



Environmental quality and health expenditures efficiency in Türkiye: the role of natural resources

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Abstract

The environmental pollution caused by climate change and global warming pose significant risks to health. This raises the question how environmental disturbances can affect health expenditures. Based on this, this study examines the asymmetric effect of environmental quality on health expenditures in Türkiye using the non-linear ARDL (NARDL) model for the 1975–2019 period. In addition to environmental quality, natural resources, economic growth, and trade openness variables are also included in the health expenditure model. The findings support the existence of an asymmetric cointegration relationship between the series. The findings also indicate that positive environmental pollution shocks affect health expenditures positively in the long run, while negative environmental pollution shocks do not have a statistically significant effect on health expenditures. Positive and negative natural resource shocks affect health expenditures negatively in the long run. Despite the effect of positive economic growth shocks on health expenditures is positive but statistically insignificant, the effect of negative economic growth shocks is positive and significant. Besides, positive trade openness shocks have a negative effect on health expenditures and negative trade openness shocks have a positive effect. The findings prove that the steps to be taken to protect the environment in the current period will increase the effectiveness of health expenditures in the future. This situation has a guiding feature for policy-makers in terms of policy decisions.

Keywords Environmental quality · Natural resources · Health expenditures · NARDL · Türkiye

Introduction

The factors determining the health expenditures have been discussed for a long time by many researchers in developing economies (Gbesemete and Gerdtham 1992; Murthy and Okunade 2009; Yavuz et al. 2013). The relationship between health expenditures and its main determinants is also of vital importance for policy-makers. Health is an essential part of development strategies in all countries, as it plays a role in improving the general level of well-being (Mushkin 1962) by increasing life expectancy at birth (Jaba et al. 2014) and foreign direct investment inflows (Giammanco and Gitto 2019). In this context, it becomes necessary to investigate the role of many socioeconomic variables such as economic growth, environmental pollution, technological innovation, foreign trade, and population using reliable econometric techniques to better comprehend policies regarding health expenditures.

The empirical literature focuses on economic growth as the main determinant of health expenditures (Matteo 2005; Chaabouni et al. 2016; Wang et al. 2018, 2019). In addition,

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attention has been drawn to other determinants of health expenditures such as CO₂ emissions (Apergis et al. 2018; Alimi et al. 2020), technological innovations (Liu 2020), globalization (Fervers et al. 2016), institutional quality (Blum et al. 2021), unemployment (Yetim et al. 2021), urbanization (Ahmad et al. 2021), financial development (Rana et al. 2021), aging population (Lopreite and Zhu 2020), and renewable energy (Ullah et al. 2019; Shahzad et al. 2020). However, the impact of natural resources on health expenditure were neglected in these studies. Therefore, we expand the environmental quality-health expenditure relationship by adding natural resources.

The deteriorating environmental quality, global warming and climate change are serious threats to future population health and global development (Costello et al. 2009). Environmental pollution further exacerbates the negative effects on human health (Majeed and Ozturk 2020). However, there are several studies in the literature showing that natural resources improve environmental quality (Kongbuamai et al. 2020; Danish et al. 2020; Khan et al. 2021). Therefore, natural resources might be an important element in reducing various health risks. For example, increasing forestry activities can alleviate environmental pressures by increasing the assimilation capacity of countries, and reduce health problems with cleaner air. Thus, the three-part process of “(i) increasing natural resources, (ii) decreasing environmental pollution and (iii) improving health quality” is hypothesized to help decrease health expenditures and/or increase the efficiency of health expenditures.

The selection of Turkish economy for this study is primarily due to the historical background. According to OECD (2021a) data, Türkiye’s per capita health expenditures increased from US\$ 152.481 in 1990 to US\$ 1266.935 in 2019. In addition, while the share of total health expenditures in GDP in Türkiye was 2.449% in 1990, the value increased to 4.344% in 2019. On the other hand, WDI (2021) data indicate that the total natural resources rent (% of GDP) was approximately 0.581 in 1990, while it dropped to approximately 0.315 in 2019. This situation shows that there is a decrease in the share of natural resources rent in economic growth in Türkiye. The increase in health expenditures in the face of the decrease in natural resources in Türkiye raises the issue of whether the relationship between the two variables is significant, or not. In the process of evaluating Türkiye’s situation in terms of environmental quality based on CO₂ emissions per capita, which is an important determinant of environmental pollution, it catches the attention that the emissions reached 4.5 tons in 2019, while it was only 2.3 tons in 1990 (OECD 2021b) while natural resources decreased and health expenditures increased in the same period. As we mentioned above, this raises the question that there may be a strong link between environmental quality, natural resources, and health expenditures.

