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Stochastic Convergence Analysis in Per Capita Health Expenditures for OECD Countries: Wavelet Unit Root Test Approach

OECD Ülkeleri için Kişi Başına Sağlık Harcamalarında Stokastik Yakınsama Analizi: Dalgacık Birim Kök Testi Yaklaşımı

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Abstract: Health is considered one of the essential factors in the growth and development of countries and the formation of human capital. Advances in the health sector have a positive effect on economic growth. With the development of technology and progress, it is evident that there have been severe increases in health expenditures in both developing and developed countries in recent years. Since investments in health expenditures contribute to the physical structure of the population, this situation brings with it an increase in productivity. For this reason, health expenditure convergence has recently become the focus of researchers in the economics literature. This study examined whether the per capita health expenditure of 21 OECD members converged to the OECD average. Stochastic convergence has been tested for the period 1975-2019 with the wavelet unit root test developed by Fan & Gencay (2010) as well as conventional unit root tests (ADF, PP and KPSS). When the wavelet unit root test results, which include both time and frequency domain information with better power characteristics than conventional tests, are examined, it is concluded that nine countries converge to the OECD average. Since health expenditures, which is one of the economic development indicators, are an essential factor for sustainable economic growth, it is an inevitable fact that if the convergence hypothesis of health expenditures is valid, it will positively affect economic growth.

Keywords: Unit Root Test, Time Series, Wavelet, Health Expenditures, Convergence

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Özet: Sağlık, ülkelerin büyüme ve gelişmesinde ve beşerî sermayenin oluşumunda temel faktörlerden biri olarak kabul edilmektedir. Sağlık sektöründeki gelişmeler ekonomik büyümeyi olumlu etkilemektedir. Gelişen teknoloji ve ilerleme ile son yıllarda hem gelişmekte olan hem de gelişmiş ülkelerde sağlık harcamalarında ciddi artışların olduğu görülmektedir. Sağlık harcamalarına yapılan yatırımlar, nüfusun fiziki yapısına katkı sağladığından, bu durum verimlilik artışını da beraberinde getirmektedir. Bu nedenle sağlık harcamalarının yakınsaması son zamanlarda iktisat literatüründe araştırmacıların odak noktası haline gelmiştir. Bu çalışma, 21 OECD üyesinin kişi başına sağlık harcamasının OECD ortalamasına yaklaşıp yaklaşmadığını inceledi. Stokastik yakınsama, Fan & Gencay (2010) tarafından geliştirilen dalgacık birim kök testi ve geleneksel birim kök testleri (ADF, PP ve KPSS) ile 1975-2019 dönemi için test edilmiştir. Sonuçlar genel olarak değerlendirildiğinde, sabit ve sabit trendli modeller için 21 OECD ülkesinin OECD ortalamasına yakınsadığı görülmektedir. Ekonomik gelişmişlik göstergelerinden biri olan sağlık harcamalarının sürdürülebilir ekonomik büyüme için vazgeçilmez bir faktör olması nedeniyle, sağlık harcamalarının yakınsama hipotezinin geçerli olması durumunda ekonomik büyümeyi olumlu yönde etkileyeceği kaçınılmaz bir gerçektir.

Anahtar Kelimeler: Birim Kök Testi, Zaman Serileri, Dalgacık, Sağlık Harcamaları, Yakınsama

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1. Introduction

The importance of investing in human capital for economic growth is emphasized in numerous economic studies and literature on developing economies. Human, one of the essential economic growth and development factors, is accepted as human capital (Kızılkaya & Dağ, 2021, p. 587). The definition of human capital includes knowledge, skills, abilities, health status, place in social relations and education level (Şenol & Onaran, 2022). The knowledge and skills used in developing human capital in health, education, and communication, apart from industry and agriculture, have a significant share (Şen & Pehlivan, 2018, p. 206). Moreover, Becker (1993) explored an alternative type of capital, encompassing factors that improve health, elevate income, or contribute to a person's enduring interest in literature. This includes expenditures on school education, medical care, computer training courses, and courses that emphasize virtues such as punctuality and honesty.

According to Schultz (1961), who focused on growth and increasing human capital stock, significant earnings differences mostly reflect differences in health and education. For example, workers in the South earn significantly less on average than workers in the North or West (in the USA). Furthermore, most migrant agricultural workers earn significantly less than other workers. The workers' poor health and lack of education are the main causes of this situation. Schultz (1961) discusses essential activities that develop people in terms of understanding human investments. At this stage, education and health are accepted as the most important components of creating productive capital. Schultz (1961) identifies five main groups of human-enhancing activities. These are listed below:

• Health services, including all expenditures that will affect the life expectancy of the people,

• Training organized by companies,

• Education in primary, secondary, and higher education,

• Training programs for adults that are not organized by companies,

• Individual or family migrations to adapt to changing conditions.

Barro (1991), emphasizing the importance of the concept of human capital, claims that human capital investments cause an overflow-spillover effect in the economy. The overflow-spillover effect leads to an increase in physical and human capital investment. As a result, economic growth increases.

