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The Relationship Between Health Expenditure Efficiency and Key Macroeconomic Variables: Evidence from MIST Countries

Sağlık Harcamalarının Etkinliği ile Temel Makroekonomik Değişkenler Arasındaki İlişki: MIST Ülkeleri Üzerine Kanıtlar

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Abstract

This study investigates the Granger causality relationship between the technical efficiency of health expenditures and key macroeconomic indicators. The aim is to assess how efficiently countries convert healthcare spending into health outcomes. The analysis covers Indonesia, Mexico, South Korea, and Türkiye over the period 2000–2022 using World Bank data. In the first stage, Data Envelopment Analysis (DEA) is applied to compute technical efficiency scores, using private, public, and out-of-pocket health expenditures as inputs, and life expectancy at birth and infant mortality rate as outputs. In the second stage, the Dumitrescu-Hurlin panel causality test examines causal links between health expenditure efficiency and macroeconomic variables: unemployment, inflation, and per capita income. The DEA results reveal differences in efficiency levels among the countries studied. The causality analysis identifies a bidirectional relationship between per capita income and health expenditure efficiency. Additionally, unidirectional causality is observed from efficiency scores to both unemployment and inflation. The findings suggest that improving health expenditure efficiency not only enhances health outcomes but also influences macroeconomic stability. While rising efficiency seems linked to lower unemployment and inflation, this claim should be moderated to avoid implying a causal relationship. Moreover, the feedback loop between per capita income and efficiency underscores the need for policies that promote both economic growth and effective healthcare spending.

Keywords: Health Expenditures, Health Services, Per Capita Income, Macroeconomic Indicators.

Öz

Bu çalışma, sağlık harcamalarının teknik etkinliği ile temel makroekonomik değişkenler arasındaki nedensellik ilişkisini incelemeyi amaçlamaktadır. Hedef, ülkelerin sağlık harcamalarını sağlık sonuçlarına ne kadar verimli dönüştürebildiğini değerlendirmektir. Çalışma, 2000–2022 döneminde Endonezya, Meksika, Güney Kore ve Türkiye'ye ait Dünya Bankası verilerini kapsamaktadır. İlk aşamada, Veri Zarflama Analizi (VZA) ile özel, kamu ve cepten yapılan sağlık harcamaları girdi; doğumda yaşam beklentisi ve bebek ölüm oranı ise çıktı olarak kullanılarak teknik etkinlik skorları hesaplanmıştır. İkinci aşamada, Dumitrescu-Hurlin panel nedensellik testi ile sağlık harcama etkinliği ile işsizlik, enflasyon ve kişi başı gelir arasındaki ilişkiler analiz edilmiştir. VZA sonuçları, ülkeler arasında sağlık harcamalarının etkinliğinde farklılıklar olduğunu göstermektedir. Nedensellik analizinde, kişi başına gelir ile sağlık harcama etkinliği arasında çift yönlü nedensellik tespit edilmiştir. Ayrıca, sağlık harcama etkinliğinden işsizlik ve enflasyona doğru tek yönlü nedensellik bulunmuştur. Sonuçlar, sağlık harcamalarının etkinliğinin yalnızca sağlık sonuçlarını değil, makroekonomik istikrarı da etkilediğini ortaya koymaktadır. Özellikle, etkinliğin artması işsizlik ve enflasyonun azalmasına katkı sağlayabilir. Kişi başı gelirle etkinlik arasındaki karşılıklı ilişki, ekonomik büyüme ile etkili sağlık harcamalarını birlikte hedefleyen politikaların önemini vurgulamaktadır.

Anahtar Kelimeler: Sağlık Harcamaları, Sağlık Hizmetleri, Kişi Başı Gelir, Makroekonomik Göstergeler.

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The Relationship Between Health Expenditure Efficiency and Key Macroeconomic Variables: Evidence from MIST Countries

The burden imposed by poor health and serious illness is particularly pronounced among individuals in low- and middle-income regions, where healthcare infrastructure and social protection mechanisms are often inadequate. While quantifying the full magnitude of health-related losses remains methodologically challenging, the repercussions are multifaceted. Illness frequently compromises individuals' physical capacity, limits their ability to engage in labor or education, and disrupts their caregiving roles within households. As a result, elevated disease prevalence is strongly associated with reductions in national labor productivity, slower economic expansion, and impeded long-term development trajectories (Cole & Neumayer, 2006). A substantial body of empirical literature attributes cross-country disparities in economic growth and productivity to factors such as educational attainment, trade liberalization, national savings rates, inflation dynamics, and per capita income levels (Kim & Loayza, 2019; Miller & Upadhyay, 2000). Nonetheless, health remains a critically important yet sometimes underemphasized determinant of economic performance (Amiri et al., 2021). Bhargava et al. (2001) contend that the contribution of health to economic growth is markedly more significant in developing nations than in advanced economies. Conversely, it is also widely acknowledged that economic growth itself plays a pivotal role in shaping population health outcomes, suggesting a bidirectional relationship between health and economic development.

