The Validity of the Convergence Hypothesis within the Framework of the Middle Income Trap: New Evidence from the Fourier Panel KPSS Test

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Received: 4 December 2022; Accepted: 24 April 2026

Abstract: This study aims to test whether the convergence hypothesis is valid in the framework of the middle-income trap for the period 1960-2019 and 47 middle-income countries. Pesaran's (2007) CADF and CIPS tests, the structural break test, Carrion-i-Silvestre, Barrio-Castro and López-Bazo (2005) panel unit root test (PANKPSS), and, the Fourier Panel KPSS (FKPSS) stationarity (as suggested by Nazlioglu and Karul (2017)) tests were used in the empirical analysis. Accordingly, the convergence hypothesis is supported by the results of both the PANKPSS and FKPSS unit root tests. Given the panel CIPS unit root test result, the convergence hypothesis is not valid. As a common finding, the convergence hypothesis was valid for only 4 countries (Argentina, Indonesia, Iran Islamic Rep., and Lesotho). Moreover, the present study revealed that countries under the convergence hypothesis can overcome the middle-income trap, while diverging countries will remain in it.
Keywords: Middle-Income Trap, Income Convergence, Panel Unit Root Tests, Structural breaks, Economic Growth.
JEL: O11, F43, O47, C23.

1. Introduction

The Industrial Revolution marked a major structural transformation in economic history, during which high-productivity industrial activities gradually replaced low-productivity agricultural sectors. This transformation led to significant increases in productivity and income levels over time. In the early stages of development, many low-income countries grew rapidly by leveraging abundant labor and adopting existing technologies. However, after reaching middle-income levels, sustaining this growth and catching up with high-income economies became considerably more difficult.

Economic convergence is a central debate in growth economics, examining whether lower- and middle-income economies can catch up with advanced countries (Robert J. Barro and Xavier Sala-i-Martin 1992; N. Gregory Mankiw, David Romer, and David N. Weil 1992). This issue gained importance with the middle-income trip (MIT) hypothesis, which suggests that many developing economies experience rapid growth in the early stages of development but then face prolonged stagnation before

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reaching high-income status (Indermit Gill and Homi Kharas 2007; Barry Eichengreen 2011). Convergence toward advanced economies may indicate escape from the middle-income trap, whereas persistent divergence may reflect continuing structural weaknesses.

Even though both income convergence and the middle-income trap drew extensive empirical interest, these two concepts are often examined separately. Moreover, a significant portion of previous studies relies on conventional panel-data methods that do not adequately consider cross-sectional dependence, structural breaks, and country heterogeneity. Since middle-income economies are highly exposed to common global shocks, institutional transitions, and nonlinear growth patterns, neglecting these factors may produce biased or misleading inferences regarding long-run convergence dynamics (M. Hashem Pesaran 2007; Josep Lluís Carrion-i-Silvestre, Tomás del Barrio-Castro and Enrique López-Bazo 2005).

However, the present study investigates whether 47 middle-income countries converged toward the income levels of high-income economies over the period 1960-2019. Unlike many previous studies employing a single benchmark economy, this study uses the average income level of high-income countries as the reference group, thereby providing a broader and more representative measure of the global income frontier. Methodologically, second-generation panel unit root and stationarity tests, which allow for cross-sectional dependence, heterogeneity, and both sharp and gradual structural shifts, were employed in this study.

The present study contributes to the literature from three main aspects. First, while income convergence is generally analyzed within the broader framework of economic growth, this study evaluates this subject directly from the perspective of the middle-income trap. Second, instead of comparing countries with a single reference economy, it employs the average of high-income countries, thereby reducing potential benchmark bias. Third, beyond traditional panel unit root approaches, it provides more robust evidence through advanced econometric techniques that explicitly consider cross-sectional dependence, structural breaks, and heterogeneity. In this respect, the present study aims to contribute to the literature both methodologically and empirically. The remainder of the paper is organized as follows. Section 2 outlines the theoretical framework, Section 3 discusses the concept of the middle-income trap. Section 4 reviews the empirical literature. Section 5 describes the data and methodology, while Section 6 presents the empirical findings. Finally, Section 7 concludes and discusses policy implications.

1.1. Research Question and Hypotheses

Research Question:

Do middle-income countries converge toward the income levels of high-income economies in the long run, or do they remain trapped at middle-income levels?

Hypotheses:

In line with this question, the economic and econometric hypothesis of this study is formulated as follows:

H_0: Middle-income countries converge toward the income levels of high-income economies.

H_1: Middle-income countries do not converge toward the income levels of high-income economies.

2. Income Convergence

Conceptually, income convergence means that income growth will tend to be slower in regions with above-average income and faster in regions with below-average income. Thus, in the long run, the relative income differences between locations (nations, states, cities) will shrink; in other words, incomes will converge. The income convergence hypothesis originates from the Neo-Classical model of economic growth, which is based on the hypothesis of diminishing returns and combines labor and capital mobility with the maximizing behavior of workers and owners. It is argued that differences in labor or capital returns across countries will decrease over time (Matthew P. Drennan, José Lobo and Deborah Strumsky 2004:583). In neoclassical growth models, a country's per capita growth rate tends to be inversely proportional to its initial per capita income. In particular, if countries are similar in structural parameters, such as preferences and technology levels, then poor countries will tend to grow faster than rich ones. That is, in neoclassical growth theory, differences in per capita income across economies are predicted to decrease or disappear over time. This situation is generally referred to as the convergence hypothesis (Syfun Nahar and Brett Inder, 2002: 2011).

According to the critical assumption regarding the diminishing marginal returns of capital in the neoclassical growth theory, also known as the Solow model, the growth process in an economy leads to a steady state at the end of the period, where output per capita, capital stock, and consumption grow at a constant rate that is equal to the rate of technological progress, which is accepted to be exogenous. With this assumption, the concept of convergence, which can be explained in two ways, was proposed (Nazrul Islam, 1995: 1129). The first one is convergence in terms of income level. Accordingly, if countries are similar in terms of preferences and technology levels, then their steady-state income levels will be the same, and they will all tend to reach this per capita income level over time. The second one is convergence in terms of growth rate. Since the steady-state growth rate in the Solow model is determined by the rate of exogenous technological progress, all countries will eventually converge to the same steady-state growth rate, provided that technology is a public good shared equally. Even though neoclassical growth theories made a significant contribution to the economic literature by taking technology into consideration, this factor lost its explanatory power because it is assumed to be exogenous, and the gap between the rich and the poor did not decrease over time.

The endogenous growth theories developed under the leadership of Paul M. Romer (1986) and Robert E. Lucas (1988), as a critique of neoclassical growth theories, drew attention to the endogenization of technological change and the convergence of rich and poor countries. According to this view, which has been the dominant view since the 1980s, the source of long-run growth is technology. The factors affecting technological development are human capital and R&D. as emphasized by Romer (1986:1003), instead of decreasing, the investment rate and the rate of return on capital may increase together with increases in capital stock. The convergence of output per capita across countries is not necessary, and growth may be consistently slower or even nonexistent in less developed countries. This is not due to any exogenously determined technical changes or differences between countries because, in this theory, the preferences and the technology factor are static and the same. The assumption of increasing rather than decreasing returns strengthened the validity of new growth theories. Therefore, it is argued that the income convergence hypothesis across countries may not always hold.