Health status will undoubtedly contribute to increased productivity in the workforce. As a result, health is considered an important factor in the formation of human capital and contributes to countries growth and development (Akarsu et al., 2019, p. 90). There is some evidence of the intangible benefits of education. Individuals with a high level of education, family income, etc., even when variables are considered, have better health knowledge and health status (Grossman, 1976; Kenkel, 1990).

It is observed that health expenditures are increasing in both developing and developed countries. The expenditures and growth rate of countries for health services are related to various market types and social elements, the diversity in the organization and funding of health systems, and the technology level of the countries. Advances in medicine, population aging, and increasing customer expectations all contribute to the rise in health expenditures (Huber & Orosz 2003). Health expenditures are productive investments. In other words, investments in the health sector make a positive contribution to economic growth.

The weakness of the health sector affects the efficiency of capital negatively (Foon Tang, 2011, p. 201). Increases in health expenditures increase economic growth. Because investments in health expenditures improve the physical structure of the population, this situation leads to an increase in productivity. The increase in physical investments is also influenced by advancements in human capital and longer life expectancies (Bloom & Canning, 2000, p. 1207). According to Bloom & Canning (2000), the positive effects of health expenditures on growth are as follows:

• Healthy individuals have high productivity,

• Healthy individuals contribute positively to human capital,

• Increased average life expectancy leads to higher physical investments. Furthermore, as health expenditures rise in the economy, so does average life expectancy. Thus, growth is positively affected.

According to Okunade et al. (2004), the increase in health expenditures is a major source of concern for health policymakers in both developing and developed countries, despite the fact that the geographical distribution of health spending is unstable. In this context, health economics researchers generally focus on the factors that determine health expenditures. In this context, health economics researchers generally focus on the factors that determine health expenditures.

In empirical studies, life expectancy at birth and health expenditures are typically the most important health indicators. Health expenditure, which is evaluated in growth theory, is one of the indicators of economic development, and it has an essential share in public expenditures. Increased real income per capita, technological innovations, general health insurance, and population aging all have a significant impact on rising health expenditures. As per capita income rises, the need for new medical technologies that improve and prolong one's life also increases (Nghiem & Connelly, 2017, p. 2). Thus, it is critical to obtain information about the behavior of health expenditures. Given the disparities in health expenditures across countries, the concept of convergence in health expenditures attracts the interest of many researchers.

The increase in health expenditures contributes positively to labor productivity. At this point, one-third of the productivity increases experienced in Organization for Economic Co-operation and Development (OECD) countries in the 1800s and after was due to improvements in health (Dhesi & Dhariwal, 1990). However, the proportion of health expenditures in Gross Domestic Product (GDP) in OECD countries is expected to rise over time. For example, in 2010, it can be said that the ratio of health expenditures to GDP in Japan, the USA, and European countries that can be considered in the developed category was over 8% (Kamaci & Ugurlu Yazici, 2017). However, by 2030, this spending rate is expected to rise to 10.2% as predicted (OECD, 2019, p. 11). At this point, effective spending on health in OECD countries positively affects growth and employment. In other words, convergence in health expenditures means that countries with low expenditures are catching up with countries with high expenditures.

The share of the public and private sectors in health expenditures increased steadily in OECD countries between 2012 and 2019 (OECD, 2023). In particular, a significant portion of the money was spent on healthcare services. Huber & Orosz (2003) attributed the increase in health expenditures to rapid advances in medical technologies, increasing public expectations, and the aging of the population. However, public health expenditures are increasing in OECD countries. Because the financing of health services or health insurance is provided by the public (Çalıskan, 2009, p. 118).

At the point of sustainable economic growth and labor productivity, ensuring improvement in health indicators is an important policy goal. For this reason, it is possible to increase total health expenditures through health policies to be implemented in countries whose health expenditures are below the OECD average. The rise in health expenditures will positively impact health indicators.