In the light of the above evaluations, the main purpose of this study is to investigate the relationship between environmental quality, natural resources, and health expenditures for Türkiye in the 1975–2019 period. This study can make important contributions to the literature in terms of different aspects. First of all, the significance of this study emerges from the relatively thin literature on the relationship between environmental pollution and health expenditures for Türkiye. Moreover, very limited empirical studies examine the relationship between natural resources and health expenditures. Cockx and Francken (2014), El Anshasy and Katsaiti (2015), Nikzadian et al. (2019), and Turan and Yanikkaya (2020) investigated the relationship in question with the help of different panel data techniques and obtained different findings. As far as we know, the absence of a time series study on this subject is one of the main motivations for our study. In addition, it is noteworthy that the non-linear ARDL (NARDL) model is not used and asymmetrical relationships are not analyzed in the literature that examine the main determinants of health expenditures. Estimations made under linearity assumption tend to produce misleading results when the true relation in the specified model is non-linear. Therefore, our study provides more efficient and consistent empirical findings compared to other studies as it exploits the NARDL approach. This enables us to evaluate both positive and negative shocks of explanatory variables, separately. To the best of the authors’ knowledge, previous studies failed to account for the structural breaks while examining asymmetric effects. Thus, another pioneering feature of this study is the inclusion of structural breaks. To further distinguish the study, dynamic multiplier analyses are also included to shed light on the dynamic effects. The asymmetric relationship between environmental quality, natural resources, and health expenditure stands out in the study. That is, the existence of cointegration between the variables is tested by the application of NARDL approach under structural breaks. In addition, the short- and long-run asymmetric effects of explanatory variables on health expenditures are examined. The asymmetrical findings obtained from the study may be an inspiration to researchers in this field, as well as a guide to policy-makers in the development of various recommendations regarding health expenditures.

The study raises the following research questions for Türkiye: (i) Is there an asymmetrical relationship between environmental pollution and health expenditures in Türkiye? (ii) What is the role of natural resources within that asymmetrical relationship? (iii) Based on empirical findings, what kind of policy recommendations can be drawn regarding the effectiveness of health expenditures in Türkiye? In the light of all these questions, the remaining sections of this paper are designed as follows: the second part of the study presents the empirical literature summary. The “**Model and data**” section focuses on the model and data set. The “**Methodology**”

section explains the methodology used in the study. “[Empirical findings and discussion](#)” section discusses the empirical findings. The “[Conclusion and policy recommendations](#)” section covers the conclusions and policy recommendations.

Empirical literature summary

In this section, the empirical literature with regard to the explanatory variables in the health expenditure function is presented in detail. The empirical literature deals with the determinants of health expenditures from different perspectives. Most of the studies in the literature include economic growth as one of the main determinants of health expenditures. In general, the literature points to the positive role of economic growth on health expenditures. Murthy and Okunade (2016) do this for the 1960–2012 period in the USA by focusing on the determinants of health expenditures. Their long-term findings from the ARDL method show that economic growth in the USA has a positive effect on health expenditures. Chaabouni and Saidi (2017) reveal that economic growth has increased health expenditures in 51 countries in the 1995–2013 period. Qu et al. (2018) find that per capita income positively affects per capita health expenditures using the sys-GMM method. Similarly, Usman et al. (2019) conclude that economic growth increases both government health expenditures and private health expenditures. Haseeb et al. (2019) explore the determinants of health expenditures for ASEAN countries in the 2009–2018 period. Their findings also show that economic growth has a positive effect on health expenditures in the long run. However, their results reveal that economic growth have no significant effect on health expenditures in the short run. Barkat et al. (2019) investigate the determinants of health expenditures for 18 Arab-World countries with data covering the period between 1995 and 2015. In the study, it is determined that economic growth positively affects health expenditures in the long run for all samples according to PMG and CCE estimations. Similarly, Shahzad et al. (2020) reveal that economic growth has a long-term positive effect on health expenditures for Pakistan in the 1995–2017 period. Apergis et al. (2020) find that economic growth increased health expenditures for 178 countries in the 1995–2017 period. On the other hand, Yetim et al. (2021) explore the socioeconomic determinants of health expenditures for the period 2000–2017 in 36 OECD countries. Findings by using the panel OLS method indicate that economic growth increases health expenditures. Using AMG and CCEMG estimators, Yang et al. (2021) reveal that economic growth has a positive effect on health expenditures in the long run for the period 1995–2018. In contrast to these studies, Wang et al. (2019) conclude that the long-term results from the ARDL