The differences in opinion between the neoclassical growth model and endogenous growth theories paved the way for empirical research on income convergence. The convergence hypothesis, which was discussed theoretically, was first tested in a pioneering study carried out by William J. Baumol (1986). His study suggested an inverse correlation between the initial and subsequent per capita income levels. It was stated that if the relationship between the variables were negative, then there would be convergence; if positive, divergence. As stated by J. Bradford De Long (1988), the study carried out Baumol (1986) lost its validity due to biased sample selection, although it provided an explanation that supports the convergence phenomenon from various perspectives. Then, the studies carried out by Robert. J. Barro, Sala-i-Martin, Xavier, Blanchard, Oliver. J., & Hall, Robert. E. (1991), Barro and Sala-i-Martin (1992), and Mankiw, Romer, and Weil (1992), which are among the first empirical analyses of the concept of convergence, aimed to fill the gap in the study carried out by Baumol (1986) by conducting regression analysis. In these studies, convergence was estimated using a coefficient called β-convergence within the framework of the neoclassical growth model. Accordingly, if the partial correlation between income growth and the initial value in a given period is negative, then poor countries grow faster than rich countries, and the convergence hypothesis holds. Another convergence coefficient developed in the studies carried out by Barro et al. (1991) and Barro and Sala-i-Martin (1992) is the σ coefficient. According to σ-convergence, the standard deviation of the per capita income distribution in a group of economies will decrease continuously over time (Andrew T. Young, Matthew J. Higgins, and Daniel Levy, 2008: 1083; Katerina Dvoroková, 2014: 89).

Various approaches to convergence emerged together with the development of empirical methodologies. Another approach explaining long-term output movements, developed under the leadership of Andrew B. Bernard and Steven N. Durlauf (1995), is stochastic convergence (Quing Li and David Papell, 1999: 268). The stochastic convergence approach assumes that shocks to the ratio of a particular country's income to the mean income of a group of countries are temporary rather than permanent. Accordingly, stationary trends in panel unit root tests are interpreted as evidence of convergence. Recently, panel data-based unit root tests were used to conduct stochastic convergence analysis (Josep Lluís Carrion-i-Silvestre and Vicente German-Soto, 2009:307; John W. Dawson and Mark C. Strazicich, 2010:910; Sefa Awaworyi Churchill, John Inekwe, and Kris Ivanovski, 2020:3).

In Bernard and Durlauf (1995), convergence between countries i and j is defined as the equality of their long-run per capita output estimates at a fixed time *t*. This definition also indicates that the convergence hypothesis is not valid if the $x_{it} \equiv y_{it} - y_{jt}$ difference does not converge to a constrained stochastic process, and it is expressed as follows:

$$\lim_{k\to\infty} E\left(y_{i,t+k} - y_{j,t+k} \middle| I_t\right) = 0 \qquad (1)$$

In equation (1), y_i represents the per capita income of country i, while y_j represents the per capita income of country j. I_t refers to the information available at period *t*.

In the study carried out Peter E. Robertson and Longfeng Ye (2013:3), income convergence is defined as follows in the context of the middle-income trap:

$$\lim_{k\to\infty} E\left(x_{i,t+k} \middle| I_t\right) = \bar{x}_i \qquad (2)$$

$$\underline{y}_{r,t} - y_{r,t} \le \bar{x}_i \le \overline{y}_{r,t} - y_{r,t}$$

In equation (2), $\bar{x}_i$ is constant. This equation shows that country i is in the middle-income trap. Therefore, it is quite important because if $x_{i,t}$ is stationary, then the long-run mean $\bar{x}_i$ may differ significantly from the current value of $x_{i,t}$ or its arithmetic mean calculated over some limited range, due to short-run dynamics. Subsequently, Longfeng Ye and Peter E. Robertson (2016) improved their study. As they stated, countries must have the same expected growth performance in terms of growth rate and income level for the $x_{it} \equiv y_{it} - y_{jt}$ difference when $t \to \infty$ expressed in the study carried out by Bernard and Durlauf (1995) to converge to zero. If a country is in the middle-income trap, then the equilibrium value of x_{it} is expected to be equal to a non-zero constant.

Within the framework of the unit root test, if the income difference series is found to be stationary (i.e., no unit root), then this supports the existence of the income convergence hypothesis. Conversely, if a unit root is detected, then the convergence hypothesis is not supported.

As an alternative to Bernard and Durlauf (1995), in the studies carried out by Peter. C. Phillips and Donggyu, Sul's (2007) and Peter. C. Phillips and Donggyu, Sul (2009), the concept of convergence is defined as the $\lim_{t\to\infty} E\left(y_{it} \middle| y_{jt}\right) = 1$ while $t\to\infty$. Accordingly, all countries with the same growth rate (that is, their logarithmic per capita income levels are parallel) will meet the relative convergence criterion $y_{it}/y_{jt} = 1$ regardless of their income levels. Thus, this concept of convergence falls short of per capita income differences between countries, which is critical to the concept of a middle-income trap because Phillips and Sul's (2007) convergence test does not explain the long-term income level for each country, but only the distribution of these income levels for a certain group (Ye and Robertson, 2016:175).

The present study examines whether the per capita income of 47 middle-income countries during 1960-2019 converged toward that of high-income countries and whether these countries could overcome the middle-income trap at this level. Based on the study carried out by Ye and Roberston (2016), x_{it} difference series was created in this study. If this difference is stable, then it is accepted that the countries are converging and can overcome the middle-income trap.

3. Middle-Income Trap

While the theoretical and empirical discussions on convergence continued, a new concept known as "middle-income trap (MIT)" emerged in the economic literature in the 2000s. This concept recently started drawing attention, especially in studies on income convergence. There are various definitions of the MIT. As a theoretical concept and phenomenon, the "MIT" was defined by World Bank experts Gill and Kharas (2007) based on long-term observations of historical economic and social transition practices in many countries. Basically, it is expressed as a slowdown or stagnation in the economic growth of middle-income economies, constrained by the existing growth mechanism (Xudong Chen and Guoqiang Tian, 2014: 348). As emphasized in the World Bank report prepared by Pierre-Richard Agénor, Otaviano Canuto, and Michael Jelenic (2012), many countries reached middle-income status quickly in the post-war period. Still, very few reached the level of high-income economies. In contrast, after the first period of rapid growth, many countries experienced a sharp slowdown in growth and productivity, falling into the so-called "MIT". As stated by Linda Glawe and Helmut Wagner (2016: 507-508), the concept of MIT commonly refers to countries that exhibit rapid growth performance, have reached the status of middle-income countries, but cannot reach the level of high-income countries, which are called developed countries, and remain in the middle-income range.

Even though the MIT is defined theoretically, some empirical studies defined the category for classifying middle-income countries. The MIT was concretely defined by Eichengreen (2011) as a per capita income level reaching $16,000, reaching 58% of the per capita income of the USA, and the share of the manufacturing industry in the national income of the countries being approximately 23%. Taking a different approach, in their empirical studies, Jesus Felipe, Arnelyn Abdon, and Utsav Kumar (2012) divided countries into two: the low-MIT and the high-MIT. In addition, they classified countries considering a certain per capita income scale. In the study carried out by Shekhar Aiyar, Romain A. Duval, Damien Puy, Yiqun Wu, and Longmei Zhang (2013), in line with the one carried out by Felipe Abdon and Kumar (2012), middle-income countries were categorized between lower limits of 1000, 2000, and 3000 dollars and upper limits of 12,000 and 16,000 dollars.

Despite various conceptual definitions of the MIT, the common point is that middle-income countries fail to reach the level of high-income countries for many years. While the concept is defined as a level of income per capita not exceeding a certain point when the macro dimension is taken into account, the importance of solving the structural problems experienced in the micro or regional dimension is emphasized (Gizem Akbulut and Barış Yıldız, 2017: 69). Considering the definitions and explanations, many middle-income countries, including Türkiye, remain within a certain income range. In this context, the question of whether middle-income countries will converge to the income level of high-income countries within the framework of the MIT constitutes the starting point of this study.