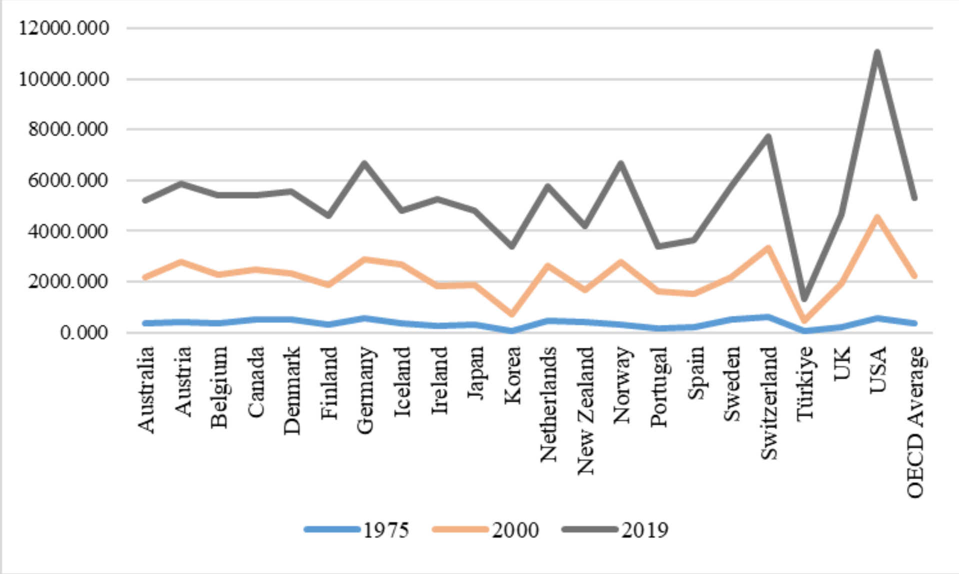
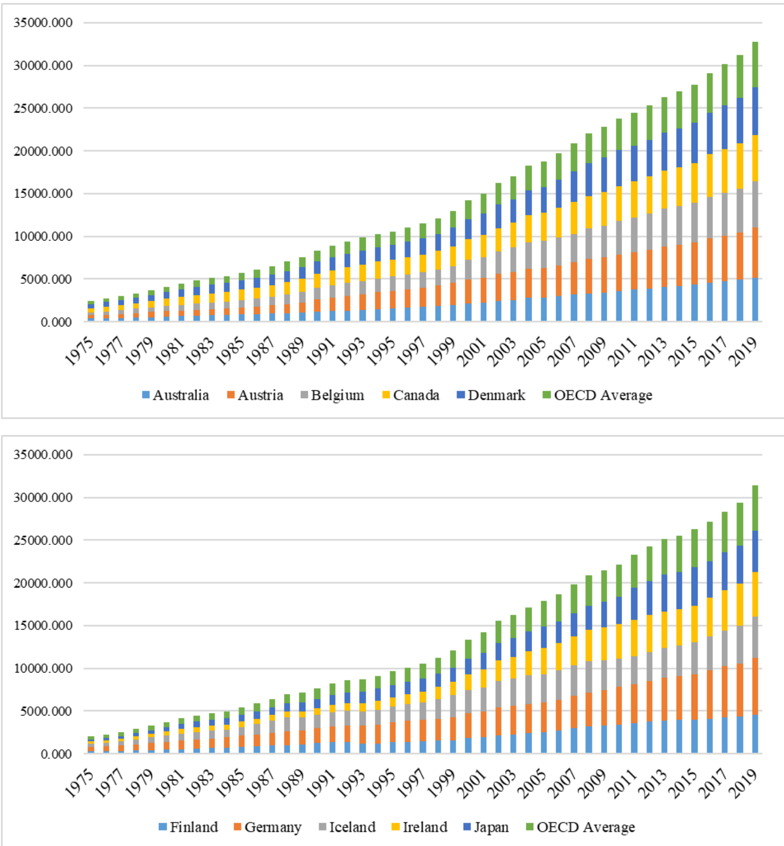


Figure 1: Health Expenditures of OECD Countries for Selected Years

Health expenditures in OECD countries have increased significantly in the last 50 years, as shown in Figure 1. There has been a significant increase in health expenditures in OECD countries from 1975 to 2019. Health expenditures, which increase faster than economic growth in OECD countries, positively affect health outcomes (Kızılkaya & Dağ, 2022, p. 589). Therefore, it is inevitable that this situation will create an essential source for economic growth and employment and that a healthy population will contribute to human capital. In addition, Figure 2 shows the comparative graphs of the average increase in health expenditures in the OECD countries.