model for Pakistan show that economic growth has a negative impact on health expenditures for the 1995–2017 period.

Many empirical studies analyze the determinants of environmental quality (Cetin 2016; Cetin et al. 2018a; Chien et al. 2021a, 2022; Sun et al. 2021, 2022; Farooq et al. 2021; Anwar et al. 2021a, b, 2022a, b; Habiba et al. 2022; Çetin et al. 2022; Liu et al. 2022). Recent studies have focused on various determinants of environmental quality such as renewable energy (Sharif et al. 2020), tourism (Wangzhou et al. 2022), natural resources (Safdar et al. 2022), political instability (Sohail et al. 2022), globalization (Karaduman 2022), income inequality (Ozturk et al. 2021), insurance sector (Li et al. 2022), agriculture sector (Çetin et al. 2020), information and communication technology (Chien et al. 2021b), urbanization (Cetin et al. 2018b). However, an overarching analysis is of essence regarding the determinants of environmental sustainability. Since environmental quality is closely related to the health of individuals and/or public, we included a measure of environmental pollution as a determinant of health expenditures in our study. In the literature, the relationship between environmental pollution and health expenditures stands out as a subject of special interest by researchers. Chaabouni et al. (2016) focus on the relationship between CO₂ emissions, health expenditures, and economic growth for 51 countries classified as low-income, low-middle income, and high-middle income groups. Long-run estimation results reveal that CO₂ emissions trigger increases in health expenditures. Apergis et al. (2018) use quantile regression analysis to investigate the relationship between CO₂ emissions and health expenditures in the USA for the 1966–2009 period. The results of the study reveal that the increase in CO₂ emissions increases health expenditures. Zeng and He (2019) directly and indirectly analyze the impact of industrial air pollution on health expenditures in China using the spatial lag model and spatial spillover technique. The findings show that industrial air pollution in Chinese provinces increases health expenditures in local and neighboring provinces. Usman et al. (2019) investigate the relationship among air pollution, economic and non-economic factors and health expenditures for the period between 1994 and 2017 in 13 emerging economies. According to their findings, CO₂ emissions and the environmental index have a positive effect on government health expenditures and negative effects on private health expenditures in the long run. Focusing on the relationship between CO₂ emissions, economic growth, and health spending, Wang et al. (2019) present findings to support that an increase in CO₂ emissions triggers increases in health expenditures for the Pakistan economy during the 1995–2017 period. Researching the determinants of R&D and health expenditures in ASEAN countries, Haseeb et al. (2019) find that environmental pollution, energy consumption and economic growth have a significant positive impact on health

expenditures and R&D expenditures in these countries in the long run. Shahzad et al. (2020) explore the relationship between economic growth, CO₂ emissions, information and communication technologies, renewable energy, and health expenditures. The long-term findings of the study are that CO₂ emissions positively affect health expenditures.

Another explanatory variable investigated in the empirical analysis in this study is the trade openness. Sagarik (2016) uses the 2SLS regression method for 9 ASEAN countries, and investigates the determinants of health expenditures with the data between 2002 and 2011. The findings show that trade openness does not have a significant effect on health expenditures. Similarly, Wang et al. (2019) use ARDL model with data covering the 1995–2017 period for Pakistan and find that foreign trade per capita does not have a significant effect on health expenditures in the long run. Anwar et al. (2021c) use difference GMM, system GMM, pooled OLS, and FE for the period of 1999–2018 for 87 countries separated by income groups. They obtain mixed results on the impact of trade openness on health expenditures by different income groups of countries.