4. Literature Review

The empirical literature on income convergence evolved substantially over time, both in terms of methodological approaches and conceptual frameworks. While the early studies primarily tested the convergence hypothesis in isolation, more recent contributions increasingly linked convergence dynamics to the MIT. Despite this progress, the literature remains fragmented, with different strands often developing independently.

To provide a clearer and more systematic overview, the previous studies can be grouped into three main categories: (i) traditional convergence studies, (ii) convergence analyses within the framework of the MIT, and (iii) studies employing alternative approaches and methodologies.

Table 1. Literature Summary

Author(s)	Country Group	Method	Approach Type	Findings
Baumol (1986)	16 countries	Cross-sectional regression	Traditional convergence	Convergence
Reza and Zahra (2008)	EU countries	LLC, IPS, MW panel tests	Traditional convergence	Absolute convergence
Tunali and Yilanci (2010)	MENA	ADF, CHLL	Traditional convergence	Divergence
Bozkurt et al. (2014)	Türkiye	ARDL	Convergence in the context of the MIT	Mixed evidence
Bozkurt, Sevinç and Haktan (2016)	Upper-middle-income countries	CADF, CIPS	Convergence in the context of the MIT	Some countries converge; others diverge.
Furuoka et al. (2019)	14 countries	FADF-SB, SUR-ADF	MIT analysis	MIT is likely valid for most countries; not valid for some; inconclusive for the rest
Lee (2019)	110 countries	Growth analysis	Alternative approach	MIT not valid
Manga, Ballı, and Güreşçi (2019)	Türkiye	Structural-break test	MIT analysis	MIT not valid
Öztürk and Tay Bayramoğlu (2019)	8 countries	Catch-up index; panel unit root (with structural breaks)	Alternative approach	MIT not valid
Konat (2021)	Balkan countries	Structural-break panel unit root test	MIT analysis	MIT valid
Yıldız and Bayraktar (2021)	Fragile Five	ADF, ZA, LP	Convergence in the context of the MIT	MIT is valid for some countries

Peker and Çak (2022)	22 countries	Fourier ADL	MIT analysis	MIT valid
Saglam and Onkan (2025)	European regions	Fourier KPSS	Regional approach	Evidence supports regional income convergence

Source: Compiled by the author

Table 1 provides a structured overview of the empirical literature on income convergence and the MIT. Findings are fragmented and method-dependent. While traditional approaches tend to support convergence, more recent studies that incorporate structural breaks, cross-sectional dependence, and nonlinearities reported more nuanced and often conflicting results. This suggests conventional methods cannot fully capture convergence dynamics, highlighting the need for more sophisticated empirical frameworks. Furthermore, the heterogeneity observed across countries implies that the MIT is not a uniform phenomenon, but rather a context-specific process shaped by structural and institutional differences.

4.1. Traditional Studies on Income Convergence

The early literature on convergence primarily examines whether income disparities across countries decline over time. The pioneering study carried out by Baumol (1986) provides initial empirical evidence suggesting that per capita incomes tend to converge among industrialized countries. This finding stimulated many empirical studies examining convergence using cross-country regressions and panel data techniques.

Subsequent studies, such as those carried out by Barro et al. (1991) and Barro and Sala-i-Martin (1992), formalized the concept of β-convergence, arguing that poorer economies tend to grow faster than richer ones. In addition, σ-convergence was introduced as a complementary concept, focusing on the reduction in income dispersion over time.

Empirical applications of these approaches yielded mixed results. For instance, Ranjpour Reza and Karimi Takanlou Zahra (2008), using panel unit root tests for European Union countries, found evidence supporting absolute convergence. In contrast, Çiğdem Börke Tunali and Veli Yilanci (2010) reported divergence among MENA countries, highlighting the importance of regional heterogeneity and structural differences. These conflicting findings suggest that convergence is not a universal phenomenon and depends heavily on country-specific characteristics.

4.2. Convergence Analysis in the Context of the MIT

More recent studies examined convergence within the framework of the MIT. In this context, convergence is interpreted as an indicator of a country’s ability to transition from middle-income to high-income status.

Eda Bozkurt et al. (2014) provide evidence that the Turkish economy exhibits convergence toward high-income countries. In a broader sample of upper-middle-income countries, Eda Bozkurt, Haktan Sevinc, and Erol Cakmak (2016) show that convergence patterns are heterogeneous, with some countries converging while others diverge. Similarly, Fumitaka Kiew Furuoka, L. Pui, Chinyere M. R. Ezeoke, Ray I.

Jacob and OlaOluwa S. Yaya (2019) and Ayşe Esra Peker and Merve Nur Çak (2022) reported that many countries remain at risk of being trapped at middle-income levels.

On the other hand, some studies offer more optimistic findings. For example, Furkan Yıldız and Yüksel Bayraktar (2021) reported that only a limited number of countries fall into the MIT. These differing results underscore the sensitivity of empirical findings to model specification, country selection, and methodological choices.

This literature shows convergence is not only a statistical result but is closely linked to structural transformation, institutional quality, and long-term growth dynamics.

4.3. Alternative Approaches and Methodological Differences

A third group of studies approaches the MIT from alternative perspectives, moving beyond standard convergence frameworks. For instance, Jong-Wha Lee (2019) defines the MIT in terms of growth slowdowns rather than income convergence and concludes that the trap is not a universal phenomenon. Other studies employed different empirical strategies. Zafer Öztürk and Arzu Tay Bayramoğlu (2019) used a catch-up index approach, while Müge Manga, Esra Ballı and Gülçin Güreşçi (2019) incorporated structural breaks into their analysis and found no evidence supporting the MIT for Türkiye. Similarly, Yagmur Saglam and Ozkan Onkan (2025) focused on regional convergence dynamics, emphasizing the spatial dimension of income disparities.

These methodological differences play an important role in shaping empirical results. In particular, the treatment of structural breaks, cross-sectional dependence, and heterogeneity significantly affects the validity of convergence tests. Moreover, the widespread use of a single benchmark country, typically the USA, raises concerns about potential bias in comparative analyses.

Taken together, the literature reveals three key limitations. First, despite their strong conceptual linkage, convergence and the MIT are often analyzed separately. Second, many studies rely on conventional methods that do not adequately take cross-sectional dependence and structural breaks into consideration. Third, the use of a single benchmark country may limit the robustness and generalizability of findings.

4.4. Evaluation of the Literature and the Contribution of this Study

This study addresses these limitations in several ways. First, it integrates the convergence hypothesis with the MIT framework, providing a unified analytical perspective. Second, it employs advanced panel unit root tests that take cross-sectional dependence, structural breaks, and heterogeneity into consideration. Third, instead of using a single reference country, it evaluates middle-income countries relative to the average of a broad group of high-income economies, thereby reducing potential benchmarking bias. In this respect, this study aims to contribute to the literature from both methodological and empirical aspects.

5. Data and Methodology

This study covers 47 middle-income countries and the period of 1960-2019 because data availability is limited across the countries and periods included in the sample. GDP per capita (2010, constant) data was used as an indicator. The data were obtained from the "World Development Indicators Online Database". The presence of stochastic convergence was tested using panel unit root tests on the logarithmic differences between each country's GDP per capita and the GDP per capita of high-income countries. The main characteristics of the dataset, including mean, standard deviation, and distribution properties, are presented in Table A1 in the Appendix.