Health expenditures encompass all financial outlays directed toward the preservation, enhancement, and continuity of individual and public health. Public health spending, in particular, serves as a key indicator of a government's prioritization of population well-being and plays a pivotal role in ensuring the long-term viability of healthcare systems. Within the framework of development economics, such expenditures are increasingly regarded as strategic social investments aimed at strengthening national health infrastructures (Lu et al., 2010). The persistent rise in healthcare costs is attributed to a complex interplay of supply- and demand-side factors. On the supply side, determinants such as economic expansion, the availability of healthcare infrastructure and personnel, and the proliferation of health insurance schemes contribute significantly. Simultaneously, demand-side pressures—driven by demographic aging, prevailing health conditions, and evolving patterns of healthcare utilization—further intensify spending growth (Zhu et al., 2014). Health expenditures not only contribute to the improvement of population health outcomes but also play a fundamental role in enhancing human capital and fostering economic growth (Tıraş & Ağır, 2018). Given the considerable variation in healthcare system design, financing mechanisms, and institutional governance across nations, there is a growing imperative to identify and understand the distinct or context-specific determinants that drive health expenditure patterns in different countries (Tajudeen et al., 2018).

Countries are frequently classified in the literature according to various economic and structural attributes. Among these classifications, the MIST countries—Mexico, Indonesia, South Korea, and Turkiye—originally introduced by Goldman Sachs economist Jim O'Neill, have gained increasing attention as emerging market economies with strong growth potential (O'Neill, 2011). These nations are characterized by their expanding populations, substantial market sizes, contributions exceeding 1% to global GDP, and membership in the G-20, positioning them as potential drivers of future global economic trends (Yıldırım et al., 2021). Consequently, empirical investigations focusing on such dynamic developing economies are regarded as valuable contributions to the existing literature. A range of methodological approaches has been employed to assess the technical efficiency of health systems. Among these, data envelopment analysis (DEA) has emerged as one of the most widely adopted techniques, particularly in high-income countries, since its introduction to the healthcare sector in the late 1970s (Kirigia et al., 2004). In empirical studies focused on healthcare efficiency, undesirable

outputs are frequently managed either by incorporating them as inputs (Prior, 2006) or by converting them into desirable outcomes—for instance, by using transformations such as survival rate = 1 − mortality rate (Afonso & Aubyn, 2005). Alternatively, some researchers opt for inverse formulations of undesirable outputs; for example, Grosskopf et al. (2006) employ the reciprocal of the infant mortality rate to evaluate healthcare efficiency. These methodological choices aim to more accurately capture the multifaceted nature of healthcare performance. Hollingsworth and Wildman (2003) developed a composite health index—primarily reflecting life expectancy—by integrating both desirable outputs and undesirable components such as morbidity. This aggregate measure is widely regarded as a meaningful output in the assessment of health system efficiency. A fundamental metric for evaluating healthcare efficiency is the ratio of health system outputs to the physical and financial resources utilized (Ravangard et al., 2014). This efficiency ratio essentially reflects the extent to which a nation's health outcomes are commensurate with its available healthcare resources. Accordingly, the optimal allocation and utilization of healthcare inputs is universally acknowledged as a critical policy objective. In this context, Top et al. (2020) applied data envelopment analysis to assess the technical efficiency of health systems, incorporating health expenditures and selected indicators as inputs, and using life expectancy at birth alongside infant mortality rates as output measures. Given the substantial influence of health spending on population health, evaluating the technical efficiency of such expenditures holds considerable relevance for policymakers seeking to improve system performance. Developing countries not only contribute to global production but also play a pivotal role in expanding the international labor force. In this context, the provision of high-quality healthcare services becomes critically important, necessitating the allocation of substantial physical and financial resources (Zhou et al., 2020). Given the demographic weight and increasing global influence of developing economies, the impact of macroeconomic variables has garnered growing attention across various sectors, including healthcare (Turgut et al., 2017). Broadly speaking, two methodological approaches are commonly employed to assess the influence of health on economic growth. The first approach derives macro-level implications by extrapolating from microeconomic estimates of health impacts, while the second involves directly quantifying the aggregate relationship using macroeconomic indicators (Rengin, 2012).

