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AN ANALYSIS OF INCOME CONVERGENCE BETWEEN NUTS-2 REGIONS OF TÜRKİYE

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Abstract

It is well-recognized that socio-economic development disparities exist both between developed and developing countries and among regions within these nations. Consequently, reducing or eliminating regional disparities remains one of the primary concerns of economic policymakers. This study aims to examine whether income disparities in Türkiye exhibit a tendency to diminish over time by converging towards a common trend. To detect potential convergence dynamics, the study employs per capita income data from Level-2 regions, covering Türkiye's 26 regions as classified in accordance with the European Union's Nomenclature of Units for Territorial Statistics (NUTS). The dataset, comprising annual series for the 2004–2022 period, was obtained from the Turkish Statistical Institute. Utilizing the PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common Components) procedure—an innovative approach that diverges from standard panel unit root analyses by accounting for idiosyncratic factors and providing more robust results—the study seeks to uncover the structural characteristics of potential convergence processes in Türkiye. Findings suggest that certain regions demonstrate a convergence tendency, with prospects of achieving the average per capita income level in the long run. Based on these results, policy recommendations are proposed to support and enhance the observed convergence patterns.

Keywords: Income Convergence, Income Disparities, Fourier PANIC Procedure

TÜRKİYE'NİN DÜZEY-2 BÖLGELERİ ARASINDA GELİR YAKINSAMASININ ANALİZİ

Öz

Günümüzde hem gelişmiş hem de gelişmekte olan ülkeler arasında, ayrıca bu ülkelerin içindeki bölgeler arasında belirgin sosyo-ekonomik gelişmişlik farklılıklarının varlığı dikkat çekmektedir. Dolayısıyla bölgesel farklılıkların yok edilmesi ya da en aza indirilmesi iktisadi karar vericilerin ilgilendiği popüler konular arasında ön sıralarda yer almaktadır. Bu çalışma, Türkiye'deki gelir farklılıklarının uzun vadede bir yakınsama sürecine girerek azalma eğilimi gösterip göstermediğini incelemeyi hedefler. Olası bir yakınsama hareketinin tespiti için Avrupa Birliği'nin İstatistiki Bölge Birimleri Sınıflandırmasına (NUTS) paralel olarak belirlenmiş ve Türkiye'nin 26 bölgesini kapsayan Düzey2 bölgelerinin kişi başı gelir seviyeleri veri seti olarak kullanılmıştır. 2004-2022 zaman aralığına ait olan ve yıllık olarak oluşturulan seriler Türkiye İstatistik Kurumundan temin edilmiştir. Çalışma literatürde görece yeni olan ve standart panel birim kök analizlerine göre daha tutarlı sonuçlar veren ve idiyosenkratik faktörleri dikkate alarak diğer yöntemlerden farklılaşan PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common Components) prosedürünü devreye sokarak Türkiye'deki olası yakınsama süreçlerinin yapısını ortaya koymayı amaçlar. Uygulanan yeni yöntem sonrası Türkiye'de belirli bölgelerin yakınsama eğilimi göstererek ortalama kişi başı gelir seviyesini uzun dönemde yakalama şansı olduğu sonucuna varılmış ve elde edilen sonuca paralel olarak politika önermeleri oluşturulmuştur.

Anahtar Kelimeler: Gelir Yakınsaması, Gelir Farklılıkları, Fourier PANIC Prosedürü

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INTRODUCTION

Since the Industrial Revolution, disparities in income and development have emerged both across countries and within regions of the same country. These disparities have become one of the most pressing issues of the 21st century, contributing to increasing differentiation and divergence between nations and regions. Such economic imbalances have laid the groundwork for chronic economic problems, including migration, urban sprawl, environmental pollution, overpopulation in urban centers, high real estate prices, cultural conflicts, social discord, and unrest. The rising divergence between regions, seen as the root cause of these costly issues, is recognized as a critical problem requiring solutions at the international level.

The 2023 OECD report notes that developing countries are converging toward high-income countries due to their relatively higher growth rates. However, it also highlights that in half of these converging countries, regional disparities are intensifying. Furthermore, adverse events such as pandemics, famines, and wars exacerbate these disparities, rendering them chronic and deep-rooted. Such inequalities, which dominate the global agenda, not only impact developing nations but also pose significant challenges for developed economies (Barrios and Strobl, 2009:576).