The group of countries examined in this study was selected from among the economies where discussions about the MIT are most intense. These countries, despite having reached a certain income level, struggle to transition into the high-income group and are therefore at the center of the literature on the "MIT". Three key criteria were considered in selecting the countries included in the sample:

- Data continuity: The availability of uninterrupted data throughout the period under review
- Comparability: Countries being at a similar level of development
- Representativeness: Covering different geographic regions to produce generalizable results

As with many empirical studies, the dataset used in this study has certain limitations. First, differences in data collection methods across countries can lead to measurement errors. In addition, the lack of data continuity for some countries limited the sample size. The sample constructed in accordance with these criteria reflects regional diversity and demonstrates a structure that can make a meaningful contribution to discussions on the MIT.

The key variable used in this study (x_{it}) is defined as the difference ($x_{it} = lny_{it} - lny_{jt}$) between the natural logarithm of the GDP per capita for each middle-income country (lny_{it}) and the natural logarithm of the average GDP per capita for the reference group of high-income countries (lny_{jt}). If this difference is stationary, then it indicates convergence; if it contains a unit root, then it indicates divergence (and thus a MIT).

5.1. Cross-Section Dependency Test

Cross-sectional dependence must be tested before the panel root tests. Ignoring cross-sectional dependence may bias results. Therefore, cross-section dependency tests developed by Trevor S. Breusch and Adrian R. Pagan (1980) and M. Hashem Pesaran, Aman Ullah, and Takashi Yamagata. (2008) were used in this study.

The Lagrange multiplier (LM) test, developed by Breusch and Pagan (1980), can be utilized when the time dimension (T) exceeds the cross-sectional dimension (N). The LM test statistic for this is as follows:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \sim X^2 N(N-1)/2 \quad (3)$$

In the study carried out by Pesaran et al. (2008) for panel data models with extrinsic regressors and normal errors, it is recommended to use the deviation-corrected LM (LM_{adj}) test, which utilizes the absolute mean and variance of the LM statistic. The LM_{adj} test statistic is as follows:

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{v_{Tij}} \sim N(0,1) \quad (4)$$

The hypotheses regarding the cross-sectional dependency tests are as follows:

H_0: Cov(u_{it}, u_{jt})=0, for all t and i≠j
H_1: Cov(u_{it}, u_{jt})≠0, for at least 1 i≠j

5.2. Stationary Tests

In the study carried out by Pesaran (2007), a different perspective was developed to address the cross-sectional dependence problem. Instead of basing the unit root tests on deviations from the predicted factors, the cross-sectional problem was addressed by adding the cross-sectional averages of the lagged levels and the first differences of the individual series to the standard DF (or ADF) regressions. Standard panel unit root tests are based on simple averages of individual "Cross-Sectional Extended ADF (CADF)" statistics. Individual CADF statistics or rejection probabilities could be obtained by making use of the modified t-bar test recommended by Im et al. (2003).

The estimated model for the CADF test statistics values is as follows:

$$y_{it} = (1 - \phi_i)\mu_i + \phi_i y_{i,t-1} + u_{it}, i = 1, \dots, N; t = 1, \dots., T \quad (5)$$

$$u_{it} = \gamma_i f_t + \varepsilon_{it} \quad (6)$$

In Equation (6), f_t shows the unobserved joint e_i. It indicates the individual-specific error.

Equations (5) and (6) can also be written as

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{it} \quad (7)$$

In equation (3), it can be explained as $\alpha_i = (1 - \phi_i)\mu_i, \beta_i = -(1 - \phi_i)$ and $\Delta y_{it} = y_{it} - y_{i,t-1}$.

The hypotheses regarding the CADF unit root test are as follows:

$$H_0: \beta_i = 0 \; for \; all \; i \quad (8)$$

$$H_1: \beta_i < 0, i = 1,2, \dots, N_1, \beta_i = 0, i = N_1 + 1, N_1 + 2, \dots, N \quad (9)$$

The CIPS test is obtained by taking the cross-sectional averages of the individual CADF tests. The CIPS unit root test is calculated as follows:

$$CIPS\,(N,T) = t - bar = N^{-1} \sum_{i=1}^{N} t_i\,(N,T) \quad (10)$$

The null hypothesis is tested by comparing the calculated CADF and CIPS test statistics with the critical values reported by Pesaran (2007). If the calculated CADF and CIPS test statistics values are absolutely higher than the critical table values, then the null hypothesis is rejected. In other words, the H_1 hypothesis, which states that the series is stationary, is accepted.

As a second method in the analysis, the panel (PANKPSS) unit root test developed by Carrion-i-Silvestre, Barrio-Castro and López-Bazo (2005), which allows for structural breaks, was applied. The PANKPSS unit root test considers both structural breaks and cross-sectional dependence. Since the asymptotic distribution of the panel KPSS test is derived under the assumption of cross-sectional independence (Kaddour Hadri, 2000), the distribution of the test statistic may change if there is contemporaneous correlation among panel units. Therefore, in the literature, critical values are obtained using the bootstrap procedure to prevent cross-sectional dependence from biasing the test results. As emphasized by Carrion-i-Silvestre, Barrio-Castro and López-Bazo (2005), it allows for different numbers of structural breaks at different dates for each cross-sectional unit in the panel. However, the test procedure is based on the panel-data unit-root version of the KPSS test developed by Hadri (2000).

The stochastic process of the PANKPSS unit root test in a fixed and trended model is as follows:

$$y_{it} = \alpha_{it} + \beta_i t + \varepsilon_{it} \quad (11)$$

$$\alpha_{it} = \sum_{k=1}^{m_i} \theta_{ik} D\left(T_{bk}^i\right)_t + \sum_{K=1}^{m_i} \gamma_{ik} DU_{ikt} + \alpha_{it-1} + v_{it} \quad (12)$$

The $v_{it} \sim i.i.d.(0, \sigma_{vi}^2)$ and $\alpha_{i0} = \alpha_i$ in Equation (12) represents a constant, i=1,…,N represents the cross-sectional dimension of the panel data, and t=1,…,T represents the time dimension. $D\left(T_{bk}^i\right)_t$ and DU_{ikt} dummy variables, $D\left(T_{bk}^i\right)_t = 1$ for t=T_{bk}^i+1, if otherwise 0, and $DU_{ikt} = 1$ for t>T_{bk}^i, and 0 if otherwise. T_{bk}^i, shows the break point, which represents k. break date for each i. unit; k=1,…, m_i, $m_i \geq 1$. It is assumed that $\{\varepsilon_{it}\}$ and $\{v_{it}\}$ are independent of each other. The hypothesis regarding the PANKPSS unit root test is as follows:

$$H_0: \sigma_i^2 = 0, \text{(i=1,…,N)} \quad (13)$$

Assuming the variance for each unit is 0, equations (12) and (13) can be rewritten as follows:

$$y_{it} = \alpha_i + \sum_{k=1}^{m_i} \theta_{ik} DU_{ikt} + \beta_i t + \sum_{K=1}^{m_i} \gamma_{ik} DT_{ikt}^* + \varepsilon_{it} \quad (14)$$

DT_{ikt}^* is a dummy variable where $t - T_{bk}^i$, for t>T_{bk}^i, 0 otherwise, and k=1,…, m_i, $m_i \geq 1$. Here, the structural break effects of the units are expressed. $\beta_i \neq 0$ indicates that the changes in the mean are affected by structural breaks, while $\gamma_{ik} \neq 0$ indicates the changes in the units in the time trend.