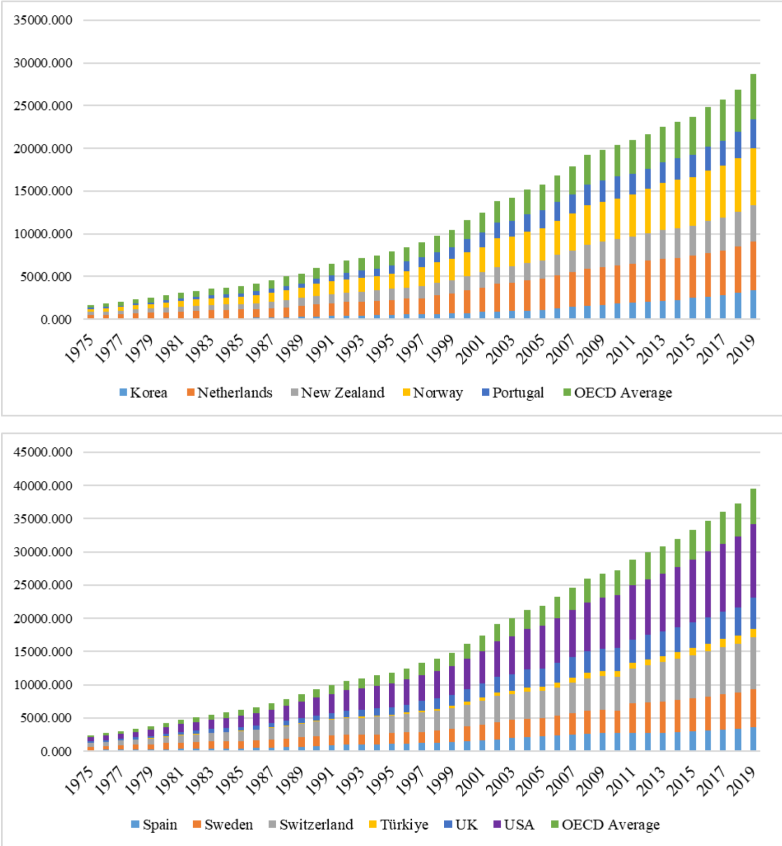


Figure 2: Comparison of Health Expenditures of OECD Countries by Average

Figure 2 shows that all OECD countries considered in the study have continued to increase. However, Australia, Finland, Iceland, Ireland, Japan, Korea, New Zealand, Portugal, Spain, Türkiye, and the United Kingdom have generally lower-than-average health expenditures.

Durlauf & Johnson (1995) and Bernard & Durlauf (1996) pioneered the use of stationarity tests to test the convergence hypothesis. When the series is determined to be stationary, they conclude that the convergence hypothesis is valid.

Convergence is investigated using various recently developed unit root tests, based on advances in the unit root test literature. Thus, it is aimed to provide more accurate results for policy makers. For example, while structural breaks were initially modeled with dummy variables, convergence with these tests was re-examined with the development of Fourier-based unit root tests. Similarly, in addition to time series, advances in the panel unit root literature have allowed researchers to investigate the same subject using panel data. Most of the unit root tests developed for both data types are based only on time domain information. It is aimed to better model the behavior of the series by using wavelet transform-based unit root tests together with time and frequency domain information. In this regard, the study used a wavelet-based unit root test.

The method used in this study differs from that of previous studies. The literature has examined the convergence of health expenditures for various countries and time periods. However, most of the methods used are time-domain-based methods. It can be said that these methods directly ignore the frequency domain information of the series. The wavelet unit root test used in the study tests the stationarity of the series by using both time and frequency domain information together. Furthermore, this approach has more power than conventional tests that only utilize the time domain (Fan & Gencay, 2010, pp. 1321-1322). Using a more reliable and higher-power test is essential because the validity of the convergence hypothesis is important to policymakers when they are deciding which policy to implement directly.

The study has five chapters in total. The second section will discuss the literature on the subject. The third section will explain the method, while the fourth section will present the results of the analysis. Finally, in the fifth section, the findings will be summarized, and policy recommendations will be presented.

2. Literature

Convergence analysis, which is based on growth theory, has recently been extensively studied not only for income but also for health field, which is considered a human capital investment. Several studies have been conducted in the literature to test the validity of the health expenditure convergence hypothesis, which is the goal of this study. Nixon (2000) demonstrates, for the period 1960-1995, that sigma convergence is valid in health expenditures and health indicators for European Union (EU) countries, while beta convergence is valid for the period 1980-1995. Hitiris & Nixon (2001) used the ADF and PP unit root tests from 1980 to 1995. Their findings showed that health expenditures in 15 EU countries support the convergence hypothesis, implying that technology diffusion and policy cohesion will ensure convergence.

In the study conducted by Narayan (2007), Im, Pesaran & Shin's (2003) (IPS) and Panel Lagrange Multiplier (LM) panel unit root tests were employed on data spanning from 1960 to 2000. The analysis demonstrated that per capita health expenditures in the United Kingdom, Canada, Japan, Switzerland, Spain, and the United States all supported the convergence hypothesis. According to Kerem et al. (2008), the share of health expenditures in GDP in different countries (EU-8, EU-12, and EU-15) converged (β) between 1992 and 2004. In EU-23 countries, the σ convergence test confirmed convergence of health expenditures from 1992 to 2004. Aslan (2009) used the IPS panel unit root test from 1970 to 2005. The findings of the study revealed a divergence in per capita health expenditure among the 19 OECD countries. Fallahi (2011) applied Lee & Strazicich's (2003) (LS) structural break unit root test to the years 1960-2006. According to the test results, OECD countries have stochastic convergence.