Increased divergence undermines the foundations of healthy economic structures and adversely affects growth rates (Barro, 2008:8). In the literature, regional divergence has been systematically conceptualized, particularly through numerous studies examining interregional disparities around the world, most notably in Italy, where it has come to be recognized as the North–South divide. In the context of Türkiye, this divergence manifests as an East-West divide. The relatively disadvantaged economic position of eastern regions contributes to slower growth in these areas, negatively affecting national average growth rates. The causes of these disparities have been attributed to various factors in economic literature. Geographic, cultural, climatic, and historical influences are considered significant drivers of regional inequalities. These factors impact societal structures, living conditions, and, consequently, per capita income levels, creating stark differences between regions.

Against this backdrop, the question of whether less-developed regions can converge with more-developed ones in the medium or long term has garnered substantial scholarly attention. A key reason for this interest lies in the neoclassical perspective, particularly Solow's (1956) seminal work, which posits that low-income regions are expected to exhibit higher growth rates in per capita income compared to high-income regions. This perspective argues that the mobility of labor and capital will eventually mitigate regional imbalances. This concept, widely tested in the literature as β-convergence, highlights two primary types of convergence. The first, absolute convergence, rooted in the neoclassical view, suggests that low-income countries grow faster than high-income countries, leading to a reduction in income disparities over time. The second, conditional convergence, adopted by endogenous growth theories, predicts that regions or countries achieve similar growth rates in the long run, considering structural differences and variations in technological levels among them. In the study by Gezici and Hewings (2004:122), absolute β-convergence is mathematically expressed as follows:

$$ln\left(\frac{Y_{i,t+T}}{Y_{i,t}}\right) = \alpha + \beta ln\left(Y_{i,t}\right) + \varepsilon_{i,t} \quad (1)$$

In this equation"$Y_{i,t}$"represents the per capita income level of region “i” at time “t”. The parameter "α"appears as a constant term in the equation, while "β" is the estimated coefficient that indicates the presence of convergence. The term $\varepsilon_{i,t}$ serves as the error term in the equation.

If the coefficient "β" is found to be negative and statistically significant, it indicates the existence of convergence among the regions under analysis, thereby validating the convergence hypothesis.

$$ln\left(\frac{Y_{i,t+T}}{Y_{i,t}}\right) = \alpha + \beta ln(Y_{i,t}) + \gamma ln(X_{i,t}) + \varepsilon_{i,t} \quad (2)$$

As previously mentioned, in cases where conditional convergence is being tested, it is essential to account for the differences among the regions under investigation. The term $\gamma ln(X_{i,t})$ on the right-hand side of Equation (2) represents one of these distinguishing factors. Such differentiating characteristics, which are believed to influence the convergence processes among regions, are incorporated into the first equation as independent variables on the right-hand side to test for conditional convergence.

This study examines whether per capita income among regions in Türkiye exhibits a tendency toward convergence. The significant disparities in per capita income between the eastern and western regions of the country, which are readily observable, have the potential to address numerous economic and social issues if they demonstrate a convergence trend. In this context, a closer examination of the issue of regional disparities in Türkiye, along with an analysis of their causes and consequences, serves as a prerequisite for making more accurate and comprehensive evaluations. The structure of the article includes a literature review, a methodology section outlining the model and data sets used, a section presenting the empirical results, and a conclusion that discusses the findings and proposes relevant policy recommendations.

LITERATURE REVIEW

The idea that relatively less developed countries can catch up with wealthier nations in the long term has garnered significant attention in literature, becoming a central topic of numerous studies. To explore evidence of convergence, various countries and regional groups—such as the United Kingdom (Bishop and Gripaios, 2004), China (Weeks and Yudong Yao, 2003), Spain (Maza and Villaverde, 2009), Germany (Kosfeld, Eckey, and Dreger, 2006), France (Bonnet and Sotura, 2021), Türkiye (Ursavaş and Mendez, 2023), and Austria (Ivanovski, Awaworyi, and Inekwe, 2020) have been tested at different regional levels.