The test statistic developed by Hadri (2000), which is used to test the null hypothesis that the panel is stationary, is as follows:

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\widehat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{it}^2 \right) \quad (15)$$

$\hat{S}_{it} = \sum_{j=1}^{t} \hat{\varepsilon}_{ij}$, in Equation (15) is the partial sum of the residuals obtained from the LS estimation of the model in Equation (14). $\widehat{\omega}_i^2$, represents a consistent estimator of ε_{it} long-run variance, $\omega_i^2 = \lim_{T\to\infty} T^{-1} E(S_{it}^2)$, i=1,…,N. With this equation, long-term variance is allowed to vary across heterogeneous units, i.e., heterogeneity.

The panel multiple structural break test statistics used to test the null hypothesis are as follows:

$$Z(\lambda) = \frac{\sqrt{N}(LM(\lambda) - \bar{\xi})}{\bar{\varsigma}} \quad (16)$$

In equation (16), ξ and $\bar{\varsigma}$ are the arithmetic mean of expected values and variances for each cross-section, respectively. In other words;

$$\xi = N^{-1} \sum_{i=1}^{N} \xi_i \text{ and } \bar{\varsigma}^2 = N^{-1} \sum_{i=1}^{N} \varsigma_i^2 \quad (17)$$

Traditional tests assume linear structural breaks. However, economic crises or policy changes, for example, are not always abrupt; sometimes they can be gradual or smooth. Fourier functions capture these structures without predefining break dates. Unlike traditional stationarity tests, Ralf Becker, Walter Enders, and Junsoo Lee (2006) introduced the Fourier KPSS (FKPSS) stationarity test by incorporating Fourier functions. The FKPSS stationarity test is effective at detecting both sudden and slow structural breaks. However, the location, number, and shape of the detected structural breaks do not negatively affect the test's reliability (Veli Yilanci, 2017: 56). Following the model recommended by Becker, Enders, and Lee (2006), Saban Nazlioglu and Cagin Karul (2017) developed the FKPSS test. In addition to taking structural breaks into account, this test allows for cross-sectional dependence and heterogeneity across sections of the panel. In their study, the test procedure was defined as a combination of the time-series stationarity test developed by Becker, Enders and Lee (2006), with structural breaks modeled using the Fourier approach. The panel stationarity test proposed by Kaddour Hadri and Eiji Kurozumi (2011, 2012), which uses a common factor structure to explain cross-sectional dependence.

The difference between the model developed by Nazlioglu and Karul (2017) and the Becker et al. (2006) model is the common factor. The data generation process in the study carried out by Nazlioglu and Karul (2017) is as follows:

$$y_{it} = \alpha_i(t) + r_{it} + \lambda_i F_t + \varepsilon_{it} \tag{18}$$

$$r_{it} = r_{it-1} + u_{it} \tag{19}$$

In the equation, i=1,…..,N shows the cross-sectional dimension, t=1,…..,T time dimension, r_{it} random walk process with the initial value r_{i0}=0 for each i. ε_{it} and u_{it} represent an independent and identical distribution error term with constant variance. F_t represents the unobservable common factor, and λ_i the weight of each factor. ε_{it}, F_t, and λ_i show the independent distribution for each i.

When modeling structural changes using the Fourier approach, the panel stationarity test with cross-sectional dependence introduced by Hadri and Kurozumi (2011, 2012) is explained by the common factor structure. The view proposed by Pesaran (2007), by taking the cross-sectional averages of the model, was referred to as a common factor (F_t) by Nazlioglu and Karul (2017). Even if cross-sectional dependence is detected, the F_t is not actually known. It should therefore be replaced by an estimate (Nazlioglu and Karul, 2017: 189-190):

$$\bar{y}_t = Z_t'\bar{\delta} + \bar{r}_t + \bar{\lambda} F_t + \bar{\varepsilon}_t \tag{20}$$

By assuming $\bar{\lambda}\neq 0$ for fixed N as N → ∞, solving Eq. (20) for F_t gives $F_t = (\bar{y}_t - Z_t'\bar{\delta} - \bar{r}_t - \bar{\varepsilon}_t)/\bar{\lambda}$. The result obtained using this solution is as follows:

$y_{it} = Z_t'\tilde{\delta}_i + \tilde{\lambda}_i \bar{y}_t + e_{it}$ where $\tilde{\delta}_i = \delta_i - \overline{\delta \tilde{\lambda}_i}$, $\tilde{\lambda}_i = \frac{\lambda_i}{\bar{\lambda}}$ and $e_{it} = r_{it} - \tilde{\lambda}_i \bar{r}_t + \varepsilon_{it} - \tilde{\lambda}_i \bar{\varepsilon}_t$ that $\bar{r}_t$ and $\bar{\varepsilon}_t$ approach to zero under the null hypothesis. This result implies that the unobserved common factor F_t can be proxied by the cross-sectional average of the dependent variable, denoted as $\bar{y}_t$. Accordingly, for each cross-sectional unit, y_{it} is regressed on Z_t and $\bar{y}_t$.

In general, both the stationary and the slope of the time trend can fluctuate over time. If the trend function is nonlinear, it can be approximated by the Fourier approximation:

$$\alpha_i(t) = \alpha_i + b_i t + \gamma_{1t} \sin\left(\frac{2\pi kt}{T}\right) + \gamma_{2i} \cos\left(\frac{2\pi kt}{T}\right) \tag{21}$$

Individual statistics developed by Becker et al. (2006) based on the KPSS test, which allows the Fourier frequency, are defined as follows:

$$\eta_i(k) = \frac{1}{T^2} \frac{\sum_{t=1}^{T} \tilde{s}_{it}(k)^2}{\tilde{\sigma}_{\varepsilon t}^2} \tag{22}$$

$\tilde{s}_{it}(k) = \sum_{j=1}^{t} \tilde{\varepsilon}_{ij}$ in Equation 22 represents the partial sum of the residuals obtained from the LS estimation of Equation 1. $\tilde{\sigma}_{\varepsilon t}^{2}$ represents the estimation of the long-run variance of ε_{it} and is defined as follows:

$$\sigma_{\varepsilon t}^{2} = \lim_{T \to \infty} T^{-1} E(S_{it}^{2}) \tag{23}$$

The Fourier panel statistic (k), which is developed by averaging the individual statistics, can be defined as follows:

$$FP(k) = \frac{1}{N} \sum_{i=1}^{N} \eta_i(k) \tag{24}$$

In the study carried out by Nazlioglu and Karul (2017), it was shown that when $T \longrightarrow \infty$ and $N \longrightarrow \infty$, under the null hypothesis, Lindberg-Levy central limit theorem approaches the standard normal distribution with the mean of $FP(k)$, $\xi(k)$ and variance of ς 2(k). In this context, the test statistic is calculated as follows:

$$FZ(k) = \frac{\sqrt{N}(FP(k) - \xi(k))}{\zeta(k)} \sim N(0,1) \tag{25}$$

In accordance with the methodological approach, the results achieved in this study were cross-validated by combining the CADF (for horizontal section dependence), PANKPSS (for sudden fractures), and FKPSS (for gradual fractures) tests. This methodological diversity demonstrates that our findings are not dependent on any single type of test.

6. Empirical Evidence

Descriptive statistics for the LNDIFDATA series (the logarithm of the difference in GDP per capita between middle-income and high-income countries) used in the analysis are presented in Table A1. Accordingly, the statistics show that the income gap between middle-income and high-income countries varies widely (-5.02 to -0.04), indicating substantial heterogeneity in the sample. Negative skewness and kurtosis values reveal the distributional characteristics of the series. At the same time, the Jarque-Bera test results indicate the presence of nonlinear structures in the series, supporting the use of advanced Fourier-type econometric techniques in the study.