Recent literature has increasingly investigated the extent to which macroeconomic indicators—such as tax revenue, inflation, and gross domestic product (GDP)—influence healthcare expenditures in the pursuit of universal health coverage. However, empirical studies utilizing macroeconomic data to explore health expenditure trends in developing economies remain relatively scarce (Behera & Dash, 2019). Moreover, the majority of existing analyses tend to emphasize linear associations between economic growth and health spending. In their comprehensive systematic review, Amiri et al. (2021) identified a wide array of macroeconomic determinants influencing healthcare expenditures, including per capita income, inflation, unemployment, GDP per capita, and poverty. Notably, the review found that approximately 75% of the analyzed studies were conducted in developed nations, particularly those within the OECD. In a country-specific study using data from Türkiye, Çıraklı (2019) demonstrated that, over the long term, increases in real GDP significantly contribute to the rising share of public health expenditures within total health spending, whereas inflation and unemployment were found to have no statistically significant impact. Taskaya and Demirkiran (2016), employing the Granger causality framework, found no statistically significant relationship between health expenditures and either inflation or per capita GDP in their empirical analysis. In contrast, Behera and Dash (2017), utilizing panel vector error correction models alongside fully modified and dynamic ordinary least squares methods, reported that per capita GDP exerts a positive and statistically significant influence on public healthcare spending. Similarly, several studies focusing on Türkiye have documented a positive relationship between health expenditures and economic growth (Çalışkan et al., 2013; Selim et al., 2014). This positive association has also been confirmed across diverse country groupings, further

reinforcing the view that healthcare investment contributes to economic expansion (Badri & Badri, 2016; Piabuo & Tieguhong, 2017). Notably, a consistent finding across much of the literature is that per capita income emerges as the most influential determinant of healthcare expenditure levels (Bustamante & Shimoga, 2017).

A growing body of literature has explored the efficiency of health spending; however, empirical research focusing on the technical efficiency of such expenditures in developing countries remains relatively scarce. The present study builds upon recent advancements in this field by incorporating methodological insights from prior empirical applications. For example, Castaldo et al. (2020) evaluated the efficiency of health systems across 30 OECD countries by employing Data Envelopment Analysis and subsequently modeling the resulting efficiency scores through a two-stage approach that combines DEA/Tobit regression and bootstrapping techniques. Their analysis identified significant associations between inefficiency and factors such as per capita GDP, vaccination coverage, and tobacco use. In another study, Melgen-Bello and García-Prieto (2017) investigated health expenditure efficiency in a group of Latin American and Caribbean countries using two alternative stochastic frontier models. The first model focused on life expectancy at birth as a general health outcome, while the second targeted infant mortality reduction as a more specific objective. Their findings underscore that health system performance is not solely determined by spending levels but is also shaped by broader structural variables such as poverty, education, and immunization rates. Drawing on these foundations, the current study aims to contribute to the literature by assessing the efficiency of health expenditures in emerging economies, with a particular focus on the MIST countries. The existing literature lacks comprehensive and integrative analyses on how health expenditures perform in a macroeconomic context specifically within emerging market economies such as the MIST countries. Moreover, most technical efficiency studies tend to focus solely on the relationship between healthcare inputs and outputs, often overlooking the bidirectional interactions between efficiency levels and macroeconomic variables. In this context, the present study aims to fill a critical gap by examining both the technical efficiency of health expenditures and its dynamic relationship with key macroeconomic indicators such as per capita income, unemployment, and inflation within the MIST country group. By addressing not only the volume of health expenditures but also their efficiency and macroeconomic relevance, this study contributes to closing a notable gap in the empirical health economics literature.

Within the scope of the reasons explained above, the following hypotheses were tested in the study:

H_1: Unemployment has a predictive relationship with the technical efficiency of health expenditures.

H_2: Per capita income has a predictive relationship with the technical efficiency of health expenditures.

H_3: Inflation has a predictive relationship with the technical efficiency of health expenditures.

H_4: The technical efficiency of health expenditures has a predictive relationship with unemployment.

H_5: The technical efficiency of health expenditures has a predictive relationship with per capita income.

H_6: The technical efficiency of health expenditures has a predictive relationship with inflation.

Method

Dataset and Variables of the Study

The data used in the study were obtained from the World Bank database (World Bank, 2024). The study utilized data from MIST countries (Indonesia, Mexico, South Korea, and Turkiye) covering the years 2000–2022. The data was downloaded from the World Bank database on July 1, 2024. The MIST countries (Mexico, Indonesia, South Korea, and Turkiye) were coined by Goldman Sachs economist Jim O'Neill and classified as “second-tier large, rapidly growing emerging economies” (O'Neill, 2011).

These countries stand out due to their large populations, G-20 memberships, and high growth potential. The variables and their abbreviations used in the research are presented in Table 1.

