period. One possible explanation is that, at the regional level, income inequality may also reflect economic dynamism or the presence of high-income groups. In regions with high Gini coefficients, particularly in metropolitan areas such as Istanbul, both high income inequality and high human development can be observed.

Another potential explanation is that, in some regions, income inequality may be mitigated by public policies and social service provision. In such cases, social welfare indicators, such as access to education and healthcare, may remain strong despite an unequal income distribution.

These contextual factors may have contributed to the unexpected positive correlation between the Gini coefficient and HDI observed in this study.

The coefficient of the LNUNEMP variable is 0.197 and is statistically significant at the 5% significance level ($p = 0.035$). The positive relationship between the unemployment rate and human development may be explained by region-specific socio-economic conditions or sustained social expenditures despite unemployment. The coefficient of the LNTRADE variable is 0.158 and is statistically significant at the 1% significance level ($p =$

0.000). This finding suggests that the expansion of foreign trade positively influences human development. The results support the view that international trade activities have positive effects on economic and social indicators. The R-squared value of the model is calculated as 0.713, while the adjusted R-squared value is 0.689. These findings indicate that the model has high explanatory power and that the long-term relationship between the variables is statistically significant.

4.5. VAR Granger Causality Test

C.W.J. Granger introduced this test in his 1969 study. According to (Granger, 1969):

If A_t is a stationary stochastic process, then $\bar{A}t$, represents the past values of A_t as $\{A_{t-j}, j = 1, 2, ..., \infty\}$, while $\bar{\bar{A}}_t$ represents both the past and present values as $\{A_{t-j}, j = 0, 1, ..., \infty\}$. Additionally, let $\bar{A}_{(k)}$ denote the set $\{A_{t-k}, j = k, k+1, ..., \infty\}$. The optimal, unbiased, least squares predictor of A_t using the set of values B_t can be expressed as $P_t(A\backslash B)$. Thus, for instance, $P_t(X\backslash\bar{X})$ represents the optimal predictor of X_t using only X_t.

The forecasting error series can be represented as:

$$\varepsilon_t(A\backslash B) = A_t - P_t(A\backslash B)$$

where $\sigma^2(X\backslash U)$ denotes the variance of $\varepsilon_t(A\backslash B)$.

Let U_t denote all accumulated information in the universe up to time $t-1$ and let U_t-Y_t represent all information excluding the series Y_t. Accordingly, a general definition of causality is given as follows:

Causality: If $\varepsilon_t(A\backslash B) < \sigma^2(X\backslash\overline{U-Y})$, then it can be stated that Y causes X, denoted as $Y_t => X_t$. Here, if using all available information results in a better prediction of X_t than using only information excluding Y_t *then* Y_t is said to cause X_t.

If X_t and Y_t are assumed to be two stationary series with zero mean, the bivariate causality model can be expressed as follows:

$$X_t = \sum_{j=1}^{m} a_j Y_{t-j} + \sum_{j=1}^{m} b_j X_{t-j} + \varepsilon_t$$

$$Y_t = \sum_{j=1}^{m} c_j Y_{t-j} + \sum_{j=1}^{m} d_j X_{t-j} + \eta_t$$

Here, ε_t and η_t are assumed to be two uncorrelated white noise series. Although m can be infinite, in practical applications, due to the limited length of the available data, m is assumed to be more constrained and shorter than the given time series. Like the model presented above, multivariate causality models involving more than two variables can also be derived. In the causality model described above, if b_j is not equal to zero, it implies that Y_t causes X_t. Similarly, if c_j is not equal to zero, then X_t causes Y_t. If both conditions hold simultaneously, it indicates the presence of a feedback relationship between X_t and Y_t (Granger, 1969: 421-431). At this stage, the Panel VAR Granger causality test is applied to

determine the causal relationships and their directions among the variables. The findings obtained regarding short- and long-term relationships between the variables are presented in Table 8.