Table A2 presents the results of the cross-section dependency tests. Accordingly, the H_0 hypothesis is strongly rejected. Given the results presented in Table A2, the LM and LM_{adj} test statistics were found to be significant, indicating strong cross-sectional dependence among the series.

6.1. Discussion and Analysis of Statistical Findings

The unit root test results presented in Tables 3A, 4A, and 5A reveal an interesting pattern that varies depending on methodological approach. While the CADF and CIPS tests, which address structural breaks only to a limited extent, indicate divergence across the panel, the PANKPSS and FKPSS tests, which model both sudden and gradual breaks, yielded results favoring convergence at the panel level.

This methodological divergence can be interpreted economically as follows: The convergence process of middle-income countries toward high-income economies does not follow a linear path. The failure of CADF/CIPS tests to detect convergence may originate from these tests interpreting deep structural transformations and regime shifts in income series as "unit roots" (permanent shocks). In contrast, Fourier-based FKPSS results reveal that these changes are actually "smooth-transition structural breaks" within a long-term convergence trend. This finding methodologically confirms that the MIT is not a static barrier but a dynamic, surmountable process.

6.2. Country-Specific Heterogeneity and the Middle Income Trap

Given the CADF unit root test results at the unit level, the null hypothesis could not be rejected for the countries other than Argentina, Honduras, Indonesia, Iran, and Lesotho. It can be stated that the income levels of these countries differ from those of high-income countries. It was observed that the 5 middle-income countries mentioned are converging toward high-income status. As a result of the CIPS unit root test, 47 middle-income countries were found to be in divergence from high-income countries (Table 3A), suggesting that middle-income countries may be unable to escape the MIT.

Table 4A presents the results obtained from the PANKPSS unit root test with a structural break. Accordingly, based on panel statistics, the null hypothesis could not be rejected for 41 countries, whether heterogeneity or homogeneity of the long-term variance was assumed. Thus, these findings differ from those obtained from the CIPS panel unit root test. When evaluated on a panel basis, these findings indicate that middle-income countries converge toward high-income countries and, in this case, can exit the MIT.

After the CIPS panel unit root test and PANKPSS structural break panel unit root tests, the findings obtained as a result of the Fourier KPSS unit root test, which was successful in detecting hard and soft breaks, are given in Table 5A. Accordingly, the null hypothesis could not be rejected for 5 countries when k=1, for 40 countries when k=2, and for 37 countries when k=3 is assumed. For these countries, the differential GDP per capita series is stationary. The results obtained from the Fourier panel stationarity test indicate that the mutually stationary null hypothesis was rejected at the 1% significance level, suggesting that the panel is not commonly stationary. Rejecting the null hypothesis on a panel basis does not mean that a common process is followed for all countries because, under the alternative hypothesis, some cross-sections are allowed to be stationary. Thus, when the frequency is evaluated as two (2) and three (3), it is possible to state that many countries converge to high-income status. This finding is consistent with the PANKPSS panel unit root test.

When all tests are evaluated together, only four countries (Argentina, Indonesia, Iran, and Lesotho) consistently exhibit stochastic convergence (Table 6A). This finding is very important in the economic literature:

Limited Convergence: The fact that only 4 out of 47 countries show clear convergence demonstrates that the MIT remains a serious risk for the vast majority of countries in the sample.

Heterogeneous Structure: The fact that countries showing convergence (such as Indonesia and Argentina) have different geographical and institutional structures indicates that there is no single recipe for convergence; rather, these countries are engaged in a "stochastic catch-up" toward the high-income group.

The MIT is neither universal nor inevitable; income disparities may persist in the vast majority of countries unless structural transformation occurs. Convergence is not only a statistical process; it depends on various structural factors such as institutional quality, technological progress, and investments in human capital.

7. Conclusion and Policy Implications

One of the primary objectives of developing countries is to reach the income levels of high-income economies. Achieving this goal requires overcoming the so-called "MIT", a stage in which countries remain stuck at intermediate income levels for extended periods.

This study examines whether the convergence hypothesis applies to 47 middle-income countries over the period 1960-2019 within the framework of the MIT. The underlying premise is straightforward: if countries converge toward high-income status, then they have the potential to escape the MIT; otherwise, they are likely to remain within it.

To test this hypothesis, the present study followed the approach of Ye and Robertson (2016) and analyzed the stationarity of the per capita GDP gap between middle-income countries and high-income economies. A set of complementary panel unit root tests was employed for this purpose. Specifically, the CADF and CIPS tests developed by Pesaran (2007) were used to take cross-sectional dependence, the PANKPSS test proposed by Carrion-i-Silvestre, Barrio-Castro and López-Bazo (2005) captures structural breaks, and the FKPSS test introduced by Nazlioglu and Karul (2017) allows for smooth structural changes into consideration.

The findings contribute in three ways.

- First, the empirical results suggest that the MIT should not be considered an inevitable outcome but a structural barrier that is difficult to overcome. The evidence of convergence becomes stronger when Fourier-type smooth structural changes are accounted for. This finding implies that gradual structural transformations, such as technological upgrading and institutional reforms, play an important role in driving convergence.
- Second, the findings achieved in this study revealed a pronounced heterogeneity across countries. Consistent with the results reported by Bozkurt et al. (2016) and Furuoka et al. (2019), convergence is not uniform but varies significantly across the sample. Unlike the study carried out by Yıldız and Bayraktar (2021), this study uses the average of high-income countries as a benchmark instead of a single reference country (such as the USA). This approach reduces benchmarking bias and provides a more comprehensive and realistic assessment of the MIT.
- Third, the results carry important implications for policymakers. The risk of persistent stagnation remains substantial for countries that do not exhibit stochastic convergence. In such cases, policy efforts should not focus solely on increasing growth rates, but also on improving the quality of growth through investments in R&D, human

capital, and institutional capacity. Moreover, the smooth transition patterns captured by Fourier-based tests suggest that gradual and sustained reforms are likely to be more effective than abrupt policy interventions in achieving long-term convergence.

Differences between the PANKPSS and FKPSS results are not unexpected. These differences primarily originate from the distinct ways, in which the two tests model structural change and cross-sectional dependence. The PANKPSS test, developed by Carrion-i-Silvestre, Barrio-Castro and López-Bazo (2005), allows for multiple structural breaks at unknown points in time and treats these breaks as sharp shifts in the intercept and/or trend of the series. In contrast, the Fourier-based FKPSS test proposed by Nazlioglu and Karul (2017) models structural change using trigonometric functions, capturing smooth and potentially nonlinear transitions. As a result, the FKPSS approach is better suited to identifying gradual shifts and low-frequency movements in the data, including regime changes that may not be well captured by models based on abrupt structural breaks. The panel-level stationarity results indicate convergence. However, discrepancies between individual and common panel unit root test outcomes, particularly in the presence of structural breaks, should be interpreted carefully. Relying solely on common panel statistics may lead to an over-rejection of the null hypothesis of stationarity, thereby biasing the inference. As emphasized by Bulent Guloglu and Serdar M. İspir (2011), in such cases, greater weight should be assigned to individual (cross-section-specific) test results since they provide more robust and reliable evidence by taking country-level heterogeneity into account. Supporting this argument, Nazlioglu and Karul (2017) emphasized that rejecting the null hypothesis of stationarity at the panel level does not necessarily imply that all cross-sectional units follow an I(1) process. This is because, under the alternative hypothesis, a subset of countries may still exhibit stationarity (I(0)). Therefore, panel-level inferences should be interpreted with caution, and greater attention should be paid to country-specific results to more accurately capture underlying heterogeneity. Taken together, the evidence from all unit root tests indicates that only four countries (Argentina, Indonesia, Iran, and Lesotho) consistently exhibit stochastic convergence within the sample. This finding suggests that these countries have the potential to overcome the MIT, while the majority of countries remain at risk of persistent divergence. The findings achieved in this study make a novel empirical contribution by showing that the MIT should not be interpreted solely as a slowdown in economic growth, but also as a failure of stochastic convergence. By explicitly taking cross-sectional dependence into account, the analysis provides a more refined and reliable understanding of income dynamics compared to the studies relying on conventional unit root tests. These results further suggest that convergence cannot be achieved through higher growth rates alone; rather, it requires structural transformation, productivity improvements, and a shift toward higher value-added production.