Table 1

Variables Used in the Study

	Variables	Abbreviations
Input Variable	Private health expenditures per capita (current US$)	PocHE
	Public health expenditures (current US$)	PubHE
	Out-of-pocket health expenditures per capita (current US$)	OoPHE
Output Variable	Life expectancy at birth (year)	LEAB
	1/Infant mortality rate (per thousand live births)	IMR
Dependent Variable	Technical efficiency score*	TE
Independent Variables	Unemployment, total (% of total labor force)	UNP
	Inflation, consumer prices (annual %)	INF
	GDP per capita, PPP (constant 2021 international $)	PCI

Note. Technical efficiency refers to the capacity of a health system to produce the maximum attainable output with a given level of inputs. In DEA, the technical efficiency score varies between 0 and 1, where 1 indicates operation on the efficiency frontier (full efficiency), and values below 1 reflect degrees of inefficiency compared to best-performing units.

Data Analysis

The empirical framework of this study is structured in two stages. In the first stage, technical efficiency scores for health expenditures were estimated using DEA based on the input-oriented CCR model. The input variables employed in the DEA model included private health expenditures, public health expenditures, and out-of-pocket health expenditures, while the output variables comprised life expectancy at birth and infant mortality rate. These efficiency scores, reflecting the performance of health spending across MIST countries, serve as the dependent variable in the subsequent analysis. In the second stage, the causal relationship between the efficiency scores and selected macroeconomic indicators was examined through the Dumitrescu-Hurlin panel causality test. Within this framework, unemployment, inflation, and per capita income were specified as the independent variables.

To ensure the selection of an appropriate causality analysis method, a series of preliminary diagnostic tests were conducted, including assessments of slope homogeneity, cross-sectional dependence, and unit root properties of the variables. All statistical analyses were performed at a 5% significance level at Stata 15.

Results

Descriptive Findings

Table 2 presents the basic descriptive statistics for the variables TE, PCI, INF, and UNP. The average value of the TE variable was found to be 0.749, with a standard deviation of 0.263. For the PCI variable, the mean was calculated as 2.802, accompanied by a standard deviation of 3.293. The INF variable exhibited a mean of 8.786 and a standard deviation of 12.826, while the UNP variable had a mean of 5.837 and a standard deviation of 3.035.

Table 2

Descriptive Statistics of Variables

	TE	PCI	INF	UNP
Mean	0.749	2.802	8.786	5.837
Median	0.876	3.382	5.585	4.405
Maximum	1	10.429	96.036	13.67
Minimum	0.205	9.286	-0.839	2.63
Std. Dev.	0.263	3.293	12.826	3.035
Skewness	-0.867	-1.117	4.423	1.066
Kurtosis	2.236	5.754	26.883	2.938

Data Envelopment Analysis

In short, it is a method used to determine the relative efficiency levels of enterprises or organizations. Based on linear programming, DEA allows comparison between two decision units that use the inputs and outputs obtained in the case of multiple inputs and outputs. In this comparison, no production function is required (Behdioğlu & Özcan, 2009).

Data envelopment analysis is considered an advantageous method for efficiency analysis with many input and output variables. At the same time, the analysis does not require any functional relationship between inputs and outputs. Differences between the units of measurement of input and output components used in efficiency measurement do not constitute an obstacle to efficiency measurement. Since DEA is not a parametric method, no statistical interpretation of efficiency results exists. With DEA, the efficiency levels of the units subject to analysis at a particular moment can be measured, and therefore, the model is called a static model (Özden, 2008).

Table 3 presents the technical efficiency scores related to health expenditures of Indonesia, Mexico, South Korea, and Turkiye between the years 2000–2022. Technical efficiency scores range between 0 and 1, where a value of 1 represents full efficiency. The values reflect each country's performance for each year. Indonesia's technical efficiency score started at a very low value of 0.205 in 2000. From the mid-2000s onward, a gradual increase in efficiency was observed. Particularly from 2010 onwards, a noticeable improvement occurred, with the score reaching 0.438 in 2011, 0.418 in 2017, and 0.438 again in 2022. However, Indonesia did not reach full efficiency in any of the years. Mexico is one of the countries that demonstrated high performance in terms of technical efficiency in health expenditures. The score, which was 0.863 in 2000, increased to 0.899 in 2005, 0.952 in 2010, and reached full efficiency (1.000) from 2018 to 2021. However, in 2022, the score dropped significantly to 0.680, indicating a loss of efficiency in resource use in the final year. South Korea's technical efficiency scores showed a consistent upward trend over the years. The score, which was 0.692 in 2000, exceeded the 0.9 level starting from 2006. South Korea reached full efficiency (1.000) for the first time in 2014 and generally maintained high performance in the following years. As of 2022, the efficiency score was again recorded as 1.000. Turkiye's technical efficiency score started at a rather low level of 0.553 in 2000. However, a remarkable increase was observed starting from 2003. In 2008, Turkiye reached 0.937, and in 2009, it achieved full efficiency (1.000) for the first time. Although the score followed a fluctuating trend after 2010, it generally remained at high levels. In 2022, Turkiye's score was once again recorded as 1.000, indicating full efficiency.