Panopoulou & Pantelidis (2012), used Phillips & Sul's (2007) club convergence method for the period 1972-2006. They found that the convergence hypothesis in per capita health expenditure is valid for 17 countries out of 19 OECD countries. Tülümce & Zeren (2013), for the period 1980-2008 found that there is a divergence in the share of health expenditures in GDP for 18 OECD countries. Lau et al. (2014) used a nonlinear unit root test for the period 1975-2008. They found that convergence in health expenditures per capita for 14 EU countries is not valid. Apergis (2015) used the club convergence method for the period 1990-2012. It has been found that Argentina, Brazil, Bulgaria, Croatia, Poland, and Romania in the first group converge with India, Pakistan, Türkiye, the Philippines, Russia, and Thailand in the second group in health expenditures among 19 developing countries. Pekkurnaz (2015) utilized conventional and nonlinear symmetric, as well as asymmetric, panel unit root tests for the period 1980-2012. While the conventional panel unit root test across 22 OECD countries failed to reject the null hypothesis of a unit root in relative health expenditures per capita for all countries, both symmetric and asymmetric nonlinear panel unit root tests indicated stationarity in the panel. Payne et al. (2015) applied the RALS-LM unit root test to data spanning from 1972 to 2008. The results suggest a convergence in per capita health expenditures across the majority of the 19 OECD countries.

Odhiambo et al. (2015) utilized a linear dynamic panel data model to analyze health expenditures from 2000 to 2011 in 41 Sub-Saharan African Countries. The findings indicate the existence of conditional convergence. Oyedele & Adebayo (2015) noted a convergence in health expenditures among 15 ECOWAS (Economic Community of West African States) countries during the period 1995-2011. Perovic (2016) used the spatial autocorrelation model for the period 1995-2010. He concluded that there is convergence in health expenditure for EU-15 countries. In the period from 2002 to 2012, Stańczyk (2016) utilized the Structural Equation Model. The analysis, focusing on testing the validity of the convergence hypothesis concerning health expenditures across 28 EU countries (260 regions), revealed evidence of beta convergence. Nghiem & Connelly (2017) used Phillips & Sul's (2007) method between 1975 and 2004. The study found no indications of convergence among OECD countries. Şahin (2018) used a panel unit root test for the period 1995-2014. He has concluded that there is no convergence in health expenditures for Türkiye and Middle

East and North Africa (MENA) countries but convergence in infant mortality rate. Akarsu et al. (2019), used nonlinear panel unit root tests for the period 1979-2016. They concluded that the convergence hypothesis is valid only for private health expenditures per capita for 18 OECD countries.

Clemente et al. (2019) used Phillips & Sul's (2007) method for the period 1980-2014. It is concluded that the convergence hypothesis is valid for the United States. Kızılkaya & Dag (2021) used Furuoka's (2017) Fourier unit root test for the period 1975-2019. They concluded that the convergence hypothesis is valid for 17 OECD countries. Using data from 1995-2018, Atılgan & Özbek (2021) tested the convergence hypothesis with the Fourier Panel LM and Reese & Westerlund (2016) panel unit root tests. The findings revealed that the idea of convergence in health indicators for Group of Seven (G7) countries is invalid.

According to the existing literature, the methods utilized mostly consist of time series unit root tests and panel unit root tests in the time domain. In this study, the wavelet unit root test, which uses frequency and time domain information, is used. The wavelet unit root test has better power and size properties than most unit root tests that only use time domain information, as discussed in the methodology section. This means that wavelet unit root tests provide more reliable and unbiased results. Examining the convergence hypothesis of health expenditure, a topic that has been extensively researched in the literature for various country groups and periods, with the wavelet unit root test also entails assessing the reliability of results obtained with conventional unit root tests.

3. Methodology and Dataset

Whether economic variables have a unit root has become increasingly important since Nelson & Plosser's (1982) work. Beginning with Dickey & Fuller (1979), the unit root literature advanced with the unit root tests developed for panel data after the time series. The search for better power and size properties for tests continued. Most of these tests were designed for the time domain.

In the Fourier transform, which only provides frequency domain information, the relevant series is moved from the time domain to the frequency domain using the sine and cosine functions. When a series is stationary—when it does not change significantly over time—these functions are good at capturing its behavior. However, because economic variables have structural break and trend components, it is impossible to capture the changes accurately. Based on these drawbacks, the proposed wavelet transform provides time and frequency information.

Fan & Gencay (2010) proposed a unit root test based on the variance rate using the discrete wavelet transformation, which combines time and frequency domain information. This test is based on Granger (1966)'s principle that most economic variables have a similar power spectrum after detrending their mean and seasonal components.

While the wavelet coefficients obtained from the discrete wavelet transformation used in the wavelet unit root test capture the high-frequency components, scaling coefficients decompose variance by capturing low-frequency components. Fan & Gencay (2010) use Haar wavelet in their test.