These findings support a dual policy framework distinguishing long-term transformation from short-term stabilization.

From a long-term perspective, convergence depends on countries' ability to implement sustained structural reforms. In particular, ministries responsible for industry and technology must play a leading role in fostering innovation by expanding R&D support and facilitating the transition to high-value-added production. At the same time, education systems need to be reoriented toward developing advanced human capital, ensuring that workforce skills align with the demands of technological upgrading and productivity growth. Moreover, development agencies should adopt more targeted and region-specific strategies to reduce structural imbalances in production capacity.

In the short run, the divergence results obtained from the CADF and CIPS tests highlight the vulnerability of middle-income economies to macroeconomic instability. These findings suggest that temporary shocks may generate persistent income gaps if not properly managed. Therefore, central banks must prioritize both price stability and financial stability, while fiscal authorities should actively employ countercyclical policies to mitigate the long-term effects of cyclical downturns. In this regard, maintaining public debt sustainability emerges as a fundamental condition for preserving macroeconomic resilience.

Furthermore, the fact that only a limited number of countries exhibit consistent convergence underscores the decisive role of institutional quality. This result aligns with the predictions of endogenous growth theory (Romer, 1986; Lucas, 1988), which emphasize that convergence is not self-sustaining in the absence of technological capability and human capital accumulation.

Taken together, these findings suggest that convergence should not be interpreted as catching up with a single benchmark economy, but rather as a broader process of aligning with the global high-income frontier. Achieving this requires a comprehensive policy agenda that enhances international competitiveness, deepens integration into global value chains, and promotes a structural shift toward technology-intensive, high-value-added exports.

8. Limitations and Future Research

Despite its contributions, this study has several limitations that also point to directions for future research. First, the analysis is constrained by data availability, which limits both the country coverage and the time period to 1960-2019. Second, even though this study takes cross-sectional dependence and structural breaks into account, it focuses primarily on linear stochastic convergence. Future research could extend this framework by employing nonlinear models or club convergence approaches to better capture complex and heterogeneous growth dynamics. Third, while the analysis examines income convergence within the middle-income trap framework, incorporating additional variables, such as institutional quality, human capital, and technological innovation, would provide a more comprehensive understanding of the underlying drivers of convergence.

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Appendix
Table 1A
Descriptive Statistics

	LNDIFDATA
Mean	-2.528520
Median	-2.421375
Maximum	-0.044851
Minimum	-5.023000
Std. Dev.	0.895289
Skewness	-0.239092
Kurtosis	2.434561
Jarque-Bera	64.43481
Sum	-7130.427
Sum Sq. Dev.	2259.546
Observations	2820

Table 2A
Results of the Cross-Sectional Dependence Test

Tests	Statistic	Probability Value
LM	1559.266	0.000
LM_{adj}	19.480	0.000

Note: Bold numbers: The null hypothesis of stationarity cannot be rejected at least at the level of significance of 10%.

Table 3A
Results of CADF and CIPS Panel Unit Root Test

Countries	lag	CADF	Countries	lag	CADF	Countries	lag	CADF
Algeria	1	**-2.250**	Egypt, Arab Rep.	3	**-3.304**	Senegal	1	**-2.997**
Argentina	3	-3.661	Fiji	1	**-2.337**	South Africa	1	**-3.170**
Bangladesh	1	**-1.734**	Gabon	1	**-1.805**	St. Vincent and the Grenadines	1	**-1.834**
Belize	4	**-3.276**	Ghana	1	**-0.168**	Nepal	1	**-2.872**
Benin	1	**-2.888**	Guatemala	2	**-3.435**	Nicaragua	1	**-0.791**
Bolivia	2	**-2.689**	Guyana	3	**-1.091**	Nigeria	2	**-2.719**
Botswana	1	**-1.026**	Honduras	1	-3.524	Pakistan	1	**-3.357**
Brazil	1	**-1.524**	India	1	**-1.385**	Papua New Guinea	1	**-1.811**
Cameroon	1	**-1.349**	Indonesia	1	-3.621	Paraguay	1	**-2.805**
China	3	**-2.005**	Iran, Islamic Rep.	1	-3.655	Peru	1	**-3.288**
Colombia	2	**-2.875**	Kenya	1	**-2.123**	Suriname	1	**-2.737**
Congo, Rep.	1	**-1.346**	Lesotho	1	-4.448	Thailand	1	**-2.976**
Costa Rica	2	**-2.233**	Malaysia	1	**-2.797**	Türkiye	1	**-2.602**
Cote d'Ivoire	1	**-2.079**	Mexico	1	**-2.041**	Zambia	1	**-0.789**
Dominican Republic	2	**-3.289**	Myanmar	3	**-2.187**	Zimbabwe	1	**-2.261**
Ecuador	1	**-0.749**	Philippines	1	**-1.972**			
CIPS-Stat	**-2.380**							

Notes: CADF and CIPS unit root testing assume a constant and trended model. The maximum delay length was determined using SIC (Schwarz-Bayesian Information Criteria). Bold statistics show that the null hypothesis cannot be rejected at least at the significance level of 10%. Critical values for CADF test: 10%=-3.45, 5%=-3.80, 1%=-4.51. Critical values for CIPS test: CIPS: 10%=-2.58, 5%=-2.65, 1%=-2.78. Bold numbers: The null hypothesis of stationarity cannot be rejected at least at the 10 percent level of significance.

Table 4A
Results of PANKPSS Unit Root Test

Countries	Panel KPSS	10%	5%	1%	m
Algeria	**0.042**	0.092	0.123	0.187	3
Argentina	**0.056**	0.105	0.134	0.186	3
Bangladesh	0.124	0.096	0.124	0.176	3
Belize	**0.025**	0.097	0.126	0.179	3
Benin	**0.056**	0.097	0.125	0.173	3
Bolivia	**0.025**	0.098	0.128	0.185	3
Botswana	**0.053**	0.076	0.101	0.156	2
Brazil	0.105	0.092	0.120	0.167	3
Cameroon	**0.064**	0.097	0.126	0.180	3
China	**0.070**	0.091	0.107	0.156	1
Colombia	**0.021**	0.091	0.122	0.172	3
Congo, Rep.	**0.034**	0.080	0.103	0.160	2
Costa Rica	**0.044**	0.093	0.120	0.168	3
Cote d'Ivoire	0.095	0.095	0.122	0.175	3
Dominican Republic	**0.040**	0.078	0.102	0.154	2
Ecuador	**0.036**	0.092	0.118	0.160	3
Egypt, Arab Rep.	**0.085**	0.095	0.120	0.175	3
Fiji	**0.029**	0.094	0.121	0.172	3
Gabon	**0.052**	0.098	0.119	0.166	2
Ghana	**0.023**	0.097	0.123	0.175	3
Guatemala	**0.023**	0.098	0.119	0.166	2
Guyana	**0.063**	0.097	0.123	0.175	3
Honduras	0.113	0.075	0.102	0.150	2
India	0.102	0.095	0.121	0.180	3
Indonesia	**0.028**	0.090	0.119	0.169	3
Iran, Islamic Rep.	**0.048**	0.081	0.104	0.160	2
Kenya	**0.041**	0.093	0.121	0.173	3
Lesotho	**0.041**	0.085	0.104	0.149	2
Malaysia	**0.051**	0.098	0.128	0.179	3
Mexico	**0.054**	0.081	0.104	0.159	2
Myanmar	**0.030**	0.098	0.126	0.175	3
Nepal	**0.021**	0.090	0.116	0.173	3
Nicaragua	0.095	0.080	0.103	0.154	2