One of the main focuses of this study is the effect of natural resources on health expenditures. Only a very limited part of the literature focuses on the impact of natural resources on health expenditures (Cockx and Francken 2014; El Anshasy and Katsaiti 2015; Zhan et al. 2015; Hong 2017; Nikzadian et al. 2019; Turan and Yanikkaya 2020). In our study, we try to fill this gap by modelling the relationship between natural resources and health. Cockx and Francken (2014) investigate the relationship between two different natural resource data—namely natural resource income and per capita natural resources—and government health expenditures. The wide panel data analysis for the 1995–2009 period reveals that both of the natural resource indicators have a negative effect on public health expenditures. The panel fixed effect estimation results obtained by El Anshasy and Katsaiti (2015) show that natural resource income (mineral rents) is positively related to per capita health expenditures and negatively related to total health expenditures (% of GDP). The panel GLS estimation results, on the other hand, reveal that there is no statistically significant relationship between natural resource income (mineral rents) and per capita health expenditures, while natural resource income (mineral rents) positively affects total health expenditures

(% of GDP). However, their research is based on decade-lagged variables and considers only mineral rents ignoring the rents arising from oil, natural gas, coal and forests. Zhan et al. (2015) investigates the effect of resource dependency ratio on health expenditures in 31 Chinese provinces for the period 1999–2009. The study uses the share of industrial production of the mining (mineral) industries in GDP as the resource dependency ratio. The findings of the study reveal that resource dependency negatively affects health expenditures. Similarly, using panel fixed effect and lagged dependent variable models, Hong (2017) determines that total natural resource rents have a negative effect on health expenditures for the period 1972–2008 in authoritarian regimes. Nikzadian et al. (2019) use the panel FMOLS method for OPEC members between 2002 and 2015. They obtain findings that support the positive effect of resource rent on government health expenditures. However, using dynamic panel data analysis Turan and Yanikkaya (2020) determine that natural resources rent has a negative effect on public health expenditures.

Model and data

The main purpose of this study is to test the relationship between environmental quality, natural resources, and health expenditures in Türkiye using annual data for the 1975–2019 period. Economic growth and trade openness are added as additional explanatory variables to the model. The natural logarithmic model discussed in the study can be defined as:

$$\ln HE_t = \alpha_0 + \alpha_1 \ln NR_t + \alpha_2 \ln GDP_t + \alpha_3 \ln CO_{2t} + \alpha_4 \ln TRD_t + \varepsilon_t \quad (1)$$

here, *HE*, *NR*, *GDP*, *CO₂*, and *TRD* represent health expenditure, natural resources, economic growth, CO₂ emissions, and trade openness, respectively. α_0 and ε_t denote the constant term and the error term, respectively. α_1 , α_2 , α_3 , and α_4 are coefficients that show the impact of natural resources, economic growth, CO₂ emissions, and trade openness on health expenditures, respectively. However, as it will be explained in the following parts of the study, the positive and negative components and coefficients of the independent variables are not mentioned here. Table 1 presents detailed information regarding the variables considered

Table 1 Description of series

Symbol	Variable	Description	Source
HE	Health expenditure	Total health spending (% of GDP)	OECD
CO ₂	CO ₂ emissions	CO ₂ emissions (per capita/tons)	OECD
NR	Natural resources	Total natural resources rents (% of GDP)	WDI
GDP	Economic growth	GDP per capita (constant 2010 US\$)	WDI
TRD	Trade openness	Trade (% of GDP)	WDI

in the empirical model. The model uses the total health spending (% of GDP) series to represent health expenditures (OECD 2021a). As for the natural resources, the total natural resources rents (% of GDP) series were collected from WDI (2021). The total natural resources rents variable is calculated using oil rents, natural gas rents, coal rents, mineral rents, and lastly forest rents. The GDP per capita (constant 2010 US\$) series from WDI (2021) is used to represent economic growth. As a measure of environmental quality, CO₂ emissions (per capita/tons) data are included in the model (OECD 2021b). Trade openness is represented by trade (% of GDP) series and is obtained from WDI (2021). Descriptive statistics and correlation matrix for the series are presented in Table 2.