Data generating processes for constant and constant with trend models are defined in equations (1) and (2).

$$y_t = \rho y_{t-1} + u_t \tag{1}$$

$$y_t = \mu + \alpha t + \rho y_{t-1} + u_t \tag{2}$$

Under the null hypothesis, ρ =1 shows the unit root process, and ρ <1 shows the stationary process. Suggested test statistics for demeaned and detrended series based on discrete wavelet transformation with Haar filter are presented in (3) and (4), respectively.

$$\hat{S}_{T,1}^{LM} = \frac{\sum_{t=1}^{T/2}\left(V_{t,1}^{M}\right)^2}{\sum_{t=1}^{T}(y_t - \bar{y})^2} \tag{3}$$

$$\hat{S}_{T,1}^{Ld} = \frac{\sum_{t=1}^{\frac{T}{2}}\left(V_{t,1}^{d}\right)^2}{\sum_{t=1}^{T}(\tilde{y}_t - \bar{\tilde{y}})^2} \tag{4}$$

The expressions $V_{t,1}^{M}$ and $V_{t,1}^{d}$ in the test statistics represent the scaling coefficients of the demeaned and trended series. $\bar{y} = T^{-1}\sum_{t=1}^{T} y_t$ is calculated as the demeaned series $(y_t - \bar{y})$ to express the sample mean.

In equation (4) $\tilde{y}_t - \bar{\tilde{y}}$ shows that the detrended series where $\tilde{y}_t = \sum_{j=1}^{t}\left(\Delta y_j - \overline{\Delta y}\right)$ and $\bar{\tilde{y}}$ is the sample mean of $\tilde{y}_t$. In addition to that $\Delta y_t = y_t - y_{t-1}$ and $\overline{\Delta y}$ is the sample mean of Δy_t.

The test's power is defined as the correct rejection of the false null hypothesis. Fan & Gencay (2010) demonstrated that this test, which includes both time and frequency domain information with wavelet transformation, has better power properties than the unit root tests commonly used in the literature (Elliott et al. (1996)'s ERS and Ng & Perron (2001)'s MPP) via simulation.

The discrete wavelet transformation used with the wavelet unit root test reduces the number of observations by half. Taking this situation into consideration, the selected country group was determined to cover the longest time interval. For 21 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, Germany, Iceland, Ireland, Japan, Korea (*South*), Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Türkiye, UK, and USA), annual data covering the period 1975-2019 on health expenditure per capita in purchasing power parity (US dollars) were obtained from the 2020 OECD Health Statistics Database.

As previously stated, this study investigated whether the per capita health expenditures of 21 OECD countries converged to the OECD average using stochastic convergence and unit root tests. Therefore, the y_{it} series in equation (5) was first calculated. In the equation ln represents the natural logarithm, HEX_{it} represents the per capita health expenditure of country i in year t, and $\overline{HEX}_i$ represents the average of per capita health expenditures 21 OECD countries.

$$y_{it} = ln(HEX_{it}/\overline{HEX}_i) \tag{5}$$

The presence or absence of a unit root in the series determines whether the countries included in the study converge to the OECD average. If the y_{it} series has a unit root, the shocks to the HEX_{it} variable are permanent, and there is no convergence.

If the y_{it} series has a unit root it means that the shocks to HEX_{it} variable are permanent, and there is no convergence. The series does not contain a unit root, which means that the shocks are temporary, and there is convergence to the OECD average.

4. Empirical Results

Table 2 displays descriptive statistics on health expenditures per capita for each of the 21 OECD countries from 1975 to 2019, along with the average for these countries. According to the table, Türkiye has the lowest health expenditure per capita (445.251 dollars), while the USA has the highest (4690.280 dollars) for the country group. Furthermore, the average per capita health expenditures in Türkiye, Korea, Portugal, Spain, New Zealand, the United Kingdom, Finland, Japan, Ireland, and Australia is lower than the average of the twenty-one OECD countries. Türkiye has the lowest volatility (396.134), and the USA has the highest volatility (3189.034) compared with the standard deviation, which measures volatility. Additionally, the Jarque-Bera test indicates that health expenditure per capita follows normal distribution except for Ireland, Japan, Korea, the Netherlands, New Zealand, Sweden, Türkiye, and the United Kingdom.

Table 1: Descriptive Statistics

Country	Mean	Median	Std. Dev.	Skewness	Kurtosis	JB
Australia	2164.100	1727.300	1454.445	0.537	1.995	4.054
Austria	2559.902	2263.500	1685.977	0.337	1.798	3.561
Belgium	2311.162	1813.500	1548.048	0.478	1.903	3.974
Canada	2526.769	2091.400	1488.299	0.416	1.934	3.425
Denmark	2426.824	1890.200	1519.996	0.547	1.964	4.259
Finland	1974.422	1474.100	1338.510	0.500	1.869	4.272
Germany	2817.063	2494.300	1705.634	0.543	2.259	3.244
Iceland	2301.784	2017.500	1256.098	0.087	1.756	2.957
Ireland	2050.953	1287.500	1640.769	0.536	1.719	5.231*
Japan	1985.256	1526.500	1398.757	0.681	2.169	4.775*
Korea	961.136	580.500	941.858	0.997	2.851	7.493**
Netherlands	2588.667	1882.000	1704.048	0.375	1.638	4.532*
New Zealand	1771.962	1418.300	1177.167	0.585	2.004	4.427*
Norway	2748.344	2196.900	1991.799	0.465	1.803	4.306
Portugal	1370.867	1143.500	986.205	0.301	1.691	3.894
Spain	1531.200	1230.900	1076.076	0.368	1.718	4.097
Sweden	2404.307	1708.600	1560.647	0.764	2.288	5.324*
Switzerland	3317.391	2871.500	2045.300	0.497	2.169	3.149
Türkiye	445.251	265.200	396.134	0.714	2.150	5.181*
UK	1878.551	1519.000	1410.833	0.409	1.663	4.610*
USA	4690.280	3905.400	3189.034	0.434	1.917	3.613
OECD Average	2229.819	1777.457	1492.787	0.483	1.919	3.942