While some studies have identified signs of convergence within their samples, others have failed to detect such indications. The table below categorizes and organizes key studies in literature based on their primary characteristics, aiming to provide a systematic overview of the convergence process in the existing body of research.

Table 1. Selected Examples from International Literature

The Author(s) of The Study	Time Interval	Countries and/or Country Groups	Methodology	The Obtained Result
Pfaffermayr, M. (2009).	1980-2002	212 European Regions	Spatial Maximum Likelihood Approach	Mix results are obtained.
Cartone, A. et all. (2021).	1981-2009	187 European Regions	Spatial Quantile Regression Model	European regions with relatively low growth rates tend to exhibit higher convergence rates.
Chiquiar Cikurel, D. (2002).	1970-2001	Mexico	Non-Linear Least Squares	No evidence of convergence is observed during the post-1985 period, including the NAFTA process.

Zhang, H. et all. (2020).	2003-2016	30 Chinese Region	Coefficient Of Variation and Gini Coefficient Method	While stochastic convergence cannot be identified at the national level, evidence of divergence is observed in numerous regions located in the eastern part of the country at the regional level.
Desli, E., Gkoulgkoutsika, A. (2021).	1980-2016	40 Top-Income Economies	Beta Convergence, Pairwise Stochastic Approach, Log(T) Convergence Approach	Based on the testing methods employed, unconditional beta convergence is identified
Kremer, M. et all. (2022).	1960-2007	Developed and Developing Countries	Panel Data Regression Models	In literature, the lack of evidence for convergence in earlier periods has now been replaced by processes of unconditional convergence.
Holobiuc, A. M. (2020).	2000-2018	European Countries	Panel Regression Analysis	The study identifies that, certain variables such as labor force participation rate, labor productivity, and gross fixed capital formation, have a positive impact on the convergence trend among European Union countries.
Cavenaile, L., Dubois, D. (2011).	1990-2007	Central And Eastern Europe and of the 15 Western Countries	Panel Regression Analysis	The study yields varying results for the country groups included in the sample. Western European countries and newly acceded members from Eastern and Central Europe exhibit distinct convergence patterns.
Ćurčić, T. T., Stanišić, N. (2023).	2000-2020	European Transition Countries	Panel Regression Analysis	The impact of migration on income convergence rates in European countries is identified at varying levels.
Shen, et all. (2021).	2019Q1-2020Q4	Chinese Regions	Distribution Dynamics Approach	Safety policies implemented during the pandemic have led to a divergence among the sample regions.
Ganong, P., Shoag, D. (2017).	1940-2010	US	Panel Regression Analysis	The reduction in population mobility within the United States and the decline in migration to relatively more developed regions, resulting from implemented policies, are associated with a decrease in the rate of income convergence between regions

Tortosa-Ausina, et all. (2005).	1965-1997	50 provinces of Spain	Panel Regression Analysis	The study finds no strong evidence of income convergence, while convergence patterns are identified for labor productivity, total factor productivity, and capital intensity.
Savoia, F. (2020).	1989-2013	EU Countries	Cross-Section And Panel Convergence Regressions Models	A divergence is observed among NUTS2 regions. Regions with similar institutions are found to have a higher probability of convergence.
Próchniak, M.,Witkowski, B. (2013).	1960-2009	post-communist countries	Bayesian averaging of classical estimates (BacE) approach	The study identifies the existence of slow convergence among the sample countries
Ursavaş, U., Mendez, C. (2023).	2007-2019	81 provinces of Türkiye	Nonlinear Dynamic Factor Model	The study identifies six convergence clubs, and the spatial distribution of these clubs highlights the east-west divide within the country.

The table above provides examples of studies that investigate convergence in income levels across countries and regions within countries. As illustrated, the findings vary across different geographical contexts, reflecting the heterogeneity in both the regions analyzed and the methodological approaches employed. Variations in the datasets and analytical techniques often lead to divergent empirical outcomes. In this context, the present study seeks to contribute to the existing literature by applying the Fourier PANIC test, a relatively recent and methodologically advanced panel unit root approach, to examine convergence dynamics with greater flexibility and robustness.