Methodology

Unit root tests

As a first step, we focus on the stationarity of variables. We first apply the conventional methods of ADF and PP presented by Dickey and Fuller (1981) and Phillips and Perron (1988) for stationarity analysis. Knowing that these tests do not account for structural breaks in the series and can result in biased and/or spurious regression results, we apply the unit root tests with two structural breaks suggested by Narayan and Popp (2010) to resolve such problems. Thus, two different models are proposed for the investigation of whether the series contain unit roots or not. The first model (M1) uses two structural breaks in constant only specification while the second model (M2) accounts for two structural

breaks with both constant and trend terms. Test equations for models M1 and M2 can be expressed as follows:

$$\text{Model M1} : y_t = \kappa + \alpha y_{t-1} + \beta t + \varphi_1 D(T_{B1})_{1,t} + \varphi_2 D(T_{B2})_{2,t} + \omega_1 DU_{1,t-1} + \omega_2 DU_{2,t-1} + \sum_{j=1}^{\rho} \theta_j \Delta y_{t-j} + e_{1t} \tag{2}$$

$$\text{Model M2} : y_t = \kappa + \alpha y_{t-1} + \beta t + \varphi_1 D(T_{B1})_{1,t} + \varphi_2 D(T_{B2})_{2,t} + \omega_1 DU_{1,t-1} + \omega_2 DU_{2,t-1} + \delta_1 DT_{1,t-1} + \delta_2 DT_{2,t-1} + \sum_{j=1}^{\rho} \theta_j \Delta y_{t-j} + e_{2t} \tag{3}$$

In Eqs. (2) and (3), Δ and ρ indicate the first difference operator and the appropriate lag length, respectively. e_{1t} and e_{2t} show the error terms. $DU_{i,t} = 1(t > T_{B,i})$ and $DT_{i,t} = 1(t > T_{B,i})(t - T_{B,i}), i = 1, 2$ denote the dummy variables used to detect the potential structural breaks in the constant and slope in the trend function that occur at times T_{B1} and T_{B2} , respectively. In addition, the null hypothesis of unit root can be analyzed against the stationary alternative hypothesis with the t-statistics of y_{t-1} . This approach determines structural break dates based on the sequential procedure. The inclusion of structural breaks increases the efficiency of the unit root tests while providing feedback for creation of dummy variables to be included in the NARDL estimation.

NARDL model

We explore the short run and long run asymmetric effects of total natural resources rents, GDP per capita, CO₂ emissions, and trade openness on the health expenditures using NARDL model proposed by Shin et al. (2014). The NARDL approach is an asymmetric version of ARDL developed by Pesaran et al. (2001). Therefore, firstly, we present the standard form of the ARDL regression model as follows:

$$\Delta \ln HE_t = \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \ln HE_{t-i} + \sum_{i=0}^q \alpha_{2i} \Delta \ln NR_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta \ln GDP_{t-i} + \sum_{i=0}^q \alpha_{4i} \Delta \ln CO_{2t-i} + \sum_{i=0}^q \alpha_{5i} \Delta \ln TRD_{t-i} + \beta_1 \ln HE_{t-1} + \beta_2 \ln NR_{t-1} + \beta_3 \ln GDP_{t-1} + \beta_4 \ln CO_{2t-1} + \beta_5 \ln TRD_{t-1} + \varepsilon_t \tag{4}$$

where Δ , \ln , and ε indicate first difference operator, natural logarithm and error term respectively. p and q are the optimal lag orders for variables. α_0 represents the intercept. $\beta_1, \beta_2, \beta_3, \beta_4,$ and β_5 are the long-run parameters while $\alpha_{1i}, \alpha_{2i}, \alpha_{3i}, \alpha_{4i},$ and α_{5i} are the short-run coefficients.

The NARDL approach is used to determine the asymmetric effects of the explanatory variables on health expenditure. The NARDL procedure has several virtues. To start with, the approach allows the series to be integrated at $I(0), I(1)$ or a combination of these. Additionally, ARDL and