Notes: ***, ** and * indicate significance levels for 1%, 5% and 10% Jarque-Bera (JB) test, respectively. The null hypothesis of the test shows that the data follows normal distribution, while the alternative hypothesis shows that it does not follow the normal distribution. The OECD Average represents the average of 21 countries included in the study.

First, the stationarity of the series was investigated using conventional unit root tests (PP, ADF, and KPSS). Table 3 presents the findings. The ADF and PPP test results in the USA, Australia, Belgium, Japan, and New Zealand provide similar findings for the same models. The KPSS test results generally differ from the results of both tests. According to the ADF test results, the model with only constant term (C) convergence hypothesis is valid for Australia, Belgium, Japan, New Zealand, and the United States. The hypothesis holds for Belgium, Japan, Korea, and New Zealand for the model with constant and trend (C+T).

Table 2: Conventional Unit Root Test Results

Country	ADF		PP		KPSS	
	C	C+T	C	C+T	C	C+T
Australia	-3.210 [0]**	-2.604 [0]	-3.210 (1)**	-2.604 (0)	0.343 (5)	0.182 (5)**
Austria	-1.494 [0]	-1.444 [0]	-1.754 (3)	-1.728 (3)	0.166 (5)	0.110 (5)
Belgium	-4.873 [1]***	-4.789 [1]***	-4.545 (4)***	-4.397 (4)***	0.090 (1)	0.060 (1)
Canada	-0.419 [0]	-2.800 [3]	-0.491 (1)	-1.880 (2)	0.785 (5)***	0.099 (5)
Denmark	-2.332 [0]	-1.330 [0]	-2.498 (4)	-1.204 (4)	0.706 (5)**	0.214 (5)**
Finland	-2.540 [1]	-2.493 [1]	-2.090 (1)	-1.997 (1)	0.088 (5)	0.073 (5)
Germany	-1.140 [0]	-0.892 [0]	-1.179 (2)	-1.223 (2)	0.735 (5)**	0.097 (5)
Iceland	-0.746 [2]	-3.818 [1]	-0.676 (0)	-2.501 (5)	0.553 (5)**	0.169 (5)**
Ireland	-0.969 [1]	-2.109 [3]	-0.652 (3)	-1.762 (3)	0.642 (5)**	0.128 (5)**
Japan	-3.284 [2]**	-3.222 [2]*	-2.040 (2)	-2.016 (2)	0.118 (5)	0.106 (5)
Korea	-2.531 [0]	-4.131 [2]***	-3.186 (11) **	-3.487 (17)*	0.838 (5)***	0.178 (5)**
Netherlands	-1.765 [0]	-1.700 [0]	-1.843 (2)	-1.797 (2)	0.181 (5)	0.121 (5)*
New Zealand	-5.162 [3]***	-4.601 [3]***	-5.971 (13)***	-4.764 (14)***	0.407 s(5)*	0.165 (5)**
Norway	-1.796 [0]	-2.021 [0]	-1.826 (6)	-2.063 (2)	0.784 (5)***	0.141 (4)*
Portugal	-1.222 [0]	-1.299 [0]	-1.205 (10)	-1.389 (6)	0.632 (5)**	0.192 (5)**
Spain	-1.299 [1]	-1.892 [1]	-1.735 (3)	-1.639 (3)	0.598 (5)**	0.143 (5)*
Sweden	-1.529 [0]	-0.903 [0]	-1.524 (2)	-0.908 (1)	0.558 (5)**	0.201 (5)**
Switzerland	-0.928 [0]	-1.135 [0]	-1.047 (3)	-1.412 (3)	0.624 (5)**	0.115 (5)
Türkiye	-0.640 [1]	-3.025 [3]	-0.531 (3)	-2.850 (3)	0.766 (5)***	0.121 (5)*
UK	-0.811 [0]	-1.439 [0]	-0.795 (2)	-1.539 (3)	0.705 (5)**	0.113 (5)
USA	-3.706 [0]***	-1.992 [0]	-3.705 (0)***	-1.968 (1)	0.484 (5)**	0.196 (5)**

Notes: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. For the KPSS test, the null hypothesis is "Stationarity", while it is "There is a unit root" for other tests. The values in square brackets indicate the optimum lag length for the ADF test. Optimal lag lengths were determined using Schwarz Information Criteria (SIC). The values in parentheses represent the Newey-West bandwidth calculated using the Bartlett kernel estimator. C: Model with only constant term, C+T: Model with constant and trend term.