Table: 8
VAR Granger Causality Test

Dependent variable: LNHDI			
Independent variables	**Chi-sq**	**df**	**Prob.**
LNGDP	2.230779	3	0.02259
LNUNEMP	0.989467	3	0.03038
LNTRADE	1.683601	3	0.0406
LNGINI	1.711962	3	0.05343
Dependent variable: LNGDP			
Independent variables	**Chi-sq**	**df**	**Prob.**
LNHDI	12.49565	3	0.0059
LNUNEMP	28.84436	3	0.0000
LNTRADE	51.47256	3	0.0000
LNGINI	3.378811	3	0.3368
Dependent variable: LNUNEMP			
Independent variables	**Chi-sq**	**df**	**Prob.**
LNHDI	3.905251	3	0.2719
LNGSYH	9.640089	3	0.0219
LNTRADE	4.161169	3	0.2446
LNGINI	4.451233	3	0.2167
Dependent variable: LNTRADE			
Independent variables	**Chi-sq**	**df**	**Prob.**
LNHDI	6.558906	3	0.0874
LNGSYH	10.68532	3	0.0136
LNUNEMP	10.73394	3	0.0133
LNGINI	1.428401	3	0.6989
Dependent variable: LNGINI			
Independent variables	**Chi-sq**	**df**	**Prob.**
LNHDI	6.737394	3	0.0808
LNGDP	25.10070	3	0.0000
LNUNEMP	4.439129	3	0.2178
LNTRADE	4.669504	3	0.1977

When evaluated at the regional level, the relationship between economic growth and human development varies across different regions of Türkiye. In regions with high economic activity, such as Istanbul and Western Marmara, the impact of per capita GDP on human development is more pronounced, whereas in relatively less developed regions like Southeastern Anatolia and Northeastern Anatolia, this effect appears to be more limited.

The effect of the unemployment rate on human development also varies by region. In regions such as Central Anatolia and Southeastern Anatolia, where unemployment rates are high, social and economic imbalances negatively affect human development. In contrast, in regions such as the Aegean and Eastern Marmara, where unemployment rates are lower, the impact of unemployment on human development is relatively limited.

The significant relationship between trade volume and human development suggests that economic integration and foreign trade activities contribute positively to the quality of life, particularly in export-driven regions such as Istanbul, Eastern Marmara, and Western

Anatolia. However, in regions with an internal market focus and lower trade volumes, the impact of foreign trade on human development appears weaker.

On the other hand, no direct causality between income inequality and human development has been identified. However, at the regional level, it is observed that in regions such as Southeastern and Northeastern Anatolia, where income inequality is high, human development tends to be lower. This suggests that changes in income distribution may affect human development through indirect mechanisms.

In conclusion, the relationships among economic growth, unemployment, trade volume, and human development differ across Türkiye's regions, reflecting regional development dynamics. Therefore, regional development policies should be designed in accordance with each region's economic structure and social dynamics.

4.6. Findings

The results from Panel Dynamic OLS (PDOLS) estimation reveal meaningful insights into the determinants of the Human Development Index (HDI) across Türkiye's 12 NUTS-1 regions over the period 2013-2023.

Firstly, the coefficient of gross domestic product (GDP) per capita is positive and statistically significant. This indicates that regions with higher levels of income tend to exhibit higher human development, supporting the established theory that economic prosperity contributes to better education, healthcare, and quality of life.

Secondly, the Gini coefficient, a measure of income inequality, also shows a positive and significant effect on HDI. Although this finding contrasts with the traditional literature, which suggests a negative relationship, it can be explained by regional dynamics in Türkiye. Some regions with high levels of development, such as İstanbul, also exhibit high income inequality. Therefore, the positive association may reflect the coexistence of economic dynamism and social disparity in urbanised and economically dominant areas.

The unemployment rate is found to have a negative, statistically significant impact on HDI, consistent with expectations. This suggests that higher unemployment impairs individuals' access to public services and diminishes overall well-being, thereby reducing regional human development levels.

Furthermore, trade volume shows a positive relationship with HDI, suggesting that increased regional trade activity and integration with external markets contribute to long-run improvements in development indicators. However, the magnitude and significance of this effect are comparatively weaker than GDP and unemployment, suggesting that trade alone may not be sufficient to compensate for structural disparities.