Table 3

Technical Efficiency Scores of Health Expenditures

Years	Indonesia	Mexico	South Korea	Türkiye
2000	0.205	0.863	0.692	0.553
2001	0.214	0.866	0.64	0.533
2002	0.21	0.868	0.677	0.631
2003	0.228	0.872	0.729	0.766
2004	0.23	0.88	0.761	0.769
2005	0.209	0.899	0.827	0.741
2006	0.245	0.91	0.903	0.741
2007	0.266	0.925	0.96	0.797
2008	0.298	0.955	0.849	0.937
2009	0.298	0.938	0.795	1
2010	0.376	0.952	0.857	0.943
2011	0.438	0.962	0.904	0.984
2012	0.414	0.963	0.916	0.99
2013	0.404	0.976	0.942	0.965
2014	0.391	0.986	1	0.917
2015	0.365	0.964	0.927	0.913
2016	0.386	0.969	0.925	0.942
2017	0.418	0.974	0.978	0.887
2018	0.409	0.983	1	0.861
2019	0.426	1	1	0.888
2020	0.438	1	1	0.917
2021	0.438	1	1	0.9
2022	0.438	0.68	1	1

Slope Homogeneity Test

The slope homogeneity test employed in the analysis is the delta test, originally introduced by Pesaran and Yamagata (Pesaran & Yamagata, 2008). This test is designed to determine whether the slope coefficients derived from panel data models are homogeneous across cross-sectional units or exhibit heterogeneity. The test yields two statistics: the delta statistic and its adjusted version, both of which serve as indicators of slope homogeneity. The delta test is widely recognized as an enhanced version of the Swamy's S test, initially proposed in 1970. Within this framework, the null and alternative hypotheses of the slope homogeneity test are formulated as follows (Gönüllü, 2024):

H_0;β_1^0=β_2^0=... = β_n^0=β^0 (The slope coefficients are homogeneous)

H_1;$\beta_i^0 \neq \beta_j^0$ (The slope coefficients are heterogeneous)

As a result of these established hypotheses, the delta and adjusted values used in calculating the slope coefficients are calculated using the following formulas (Gönüllü, 2024):

$$\tilde{\Delta}= \sqrt{N}\frac{(N^{-1}\bar{S}-k)}{\sqrt{2k}}\sim X_k^2$$

$$\tilde{\Delta}_{adj}=\sqrt{N}\frac{(N^{-1}\bar{S}-k)}{v(T,k)}\sim N(0,1)$$

In this context, the calculated slope homogeneity test results are presented below in Table 4.

Table 4

Slope Homogeneity Test Results

Test	Statistics	Test Value	Probability Value
$\tilde{\Delta}_{(HAC)}$	$\sqrt{N}\frac{(N^{-1}S_{(HAC)}-k)}{\sqrt{2k}}\sim X_k^2$	4.114	<0.001***
$\tilde{\Delta}_{(HAC)_{adj}}$	$\sqrt{N}\frac{(N^{-1}S_{(HAC)}-k)}{v(T,k)}\sim N(0,1)$	4.650	<0.001***

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

An examination of the slope homogeneity test results presented in Table 4 indicates that the null hypothesis of parameter homogeneity is rejected, based on the p-values associated with the computed delta statistics. This finding suggests that the variables included in the analysis exhibit a heterogeneous structure across cross-sectional units.

Horizontal Cross-Section Dependence Test

Testing for cross-sectional dependence among the series used in the analysis is a critical step, as it informs the appropriate selection of unit root and causality testing procedures. Accordingly, the existence of cross-sectional dependence must be examined prior to further econometric analysis. The choice of the appropriate test for cross-sectional dependence depends on the relative dimensions of the time series (T) and the cross-sectional units (N). Specifically, when the time dimension exceeds the cross-sectional dimension (T > N), the Breusch-Pagan Lagrange Multiplier (LM) test is typically employed (Göçer et al., 2012). The null hypothesis of the Breusch-Pagan LM test posits the absence of cross-sectional dependence across units, and the test statistic asymptotically follows a chi-squared distribution (Koçbulut & Altıntaş, 2016). The formal representation of the Breusch-Pagan LM test is given as follows:

$$\text{LM}= \text{T}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\tilde{\rho}_{ij}{}^2$$

An alternative approach for testing cross-sectional dependence is the CDLM test, developed by Pesaran. This test is particularly suitable in settings where both the time dimension (T) and the cross-sectional dimension (N) are sufficiently large (Turna & Polat, 2024). The CDLM test is widely regarded as an improved version of the traditional Breusch-Pagan LM test, offering greater robustness in the presence of large panels. The CDLM statistic is computed as follows:

$$CD_{LM}=\sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(\tilde{\rho}_{ij}{}^2-1$$

However, $CDLM$ test leads to biased results when the cross-section dimension is larger than the time dimension. The distortions in these biased results increase as the cross-section size increases. For this

reason, the CD test has been developed, which provides more efficient results when the crosssectional dimension is larger than the time dimension. In this framework, it can be stated that the CD test gives more efficient results when the crosssectional dimension is larger than the time dimension. Accordingly, the defined CD test is calculated as follows (Koçbulut & Altıntaş, 2016).

$$CD=\sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(\tilde{\rho}_{ij})$$

Based on these explanations, the cross-sectional dependence test results for the variables included in the analysis are presented in the table below.