Belgium, Korea, and the Netherlands do not have unit roots for both models, according to the results of the PP test. Moreover, the unit root hypothesis of the series for Australia and the USA is rejected for the models with only constant term. Where the hypothesis is rejected, it is concluded that convergence exists for these countries.

The KPSS unit test will be the last conventional unit root test in which the results will be examined. Firstly Austria, Belgium, Finland, and Japan are stationary for both models. Australia and Netherlands are stationary for model with only constant term. Finally, for the model with constant and trend terms, Canada, Germany, Switzerland, and the United Kingdom are stationary. Based to the conventional unit root test results, Belgium is the only stationary country for all tests and models.

Finally, the series' stationarity was investigated using Fan & Gencay's (2010) wavelet unit root test, the results of which are shown in Table 4. According to the table, only for the constant model, Belgium, Finland, Japan, and the Netherlands; For the model with constant and trend, it is seen that the unit root hypothesis is rejected in Canada, Denmark, Germany, and Korea. For Portugal, Spain, Switzerland, Türkiye, and the United States, the hypothesis is rejected for both models.

Table 3: Wavelet Unit Root Test Results

Country	Wavelet Unit Root Test	
	C	C+T
Australia	-12.183	-13.327
Austria	-13.437	-13.223
Belgium	-23.686*	-18.254
Canada	-10.192	-68.349***
Denmark	-12.800	-50.728***
Finland	-23.823*	-24.616
Germany	-18.285	-57.611***
Iceland	-6.305	-9.009
Ireland	-6.683	-14.848
Japan	-23.715*	-22.984
Korea	-21.486	-271.726***
Netherlands	-27.835**	-22.915
New Zealand	-8.437	-8.470
Norway	-2.484	-14.353
Portugal	-23.400*	-55.258***
Spain	-27.288*	-61.993***
Sweden	-9.708	-18.964
Switzerland	-37.188**	-81.629***
Türkiye	-45.545***	-189.712***
UK	-10.159	-28.618
USA	-39.155**	-66.343***

Notes: ***, ** and * indicate significance levels for 1%, 5% and 10%, respectively. The critical values for the constant model (C) are -40.38, -27.38 and -21.75 for 1%, 5% and 10%, respectively, while -50.77, -36.54 and -30.23 for the constant with trend model (C+T). The bandwidth required to calculate the test statistic was calculated with the formula $4(T/100)^{2/9}$ based on the sample length (T) as suggested by Newey & West (1987) for the Bartlett kernel.

5. Conclusion

Concepts like the level of education and the general health of the population are expressed through human capital. For countries to prosper economically, they must increase their human capital through health and education. Improving productivity and knowledge depend heavily on one's health, which is an essential component of human capital. Human capital can only be improved in a healthy population. Although the types and instruments of education are different, the benefits obtained from education also vary. An increase in education level will have a positive impact on nutrition and general well-being. An investment in the health sector is represented by the labor and material resources provided to health services. Health expenditures increase workforce productivity and yield long-term benefits. In addition to increasing labor productivity, health services reduce future health expenditures because fewer illnesses mean lower costs in the future.

Based on the proverb "*There is no greater wealth than health*" growth theory also addresses the phenomenon of health, which has been a critical issue throughout human history. Health expenditures are one of the economic development indicators. The development of health expenditures is critical to maintaining long-term economic growth. If the health expenditure convergence hypothesis is valid, it will almost certainly have a positive impact on economic growth.

This study differs from previous research in that it uses the wavelet unit root test based on Fan & Gencay's (2010) discrete wavelet transform, which has better power and size properties than conventional time domain unit root tests. The question of whether 21 OECD countries converged to the 1975–2019 mean was investigated.

The only constant and constant with trend models for Australia, Austria, Iceland, Ireland, New Zealand, Norway, Sweden, and the UK show that the convergence hypothesis is invalid. The hypothesis for Portugal, Spain, Switzerland, Türkiye, and the United States is valid for both models. However, the findings indicated that the convergence hypothesis valid for the constant with trend model in Canada, Denmark, Germany, and Korea, and for the only constant model in Belgium, Finland, Japan, and the Netherlands.

Findings are consistent with Fallahi (2011), Panopoulou & Pantelidis (2012), Payne et al. (2015), Akarsu et al. (2019), and Kızılkaya & Dağ (2021). On the other hand, it differs from Aslan (2009), Tülümce & Zeren (2013), and Nghiem & Connelly (2017).

The validity of the convergence hypothesis in health expenditures among OECD countries means that economic growth can be achieved by spending more effectively on health services in these countries. It is possible to argue that in cases where the convergence hypothesis is valid, there is no need for policies that promote convergence through continuous improvement of healthcare services.

Future research can reveal a convergence relationship in health with differences in economic development by comparing country groups. As a result, it will be possible to contribute to the literature by making policy recommendations specific to country groups.

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