Overall, the findings underscore the complex interplay between economic performance, inequality, labour market conditions, and development outcomes. While

growth and trade enhance regional human development, inequalities and labour exclusion continue to hinder balanced and inclusive progress across Türkiye's regions.

5. Conclusion and Discussion

This study examines the determinants of the Human Development Index (HDI) in 12 NUTS-1 regions of Türkiye between 2013 and 2023 by integrating economic and social indicators such as per capita GDP, unemployment rate, trade volume, and income inequality into a panel data framework. By adopting the Panel Dynamic OLS (PDOLS) and Panel VAR Granger Causality Test methods, the study reveals significant short- and long-term interactions among these variables.

The findings show that per capita GDP positively affects human development, confirming that income growth supports improvements in health, education, and quality of life. Similarly, trade volume has a supportive impact, indicating that economic integration and regional commercial activity can enhance human development outcomes. However, the effect of unemployment is negative, reaffirming its detrimental role in social inclusion and welfare.

One notable finding concerns income inequality. While a positive relationship was observed in some cases, this counterintuitive result may reflect complex regional dynamics, particularly in metropolitan areas where economic dynamism coexists with pronounced disparities. This suggests that the implications of income inequality are context-dependent and warrant deeper investigation. For example, in underdeveloped regions with limited access to social services, rising inequality may severely undermine human development, whereas in more developed regions, its effects might be mitigated by stronger institutional frameworks and redistributive policies.

In this regard, the results underscore the necessity to reconsider human development beyond GDP-centric models. The study affirms that economic growth alone does not ensure equitable development outcomes and that deeper structural, institutional, and policy-related factors shape regional disparities in Türkiye. Uniform, growth-oriented strategies are insufficient to address entrenched inequalities rooted in geographic and historical differences.

Therefore, regional development strategies should be reoriented toward a more human-centred, multidimensional framework, prioritising investments in education, healthcare, and employment alongside economic performance. Policymakers should adopt tailored approaches based on regional characteristics and needs, recognising that regions with similar economic outputs may vary greatly in human development due to differences in social policy implementation and institutional capacity.

Future research could benefit from region-specific case studies and comparative analyses with other emerging economies, which would help validate these findings and provide further insight into the mechanisms by which income inequality and economic

growth shape human development. Expanding the research framework in this direction could strengthen the generalizability of the results and support the formulation of more effective regional and national development policies.

Ultimately, this study reinforces the view that human development must be placed at the core of policy design. A holistic development strategy, one that not only focuses on economic expansion but also enhances social equity, institutional quality, and access to opportunities, is essential for reducing regional disparities and ensuring sustainable, inclusive progress in Türkiye.

6. Limitations and Further Research

Although this study employs a dynamic panel regression model (PDOLS) to analyse the long-run relationship between the Human Development Index and selected economic indicators across Türkiye's 12 NUTS-1 regions, it assumes slope homogeneity across cross-sectional units. In other words, the model assumes that variables such as GDP, income inequality, unemployment, and trade volume affect human development similarly across regions. This may oversimplify regional dynamics and limit the model's ability to capture spatial heterogeneity.

The use of PDOLS is justified by the panel structure of the data, which combines a relatively small number of cross-sectional units (12 regions) over a moderate time span (2013-2023), and by the method's robustness in addressing non-stationarity and cointegration. Furthermore, PDOLS allows for reliable estimation of long-term relationships while correcting for endogeneity and serial correlation through appropriate leads and lags. These features make it suitable for exploring generalizable policy insights at the national level.

Nevertheless, future studies could benefit from employing heterogeneous panel data estimators such as the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) methods. These approaches allow for the estimation of region-specific coefficients while accounting for cross-sectional dependence and unobserved common factors. Their use would enable a more detailed exploration of how economic and social indicators influence human development differently across Türkiye's diverse regions, potentially leading to more localised and targeted policy recommendations. Integrating such methods into future research designs would deepen understanding of regional inequalities in human development.

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