Table 2 Descriptive statistics and correlations

Panel A: descriptive statistics					
	<i>lnHE</i>	<i>lnNR</i>	<i>lnGDP</i>	<i>lnCO₂</i>	<i>lnTRD</i>
Mean	1.167	-0.798	8.991	0.980	3.588
Median	1.117	-0.889	8.953	1.029	3.746
Maximum	1.703	0.299	9.628	1.547	4.138
Minimum	0.398	-1.967	8.510	0.405	2.208
Std. dev	0.387	0.592	0.349	0.345	0.461
Skewness	-0.167	0.071	0.349	-0.095	-1.333
Kurtosis	1.567	2.055	1.938	1.776	4.076
Observations	45	45	45	45	45
Panel B: correlations matrix					
	<i>lnHE</i>	<i>lnNR</i>	<i>lnGDP</i>	<i>lnCO₂</i>	<i>lnTRD</i>
<i>lnHE</i>	1				
<i>lnNR</i>	-0.683	1			
<i>lnGDP</i>	0.799	-0.640	1		
<i>lnCO₂</i>	0.846	-0.710	0.980	1	
<i>lnTRD</i>	0.685	-0.646	0.791	0.852	1

NARDL procedures perform exceptionally well under small sample conditions. The NARDL framework of the model used in the study can be expressed as follows:

$$\ln HE_t = \alpha_0 + \alpha_1 \ln NR_t^+ + \alpha_2 \ln NR_t^- + \alpha_3 \ln GDP_t^+ + \alpha_4 \ln GDP_t^- + \alpha_5 \ln CO_2_t^+ + \alpha_6 \ln CO_2_t^- + \alpha_7 \ln TRD_t^+ + \alpha_8 \ln TRD_t^- + \varepsilon_t \tag{5}$$

where α_i and ε indicate coefficients vector for the long-run and error term, respectively. $(\ln NR_t^+, \ln NR_t^-)$, $(\ln GDP_t^+, \ln GDP_t^-)$, $(\ln CO_2_t^+, \ln CO_2_t^-)$, and $(\ln TRD_t^+, \ln TRD_t^-)$ are positive and negative shocks to natural resources, economic growth, CO₂ emissions, and trade openness, respectively. The vectors of the independent variables can be decomposed as

$$\ln NR_t = \ln NR_0 + \ln NR_t^+ + \ln NR_t^- \tag{6}$$

$$\ln GDP_t = \ln GDP_0 + \ln GDP_t^+ + \ln GDP_t^- \tag{7}$$

$$\ln CO_{2t} = \ln CO_{20} + \ln CO_{2t}^+ + \ln CO_{2t}^- \tag{8}$$

$$\ln TRD_t = \ln TRD_0 + \ln TRD_t^+ + \ln TRD_t^- \tag{9}$$

where $\ln NR_0, \ln GDP_0, \ln CO_{20}$, and $\ln TRD_0$ represent random initial values. $\ln NR_t^+$ (or $\ln GDP_t^+, \ln CO_{2t}^+, \ln TRD_t^+$) and $\ln NR_t^-$ (or $\ln GDP_t^-, \ln CO_{2t}^-, \ln TRD_t^-$) are the partial sum process exhibiting the positive and negative changes in $\ln NR_t$ (or $\ln GDP_t, \ln CO_{2t}, \ln TRD_t$). Following Shin et al. (2014), the positive and negative components of natural resources, economic growth, CO₂ emissions, and trade openness can be expressed in a partial sum process as follows:

$$\ln NR_t^+ = \sum_{i=1}^t \Delta \ln NR_i^+ = \sum_{i=1}^t \max(\Delta \ln NR_i, 0) \tag{10}$$

$$\ln NR_t^- = \sum_{i=1}^t \Delta \ln NR_i^- = \sum_{i=1}^t \min(\Delta \ln NR_i, 0) \tag{11}$$

$$\ln GDP_t^+ = \sum_{i=1}^t \Delta \ln GDP_i^+ = \sum_{i=1}^t \max(\Delta \ln GDP_i, 0) \tag{12}$$

$$\ln GDP_t^- = \sum_{i=1}^t \Delta \ln GDP_i^- = \sum_{i=1}^t \min(\Delta \ln GDP_i, 0) \tag{13}$$

$$\ln CO_{2t}^+ = \sum_{i=1}^t \Delta \ln CO_{2i}^+ = \sum_{i=1}^t \max(\Delta \ln CO_{2i}, 0) \tag{14}$$

$$\ln CO_{2t}^- = \sum_{i=1}^t \Delta \ln CO_{2i}^- = \sum_{i=1}^t \min(\Delta \ln CO_{2i}, 0) \tag{15}$$

$$\ln TRD_t^+ = \sum_{i=1}^t \Delta \ln TRD_i^+ = \sum_{i=1}^t \max(\Delta \ln TRD_i, 0) \tag{16}$$

$$\ln TRD_t^- = \sum_{i=1}^t \Delta \ln TRD_i^- = \sum_{i=1}^t \min(\Delta \ln TRD_i, 0) \tag{17}$$