In addition to studies focusing on the convergence of per capita income levels across regions toward economically more developed areas, the concept of convergence has been tested in various other contexts. International literature includes analyses of convergence tendencies in per capita CO2 emissions (Criado and Grether, 2011), factor productivity (Miller and Upadhyay, 2002), socio-economic factors (Otoiu, and Titan, 2015), employment rates (Maynou, Ordóñez and Silva, 2022), and the sizes of various sectors, highlighting the application of convergence processes across diverse domains.

METHODOLOGY: MODEL, UNIT ROOT TEST AND DATA DESCRIPTION

Model

The concept of convergence originated from Solow's (1956) neoclassical framework, which posits that countries with relatively lower income levels tend to have higher growth rates, thereby showing a tendency to converge in terms of income levels with wealthier countries. At this point, Carlino and Mills (1993:336) proposed that two conditions must be met for convergence processes to occur, classifying them as stochastic convergence and Beta convergence. The study linking the stochastic convergence process to the existence of stationarity in relative series, meaning that the series tend to deviate from one another within a limited range, identifies stochastic convergence for U.S. regions during the period from 1929 to 1990. Therefore, if the tested relative series do not represent a unit root process, i.e., if they are stationary, the existence of stochastic convergence is

confirmed. In this sense, the presence of stochastic convergence implies that the series exhibits a long-term relationship. If unit root detection is found in relative series, a long-term relationship between the series cannot be established, and the existence of stochastic convergence is rejected. If stochastic convergence is calculated for per capita income levels in the selected sample regions, the analysis continues based on this assumption;

$$(Relative\ per\ Capita\ Incame\ Level)_{i,t} = ln\left(\frac{Per\ Capita\ Incame\ Level_{i,t}}{\overline{Per\ Capıta\ Incame\ Level_t}}\right) \quad (3)$$

In this equation, "ln" represents the logarithmic process, "i" denotes the cross-sectional dimension, and "t" represents the time dimension. Therefore, *"*$Per\ Capita\ Incame\ Level_{i,t}$ refers to the per capita income level of region "i" at time "t", while $\overline{Per\ Capıta\ Incame\ Level_t}$ represents the average per capita income level across all regions at time "t". The data calculated for each region will indicate whether the regions are converging toward each other or not.

In this study, the potential stationarity of the per capita income series for the NUTS-2 regions of Türkiye will be tested using panel unit root analysis. The detection of stationarity will indicate the presence of a convergence tendency among the regions. However, using the panel data method to detect stationarity may carry the risk of biased results by overlooking cross-sectional dependence. To address this issue, the recently introduced PANIC procedure will be employed.

Unit Root Test and PANIC Procedure

Considering the stationarity of the series used is closely related to obtaining more consistent results. Unit root analysis can be employed to identify potential stationarity characteristics in the series, thereby revealing the relationships among the series. If stationarity is not found in the series under analysis, it indicates that permanent economic shocks may occur, and there will be no convergence process between the series. Payne et al. (2022), differing from standard unit root tests, introduced a new unit root test to examine stochastic convergence for per capita greenhouse gas emissions. With this new approach, two key issues that need to be considered are emphasized: cross-sectional dependence and structural breaks. Ignoring these two factors may lead to incorrect results in unit root analysis. Taking into account these real-world phenomena, such as cross-sectional dependence and structural breaks, opens the way for more robust results. To address these objectives, Payne et al. based their analysis on the widely used Lagrange Multiplier (LM) unit root test proposed by Lee and Strazicich (2003), which accounts for two structural breaks, and the PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common Components) procedure developed by Bai and Ng (2004), which considers both the common factors affecting the series collectively and the idiosyncratic factors specific to each series (thus accounting for cross-sectional dependence). In this context, the panel data model created by Nazlioglu et al. (2023:81) to analyze the structure of these factors' movements across sections, using the new unit root test, is expressed as follows:

$$Y_{i,t} = d_{i,t} + \acute{V}_i F_t + \varepsilon_{i,t} \quad (4)$$

In this equation, $Y_{i,t}$ represents the observation data of unit "i" at time "t", $d_{i,t}$ denotes the non-stochastic, deterministic constant or trend for unit "i" at time "t", and "F"$_t$ is the vector of common factors excluding the observation. "$\acute{V}_i$" reflects the factor representing each series' individual response to the common factor. At this point, the PANIC tests, enriched with a Fourier function, are introduced as a version of the LM test, which does not yield reliable results in the presence of slow and smooth breaks. Also, this novel approach offers several methodological advantages. Traditional unit root tests often fail to adequately account for structural breaks; however, the Fourier Panic Procedure can yield more reliable and robust results even when the time dimension is relatively short (Nazlioglu and Karul, 2017). Consequently, in cases where the sample period comprises fewer than