Table 5

Horizontal Cross-Section Dependence Test Results

Test	Statistics	Probability value
Breusch-Pagan LM	46.10	<0.001***
Pesaran Scaled LM	11.57	<0.001***
Pesaran CD	6.28	<0.001**

Note. Null hypothesis: No cross-section dependence (correlation) in residuals. ***, **, * denote 1%, 5% and 10% significance levels, respectively.

The results of the cross-sectional dependence tests presented in Table 5 confirm the existence of statistically significant dependence among panel units. Accordingly, the null hypothesis of no cross-sectional dependence is rejected. In light of this outcome, the application of second-generation panel unit root tests, which explicitly account for cross-sectional dependence, becomes necessary to ensure methodological rigor and enhance the robustness of the empirical findings.

CIPS Panel Unit Root Test

In panel data analysis, unit root tests used to assess the stationarity properties of time series are typically classified into first-generation and second-generation approaches. When cross-sectional dependence is identified among the panel units, second-generation unit root tests are considered more appropriate, as they provide more reliable and consistent results under such conditions. Given the presence of cross-sectional dependence in this study, the CIPS (Cross-Sectionally Augmented Im, Pesaran, and Shin) unit root test was employed. Proposed by Pesaran, the CIPS test enhances the standard ADF methodology by incorporating cross-sectional averages to account for unobserved common factors. The procedure begins by applying the CADF (Cross-sectionally Augmented Dickey-Fuller) test to each cross-sectional unit individually. The final CIPS statistic is then calculated as the arithmetic mean of the CADF statistics across all cross-sections. Accordingly, the CIPS test provides a robust framework for evaluating the stationarity of the entire panel dataset (Gençoğlu et al., 2020). The results of the CIPS unit root test for the variables used in the analysis are presented in the following table.

Table 6

CIPS Unit Root Test Result

Tests	**CIPS**	
Variables	**T Statistic**	**Stasis**
TE_{it}	-2.2890***	I(0)
UNP_{it}	-1.7753**	I(0)
PCI_{it}	-3.0573***	I(0)
INF_{it}	-2.2841*	I(0)

Note. ***, **, * denote 1%, 5% and 10% significance levels, respectively. TE: Technical Efficiency, PCI: Per Capita Income

As indicated by the panel unit root test results in Table 6, all variables were found to be stationary at level. Given the stationarity of the series, the Dumitrescu-Hurlin panel causality test was subsequently employed to investigate the causal relationships among the variables.

Dumitrescu-Hurlin Panel Causality Test

The Dumitrescu-Hurlin panel causality test, introduced by Dumitrescu and Hurlin (2012), offers a significant advantage over traditional panel causality methods by accommodating both cross-sectional dependence and heterogeneity across units. Unlike conventional techniques, this approach is suitable for both balanced and unbalanced panel datasets, making it particularly valuable in empirical applications involving real-world data (Alper & Oransay, 2015). Moreover, the test is robust in settings where the cross-sectional (N) and time (T) dimensions differ, and its performance improves with an increase in the number of observations. A key assumption underlying the test is that the existence of causality in one cross-sectional unit (e.g., a country) may imply the presence of similar causality patterns in others.

Within this study, the Dumitrescu-Hurlin test is applied to series that are stationary, consistent with the test's assumptions. The test extends the Granger causality framework by averaging the individual Wald statistics computed for each cross-sectional unit. An additional strength of the Dumitrescu-Hurlin approach is that it does not require the existence of a cointegration relationship among the variables, thus eliminating a common constraint found in many other panel causality techniques (Demir, 2020). In this context, the causal relationship between series x and y is modeled as follows (Akın et al., 2024):

$$y_{it}=\alpha_i+\sum_{k=1}^{K}\theta_i^{(k)}y_{i,t-k}+\sum_{k=1}^{K}\beta_i^{(k)}x_{i,t-k}+\varepsilon_{it}$$

In line with the aforementioned methodological considerations, the results of the Dumitrescu-Hurlin panel causality test—used to examine the causal relationships among the variables included in the analysis—are presented in Table 7 below.