Nigeria	**0.029**	0.098	0.127	0.178	3
Pakistan	**0.032**	0.097	0.126	0.176	3
Papua New Guinea	**0.066**	0.097	0.123	0.177	3
Paraguay	**0.033**	0.100	0.127	0.181	3
Peru	**0.029**	0.083	0.110	0.155	2
Philippines	**0.036**	0.093	0.119	0.173	3
Senegal	**0.040**	0.078	0.103	0.157	2
South Africa	**0.057**	0.101	0.126	0.178	3
St. Vincent and the Grenadines	**0.077**	0.092	0.120	0.180	3
Suriname	**0.072**	0.095	0.123	0.181	3
Thailand	**0.029**	0.096	0.122	0.173	3
Türkiye	**0.019**	0.076	0.102	0.153	2
Zambia	**0.026**	0.091	0.122	0.171	3
Zimbabwe	**0.021**	0.099	0.123	0.174	2
Panel- Homogeneity Test	**13.733**	19.119	20.601	23.621	
Panel- Heterogeneous Test	**20.787**	25.392	27.142	30.619	

Note: The PANKPSS structural break unit root test assumes a constant and trended model. m is the number of structural breaks obtained using the LWZ criterion. The maximum number of breaks was taken as 3. Critical Values were obtained with 5000 Bootstrap cycles. Long-term variance was estimated using a 4 (T/100) ^2/9 bandwidth Bartlett Kernel. Bold numbers: The null hypothesis of stationarity cannot be rejected at least at the significance level of 10%.

Table 5A

Results of the Fourier KPSS Unit Root Test

		Gradual/smooth shifts	
Countries	*k=1*	*k=2*	*k=3*
Algeria	0.053	**0.040**	**0.113**
Argentina	0.057	**0.046**	**0.078**
Bangladesh	0.060	**0.096**	**0.113**
Belize	0.054	**0.080**	**0.094**
Benin	0.053	**0.082**	**0.107**
Bolivia	0.050	0.106	**0.075**
Botswana	0.051	**0.086**	**0.113**
Brazil	0.059	**0.083**	**0.109**
Cameroon	**0.046**	**0.042**	**0.110**
China	0.057	0.111	0.128

Colombia	0.053	**0.057**	**0.069**
Congo, Rep.	0.048	**0.084**	**0.106**
Costa Rica	0.051	**0.040**	**0.085**
Cote d'Ivoire	**0.046**	0.110	0.122
Dominican Republic	0.047	**0.051**	**0.049**
Ecuador	0.047	**0.069**	**0.101**
Egypt, Arab Rep.	0.049	**0.087**	**0.069**
Fiji	0.047	**0.069**	**0.063**
Gabon	0.057	**0.102**	0.126
Ghana	0.055	**0.103**	0.124
Guatemala	0.053	**0.087**	**0.091**
Guyana	0.049	0.107	**0.109**
Honduras	0.061	**0.091**	**0.073**
India	0.063	0.105	0.122
Indonesia	0.061	**0.080**	**0.077**
Iran, Islamic Rep.	0.058	**0.085**	**0.069**
Kenya	0.063	**0.103**	0.121
Lesotho	**0.034**	**0.055**	**0.055**
Malaysia	0.051	**0.064**	**0.079**
Mexico	0.048	**0.082**	0.127
Myanmar	**0.045**	**0.096**	0.126
Nepal	0.061	0.106	0.115
Nicaragua	0.064	**0.076**	**0.072**
Nigeria	0.055	**0.046**	**0.061**
Pakistan	0.055	**0.044**	**0.066**
Papua New Guinea	0.048	**0.100**	**0.064**
Paraguay	0.060	**0.085**	**0.098**
Peru	0.056	**0.062**	**0.073**
Philippines	0.054	**0.084**	**0.112**
Senegal	0.057	**0.093**	**0.119**
South Africa	0.052	**0.060**	**0.087**
St. Vincent and the Grenadines	0.058	0.111	0.124
Suriname	0.059	**0.090**	**0.114**
Thailand	0.051	**0.072**	**0.095**
Türkiye	0.059	**0.060**	**0.106**
Zambia	**0.044**	**0.068**	**0.103**
Zimbabwe	0.050	**0.089**	**0.066**

Panel (p-value)	12.562 (0.000)	4.845 (0.000)	5.866 (0.000)

Notes:

a) Critical values of FKPSS test statistics were obtained from Becker et al. (2006:389) article. Critical Values were obtained with 5000 Bootstrap cycles. In constant and trend model, critical values are 0.0471(10%), 0.0546(5%), 0.0716(1%) for k=1, 0.1034(10%), 0.1321(5%), 0.2022(1%) for k=2, 0.1141(10%), 0.1423(5%), 0.2103(1%) for k=3.

b) Bold numbers: The null hypothesis of stationarity cannot be rejected at least at the significance level of 10%.

Table 6A
Summary of Empiric Findings

Countries	CADF/CIPS	PANKPSS	FKPSS (For k=2)
Algeria	No	Yes	Yes
Argentina	Yes	Yes	Yes
Bangladesh	No	Yes	Yes
Belize	No	Yes	Yes
Benin	No	Yes	Yes
Bolivia	No	No	No
Botswana	No	Yes	Yes
Brazil	No	Yes	Yes
Cameroon	No	Yes	Yes
China	No	No	No
Colombia	No	Yes	Yes
Congo, Rep.	No	Yes	Yes
Costa Rica	No	Yes	Yes
Cote d'Ivoire	No	No	No
Dominican Republic	No	Yes	Yes
Ecuador	No	Yes	Yes
Egypt, Arab Rep.	No	Yes	Yes
Fiji	No	Yes	Yes
Gabon	No	Yes	Yes
Ghana	No	Yes	Yes
Guatemala	No	Yes	Yes
Guyana	No	No	No
Honduras	Yes	No	No
India	No	No	No
Indonesia	Yes	Yes	Yes
Iran, Islamic Rep.	Yes	Yes	Yes
Kenya	No	Yes	Yes
Lesotho	Yes	Yes	Yes
Malaysia	No	Yes	Yes
Mexico	No	Yes	Yes
Myanmar	No	Yes	Yes
Nepal	No	No	No
Nicaragua	No	Yes	Yes
Nigeria	No	Yes	Yes
Pakistan	No	Yes	Yes
Papua New Guinea	No	Yes	Yes
Paraguay	No	Yes	Yes
Peru	No	Yes	Yes
Philippines	No	Yes	Yes

Senegal	No	Yes	Yes
South Africa	No	Yes	Yes
St. Vincent and the Grenadines	No	No	No
Suriname	No	Yes	Yes
Thailand	No	Yes	Yes
Türkiye	No	Yes	Yes
Zambia	No	Yes	Yes
Zimbabwe	No	Yes	Yes
Panel	No	Yes	Yes

Note: “Yes” shows income convergence hypothesis is valid while “No” shows it is not valid.