20 time points, as in this study, the Fourier Panic Procedure is likely to provide more stable and consistent outcomes compared to conventional panel unit root tests. The model in which unknown types of nonlinear breaks are expressed using the Fourier function is formulated as follows:

$$d_{i,t} = \alpha_i + \beta_{i,t} + \sum_{k=1}^{m_i} c_{i,k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{m_i} d_{i,k} \cos\left(\frac{2\pi kt}{T}\right) \quad (5)$$

In the constructed model, the term "m_i" represents the Fourier frequencies that need to be estimated individually for cross-sectional units, taking the values "$m_i = 1$" and "$m_i = 2$", according to Enders and Lee (2012).

Data Description

This study utilizes Türkiye 's Level 2 data, which is integrated with the NUTS system used by the European Union, based on fundamental values such as the more effective implementation of regional policies and the alignment of regional statistics at the international level. The datasets created by the Turkish Statistical Institute (TUİK) include data from 26 geographical regions that share socio-economic similarities. The data sets used for the analysis consist of annual data from the period 2004-2022. Like many developed and developing countries, Türkiye has been implementing regional development policies for many years to reduce regional inequalities. This study aims to assess whether income inequalities in Türkiye 's Level 2 regions show a trend of convergence within the framework of convergence dynamics. Table 2 below systematically presents the regional codes of Türkiye 's Level 2 regions and the provinces included in these regions.

Table 2. NUTS2 Regions of Türkiye

Nuts2 Region Code	Regions
TR10	İstanbul
TR21	Tekirdağ, Edirne, Kırklareli
TR22	Balıkesir, Çanakkale
TR31	İzmir
TR32	Aydın, Denizli, Muğla
TR33	Manisa, Afyon, Kütahya, Uşak
TR41	Bursa, Eskişehir, Bilecik
TR42	Kocaeli, Sakarya, Düzce, Bolu, Yalova
TR51	Ankara
TR52	Konya, Karaman
TR61	Antalya, Isparta, Burdur
TR62	Adana, Mersin
TR63	Hatay, Kahramanmaraş, Osmaniye
TR71	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir
TR72	Kayseri, Sivas, Yozgat
TR81	Zonguldak, Karabük, Bartın
TR82	Kastamonu, Çankırı, Sinop
TR83	Samsun, Tokat, Çorum, Amasya
TR90	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane
TRA1	Erzurum, Erzincan, Bayburt
TRA2	Ağrı, Kars, Iğdır, Ardahan
TRB1	Malatya, Elâzığ, Bingöl, Tunceli
TRB2	Van, Muş, Bitlis, Hakkâri
TRC1	Gaziantep, Adıyaman, Kilis
TRC2	Şanlıurfa, Diyarbakır

TRC3	Mardin, Batman, Şırnak, Siirt

The descriptive statistics of the per capita income variable are presented in Table 3.