Table 7

Dumitrescu-Hurlin Panel Causality Test Results

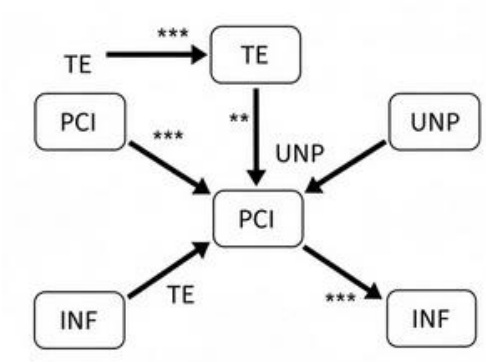
$Z_{N,T}^{Hnc}$ Test Statistic			
	W-bar statistics	**Z-bar statistics**	**Probability**
UNP→TE	0.2880	-1.0069	0.3140
PCI→TE	6.6409	4.6409	<0.001***
INF →TE	0.1229	-1.2404	0.2148
TE→UNP	5.1985	3.1985	0.0014***
TE→PCI	4.3971	2.3971	0.0165**
TE→INF	3.3048	3.2595	0.0011***

Note. ***, **, * denote 1%, 5% and 10% significance levels, respectively. TE: Technical Efficiency, PCI: Per Capita Income

According to the Dumitrescu-Hurlin panel causality test results presented in Table 7, the effects of unemployment (UNP) and inflation (INF) on technical efficiency (TE) were found to be statistically insignificant, whereas per capita income (PCI) exhibited a statistically significant effect on TE. Accordingly, hypotheses H_1 and H_3 are rejected, while H_2 is accepted. Conversely, the impact of TE on UNP, PCI, and INF was found to be statistically significant, leading to the acceptance of hypotheses H_4, H_5, and H_6. These findings indicate a bidirectional causality between PCI and TE, and a unidirectional causality running from TE to UNP and INF. The causal diagram of the variables in the table is presented in Figure 1.

Figure 1

Causal Diagram of Dumitrescu-Hurlin Panel Causality Test Results



Note. ***, **, * denote 1%, 5% and 10% significance levels, respectively. TE: Technical Efficiency, PCI: Per Capita Income, UNP: Unemployment Rate, INF: Inflation.

Discussion

The interplay between macroeconomics and health was comprehensively addressed by a landmark commission led by Jeffrey Sachs, which reported to the World Health Organization in 2001 (World Health Organization, 2001). The Commission on Macroeconomics and Health emphasized the necessity for low- and middle-income countries, with support from high-income nations, to expand access to primary healthcare services for impoverished populations. In the literature, two primary approaches are

employed to estimate the effect of health on economic growth: the first involves extrapolating microeconomic estimates of health impacts to calibrate aggregate-level outcomes, while the second directly estimates macro-level relationships using panel or time series data (Rengin, 2012). Developing countries tend to experience disproportionately higher incidences of infectious diseases, which impose substantial economic and social costs. Investments in managing such diseases not only generate immediate public health benefits but also contribute to long-term intergenerational improvements in population health (Akin, 2007). Consequently, the impact of health expenditures tends to be more pronounced and observable in less developed countries than in advanced economies. Against this backdrop, the present study aims to examine the relationship between the technical efficiency of health expenditures and key macroeconomic indicators in the context of emerging market economies.

The findings of this study reveal a bidirectional causal relationship between per capita income and the technical efficiency of health expenditures. This result aligns with several studies in the existing literature. For instance, Elmi and Sadeghi (2012), using data from 1990 to 2009 for 20 developing countries, identified a long-run bidirectional causality between health expenditures and economic growth. Similarly, Ogungbenle et al. (2013), in their analysis of Nigeria's public health expenditures from 1977 to 2008, reported reciprocal causality between the two variables. In a related study, Sghari and Hammami (2013) examined data from 30 developed countries spanning 1975 to 2011 and found a bidirectional relationship between per capita income and per capita health expenditures. Bayraktutan and Alancıoğlu (2020) further corroborated these findings through an analysis of data from 17 OECD countries covering the period 2000–2017. Their panel causality analysis identified bidirectional causality between health expenditures and economic growth in Austria, Switzerland, Ireland, and Turkiye. Taken together, the body of empirical evidence from both developing and developed economies consistently points to a mutually reinforcing relationship between health spending and economic growth. These results underscore the critical role of efficient allocation and utilization of health resources in promoting and sustaining long-term economic performance.

In this context, the findings of the present study are consistent with those in the existing literature. The observed bidirectional causality between per capita income and the technical efficiency of health expenditures underscores a mutually reinforcing dynamic: improvements in income levels can enhance health expenditure efficiency, while increased efficiency in health spending may, in turn, support income growth. This result highlights the interconnected nature of health and economic policy domains. The bidirectional relationship suggests the presence of a feedback loop, whereby economic expansion and health system improvements sustain and strengthen one another over time. Such interactions are particularly significant when evaluating the performance of national health systems, as they indicate that effective investment in health can facilitate healthier labor force participation, thereby accelerating economic growth. As noted by Bloom and Canning (2008), where health follows income, economic growth should be prioritized, particularly in developing countries. Conversely, in settings where income follows health, health investments may yield substantial returns even in the poorest nations. The significant influence of per capita income on both total and public health expenditures found in this study further emphasizes the crucial role of the public sector in financing and delivering healthcare services in developing economies.