Table 3. Descriptive Statistics of Per Capita Income Series

Region	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
TR10	16618.75	17326.22	20882.71	10331.55	2705.608	-0.593	2.838
TR21	11891.3	12539.28	14168.4	7572.197	1768.402	-0.883	3.04
TR22	7340.156	7493.138	9126.722	4561.969	1257.905	-0.478	2.476
TR31	11692.83	12317.76	14449.65	7233.145	1867.719	-0.736	2.935
TR32	8918.903	9192.802	10921.54	5919.417	1359.304	-0.458	2.479
TR33	8246.712	8843.4	10134.22	4647.829	1434.457	-0.956	3.332
TR41	11436.05	11769.03	14375.01	7126.699	1842.536	-0.533	2.813
TR42	12964.32	13353.12	15925.78	7717.908	2126.671	-0.841	3.141
TR51	14215.19	14550.45	18361.84	8784.42	2396.112	-0.401	2.718
TR52	7744.832	7868.28	9987.8	4419.908	1446.669	-0.621	2.93
TR61	10697.37	10466.58	13781.4	7047.44	2007.865	-0.231	2.152
TR62	7648.846	7999.094	9349.675	4611.118	1247.98	-0.815	3.06
TR63	6185.858	6600.688	7613.799	3665.116	1048.991	-0.91	2.996
TR71	6934.991	7169.048	8653.563	4010.515	1292.224	-0.67	2.634
TR72	7629.934	7831.924	9665.187	4531.464	1334.769	-0.559	2.802
TR81	7193.667	7556.498	9291.603	3837.9	1472.98	-0.689	2.717
TR82	7340.156	7493.138	9126.722	4561.969	1257.905	-0.478	2.476
TR83	6405.452	6254.195	8048.387	3790.016	1179.936	-0.469	2.38
TR90	6702.202	6609.447	8460.129	3905.493	1233.555	-0.418	2.474
TRA1	6370.622	6270.252	8370.04	3544.181	1266.281	-0.556	2.766
TRA2	4183.952	4180.983	5341.049	2323.625	832.969	-0.642	2.613
TRB1	5892.186	5796.384	7585.57	3338.793	1063.75	-0.662	3.091
TRB2	3854.539	3877.685	5100.864	2137.688	766.672	-0.486	2.871
TRC1	6192.912	6230.804	7819.133	3549.981	1205.588	-0.594	2.564
TRC2	4184.672	4187.164	5530.842	2851.642	732.036	0.04	2.005
TRC2	4184.672	4187.164	5530.842	2851.642	732.036	0.04	2.005
TRC3	4750.127	4852.25	6137.326	2541.611	949.594	-0.809	3

Note: Min. is minimum value of per capita income. Max. is maximum value of per capita income. Std. Dev. is the standard deviation.

Table 2 presents various descriptive statistics related to per capita income for NUTS-2 regions in Turkey. The statistics provided in the table offer a general overview of the central tendencies and distributional characteristics of income across these regions. The fact that nearly all skewness values in the table are negative indicates that the income distribution is left-skewed. This implies that the data set includes a small number of regions with very low-income levels, while most regions exhibit relatively high levels of per capita income. Additionally, the fact that most kurtosis values are around 3 indicates that the distribution is approximately normal.

EMPRICAL RESULTS

As mentioned in previous sections of the study, cross-sectional dependence in panel data analyses can negatively affect the results of standard panel data methods, reducing their reliability. To address this issue, the PANIC procedure, which accounts for both the common factors affecting the series and the idiosyncratic factors (cross-sectional dependencies) specific to each series, is employed to test whether Türkiye 's NUTS2 regions are involved in a convergence process.

Initially, the Fourier PANIC Test analysis results for m=1 and m=2 Fourier frequency values are systematically presented in Tables 4 and 5, respectively. Therefore, the null hypothesis and alternative

hypothesis for the PANIC procedure, which tests the stationarity hypothesis in the idiosyncratic and common components, are formulated as follows:

H_0: The series contains unit root, meaning that there is no long-run convergence of per capita income levels and no longer-run convergence.

H_1: The series are stationary, and a tendency for long-run convergence is observed.

When the Fourier PANIC procedure is applied, small sample sizes tend to reduce the power of the test; therefore, a 10% significance level is commonly used as the basis for statistical inference. Therefore, if the obtained p-value is smaller than the 0.1 significance level, the series is stationary, and the null hypothesis is rejected. This implies that the per capita income level in the relevant region shows a tendency for convergence. The primary distinction between the m=1 and m=2 Fourier frequency values can be said to highlight the nature of structural breaks. In this context, Table 4, created for the m=1 Fourier frequency value, presents the unit root analysis under simple structural breaks and results containing only one Fourier term, while Table 5, created for m=2, contains results for more complex structural breaks with two Fourier terms.

Table 4. Fourier PANIC Test Analysis Results (m=1 Specification)

Regions	Fourier Statistics	P-Values	Lags	Critical Values		
				%10	%5	%1
TR10	-2.7904	0.4625	0	-4.0381	-4.6071	-5.8648
TR21	-2.8850	0.3889	2	-3.9069	-4.4512	-5.7301
TR22	-4.1149	0.0848	1	-3.9844	-4.5308	-5.7953
TR31	-3.9404	0.0961	2	-3.9069	-4.4512	-5.7301
TR32	-4.3927	0.0648	0	-4.0381	-4.6071	-5.8648
TR33	-3.2146	0.3003	0	-4.0381	-4.6071	-5.8648
TR41	-7.1062	0.0028	3	-3.8058	-4.3684	-5.6691
TR42	1.1820	0.9998	2	-3.9069	-4.4512	-5.7301
TR51	-4.8666	0.0338	1	-3.9844	-4.5308	-5.7953
TR52	-2.4978	0.5971	0	-4.0381	-4.6071	-5.8648
TR61	-2.3691	0.6583	0	-4.0381	-4.6071	-5.8648
TR62	-2.8900	0.3870	2	-3.9069	-4.4512	-5.7301
TR63	-3.6469	0.1229	3	-3.8058	-4.3684	-5.6691
TR71	-4.8618	0.0308	2	-3.9069	-4.4512	-5.7301
TR72	-2.0514	0.8188	0	-4.0381	-4.6071	-5.8648
TR81	-5.2973	0.0185	1	-3.9844	-4.5308	-5.7953
TR82	-4.1149	0.0848	1	-3.9844	-4.5308	-5.7953
TR83	-5.8860	0.0069	3	-3.8058	-4.3684	-5.6691
TR90	-2.9554	0.3892	1	-3.9844	-4.5308	-5.7953
TRA1	-3.7022	0.1485	1	-3.9844	-4.5308	-5.7953
TRA2	-3.1138	0.3252	1	-3.9844	-4.5308	-5.7953
TRB1	-3.3109	0.2281	2	-3.9069	-4.4512	-5.7301
TRB2	-3.3967	0.2024	2	-3.9069	-4.4512	-5.7301
TRC1	-7.2384	0.0025	3	-3.8058	-4.3684	-5.6691
TRC2	-5.3488	0.0197	0	-4.0381	-4.6071	-5.8648
TRC3	-3.0548	0.3499	1	-3.9844	-4.5308	-5.7953

The results derived from the m=1 Fourier frequency values, as presented in Table 4, suggest that the per capita income levels of the provinces representing the statistical regions TR22, TR31, TR32, TR51, TR41, TR71, TR81, TR82, TR83, TRC1 and TRC2 exhibit a convergence trend at the 10% significance level. Conversely, for the statistical regions TR10, TR21, TR33, TR42, TR52, TR61, TR62, TR63, TR72, TR90, TRA1, TRA2, TRB1, TRB2 and TRC3 the null hypothesis cannot be rejected. Consequently, these regions do not participate in the convergence process at the same significance level. Based on the findings, it can be inferred that nearly half of the series exhibit a convergence tendency when analyzed using the m=1 Fourier PANIC procedure, which accounts for simple structural breaks. The results from the Fourier PANIC test, which incorporates two Fourier terms and accounts for more complex structures (or economic shocks), are presented in Table 5.

Table 5. Fourier PANIC Test Analysis Results (m=2 Specification)