Another key finding of the study is the presence of a unidirectional causal relationship running from the technical efficiency of health expenditures to unemployment. This result is consistent with prior empirical evidence in the literature. For instance, Onya et al. (2024), using a dataset covering West African countries from 1980 to 2022, demonstrated that health expenditures have a positive short-run effect on labor productivity. Similarly, Bassey et al. (2025) emphasized that government health spending enhances population health, thereby contributing to the accumulation of human capital, which in turn

fosters the development of a more skilled, efficient, and productive workforce. In support of this view, Khan et al. (2016) found a significant positive long-term relationship between labor force participation and total health expenditures, reinforcing the idea that more efficient health spending can positively influence labor market outcomes. The link between technical efficiency in healthcare and unemployment is thus both empirically supported and conceptually plausible. Moreover, evidence from Raifu et al. (2024), who analyzed Nigerian data from 1984 to 2019, reveals unidirectional causality from unemployment to total and capital government expenditures, and partial unidirectional causality from recurrent expenditures to unemployment. Although the directionality in that study differs, the findings similarly underscore the interconnectedness of public expenditure patterns—including those in health—and labor market dynamics. However, the literature also reports mixed findings regarding the relationship between health expenditures and unemployment or employment. For example, Uçar and Yılmaz (2025) found no significant Granger causality between individual health expenditures and unemployment in Türkiye. Conversely, Yılmaz (2023) reported that public health expenditures positively affect employment in the long run. Similarly, Taşkaya and Demirkıran (2016) demonstrated causality between health resources (doctors, hospital beds) and total health expenditures in Türkiye, suggesting that expenditure increases may not solely be driven by efficiency gains. These findings indicate that the observed unidirectional relationship from technical efficiency to unemployment in this study should be interpreted considering multiple potential mechanisms, including expenditure size, policy reforms, and health system characteristics.

According to the final finding of the study, a unidirectional causal relationship was identified from the technical efficiency of health expenditures to inflation. This result is supported by several empirical studies. For example, Akobi et al. (2021), using a 39-year dataset covering the period 1981–2019 for Nigeria, found that government health expenditures exert a positive and statistically significant impact on the inflation rate. Similarly, Sousa et al. (2024) emphasized the link between inflation and healthcare costs, indicating that health expenditures can influence inflation dynamics. Feliciano et al. (2017) also reported a strong correlation between health spending and inflation. Hartwig (2008) found a statistically significant relationship between general inflation and the growth rate of real per capita health expenditures. In contrast, Pakdaman et al. (2019) observed a negative association between health expenditures and inflation, suggesting mixed empirical evidence. Despite these contributions, there remains limited research focusing specifically on the relationship between the technical efficiency of health expenditures and key macroeconomic indicators such as inflation. The presence of a unidirectional causality in the current study may be attributed to the notion that increased efficiency in health spending could exert indirect effects on inflation. Improvements in efficiency enable the delivery of healthcare services with fewer resources and potentially lower costs, which may help stabilize healthcare prices and mitigate inflationary pressures.

These findings indicate that the technical efficiency of health expenditures in emerging market economies must be addressed as an integral part of macroeconomic policy design. Since the sustainable growth of health expenditures in the long term is largely dependent on a robust economic growth path, policymakers should focus not only on the level of spending but also on the extent to which resources are used efficiently. In this context, improving public procurement and supply chain processes, increasing operational efficiency in healthcare delivery, prioritizing cost-effective interventions, and reducing unnecessary or low value-added medical practices are important. Increasing the technical efficiency of health expenditures can contribute to the formation of a more productive workforce by improving the health status of the population, while also helping to alleviate inflationary pressures by keeping healthcare costs under control.

In conclusion, health expenditures are closely interlinked with key macroeconomic variables, and fluctuations in macroeconomic conditions have substantial implications for the performance and sustainability of health systems. Future research could extend this analysis to different country groups, periods, and additional evaluation variables, in order to identify more precisely the institutional and macroeconomic conditions under which efficiency-oriented health reforms yield the greatest economic and social returns.

Compliance with Ethical Standards

Ethical Approval

Since the data is publicly available on the internet, it does not require ethical approval.

Author Contributions

All authors contributed significantly to the preparation of this manuscript. [Author İB] conceived and designed the study. [YT] collected the data and performed the initial analyses. [CÇ] contributed to data interpretation and revised the manuscript critically for intellectual content. All authors participated in drafting the manuscript, reviewed and approved the final version, and agree to be accountable for all aspects of the work.

Declaration of Conflicting Interests

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