Regions	Fourier Statistics	P-Values	Lags	Critical Values		
				%10	%5	%1
TR10	-6.9498	0.0161	2	-5.0447	-5.7308	-7.5810
TR21	-5.8113	0.0528	0	-5.1591	-5.8555	-7.7033
TR22	-2.9879	0.6411	0	-5.1591	-5.8555	-7.7033
TR31	-38.0017	0.0001	3	-4.9135	-5.6185	-7.5242
TR32	-7.6142	0.0085	3	-4.9135	-5.6185	-7.5242
TR33	-4.2905	0.2260	0	-5.1591	-5.8555	-7.7033
TR41	-3.3728	0.4914	0	-5.1591	-5.8555	-7.7033
TR42	2.2076	1.0000	2	-5.0447	-5.7308	-7.5810
TR51	-3.9132	0.2504	3	-4.9135	-5.6185	-7.5242
TR52	-3.8550	0.3313	0	-5.1591	-5.8555	-7.7033
TR61	-5.9998	0.0416	1	-5.1266	-5.8098	-7.6407
TR62	-5.5998	0.0513	3	-4.9135	-5.6185	-7.5242
TR63	-3.6384	0.3966	0	-5.1591	-5.8555	-7.7033
TR71	-3.3906	0.4508	2	-5.0447	-5.7308	-7.5810
TR72	-5.6227	0.0612	1	-5.1266	-5.8098	-7.6407
TR81	-5.0383	0.1086	1	-5.1266	-5.8098	-7.6407
TR82	-2.9879	0.6411	0	-5.1591	-5.8555	-7.7033
TR83	-4.2368	0.2351	1	-5.1266	-5.8098	-7.6407
TR90	-5.7753	0.0481	2	-5.0447	-5.7308	-7.5810
TRA1	-5.9869	0.0421	1	-5.1266	-5.8098	-7.6407
TRA2	-3.7357	0.3654	1	-5.1266	-5.8098	-7.6407
TRB1	-15.3584	0.0001	3	-4.9135	-5.6185	-7.5242
TRB2	-4.7537	0.1319	2	-5.0447	-5.7308	-7.5810
TRC1	0.1254	1.0000	2	-5.0447	-5.7308	-7.5810
TRC2	-4.7859	0.1277	2	-5.0447	-5.7308	-7.5810
TRC3	-11.8813	0.0001	1	-5.1266	-5.8098	-7.6407

Considering the results obtained, the null hypothesis is rejected for the statistical regions of TR10, TR21, TR31, TR32, TR61, TR62, TR72, TR81, TR90, TRA1, TRB1 and TRC3. Therefore, the per capita income series for these regions are found to be stationary, indicating that these regions are in a convergence process. On the other hand, for the regions of TR22, TR33, TR41, TR42, TR51, TR52, TR63, TR71, TR82, TR83, TRA2, TRB2, TRC1 and TRC2 the probability values greater than 0.1 lead to the acceptance of the null hypothesis, thus confirming the presence of a unit root. Consequently, it is concluded that these regions do not exhibit income convergence. When considering the results presented in Table 4 and Table 5 together, contrasting findings emerge. For instance, TR61 and TR62 statistical regions do not show convergence in Table 4, but in Table 5, per

capita income levels in these regions converge towards the average per capita income level. This discrepancy suggests that these regions only demonstrate convergence under complex, nonlinear influences. On the other hand, TR31, TR32, and TR81 regions exhibit convergence towards the average per capita income in both Table 4 and Table 5. Thus, these regions exhibit an income convergence tendency under both simple and complex nonlinear effects.

CONCLUSION

As previously discussed, regional income disparities in Türkiye, as in many other countries, give rise to various socio-economic challenges. This issue remains one of the foremost problems that Türkiye, like any other nation, must address. This study provides an opportunity to examine more closely the East-West divide in Türkiye, which can be viewed as a local counterpart to the North-South regional inequalities observed in the international literature. The results derived from the application of the relatively novel and promising Fourier PANIC procedure to Türkiye 's Level 2 regions indicate that a significant number of regions demonstrate a convergence trend towards the national average income level. However, it is also apparent that income disparities, particularly in the eastern regions, persist. Specifically, the statistical regions A2, which encompasses the provinces of Ağrı, Kars, Iğdır, and Ardahan, and B2, which includes Van, Muş, Bitlis, and Hakkâri, show no evidence of income convergence according to both the m=1 and m=2 Fourier PANIC test results. The ongoing tendency of income inequality, which may lead to various socio-economic issues such as inefficient resource utilization, underemployment, low welfare levels, unemployment, and social unrest, highlights the critical need for further targeted interventions aimed at improving these regions. Public investments, incentive policies to stimulate private sector involvement, as well as strategic infrastructure and development programs, could serve to support the aforementioned regions. Such measures would contribute to improving the growth rates of Türkiye 's Eastern regions, thereby amplifying their positive impact on the overall national growth trajectory.

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