By extending the ARDL regression model (Eq. 4), the NARDL model can be written as

$$\begin{aligned} \Delta \ln HE_t = & \alpha_0 + \sum_{i=1}^p \alpha_{1i} \Delta \ln HE_{t-i} + \sum_{i=0}^q \alpha_{2i} \Delta \ln NR_{t-i}^+ + \sum_{i=0}^q \alpha_{3i} \Delta \ln NR_{t-i}^- \\ & + \sum_{i=0}^q \alpha_{4i} \Delta \ln GDP_{t-i}^+ + \sum_{i=0}^q \alpha_{5i} \Delta \ln GDP_{t-i}^- + \sum_{i=0}^q \alpha_{6i} \Delta \ln CO_{2t-i}^+ \\ & + \sum_{i=0}^q \alpha_{7i} \Delta \ln CO_{2t-i}^- + \sum_{i=0}^q \alpha_{8i} \Delta \ln TRD_{t-i}^+ + \sum_{i=0}^q \alpha_{9i} \Delta \ln TRD_{t-i}^- \\ & + \beta_1 \ln HE_{t-1} + \beta_2 \ln NR_{t-1}^+ + \beta_3 \ln NR_{t-1}^- + \beta_4 \ln GDP_{t-1}^+ + \beta_5 \ln GDP_{t-1}^- \\ & + \beta_6 \ln CO_{2t-1}^+ + \beta_7 \ln CO_{2t-1}^- + \beta_8 \ln TRD_{t-1}^+ + \beta_9 \ln TRD_{t-1}^- + \varepsilon_t \end{aligned} \tag{18}$$

where p and q are the optimal lag orders for variables. α_0 represents the intercept. Δ and ε indicate the first difference operator and error term respectively. $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8,$ and β_9 are the long-run parameters while $\alpha_{1i}, \alpha_{2i}, \alpha_{3i}, \alpha_{4i}, \alpha_{5i}, \alpha_{6i}, \alpha_{7i}, \alpha_{8i},$ and α_{9i} are the short-run coefficients.

In the NARDL process, the presence of non-linear cointegration is analyzed by the F_{PSS} (Pesaran et al. 2001) and t_{BDM} (Banerjee et al. 1998) tests. The null hypothesis in this test is no cointegration. The null hypothesis is rejected when the calculated F_{PSS} (or t_{BDM}) statistic exceeds the upper critical bound. Contrarily, the null hypothesis is validated when the calculated F_{PSS} (or t_{BDM}) statistic is smaller than lower critical bound. When the calculated F_{PSS} (or t_{BDM}) statistic falls between these critical bounds, the finding is not certain. Additionally, several diagnostic tests for serial correlation, normal distribution, autoregressive conditional heteroscedasticity, and functional form are applied to examine the suitability of the model used in the study. Finally, we apply the WALD test to determine the short-run and long-run asymmetries.

Empirical findings and discussion

In the first stage of the empirical analysis, the stationarities of the series were tested. Table 3 shows the findings from the ADF and PP unit root tests with constant only and with constant and trend. Considering the constant only results, it can be deduced that all series become stationary at the first difference. However, the constant and trend test results indicate that CO₂ is stationary at the level. Traditional unit root tests do not take into account structural changes caused by crises, supply shocks and other fluctuations. Therefore, to

Table 3 Unit root test results

Variables	ADF		PP	
	Constant	Constant and trend	Constant	Constant and trend
Level				
<i>lnHE</i>	-1.020(0)	-1.595(0)	-1.067(4)	-1.868(4)
<i>lnNR</i>	-1.619(0)	-1.917(0)	-1.614(4)	-2.023(2)
<i>lnGDP</i>	0.520(0)	-2.290(0)	0.586(3)	-2.327(2)
<i>lnCO₂</i>	-0.742(0)	-3.715(0)**	-0.746(12)	-3.733(1)**
<i>lnTRD</i>	-1.555(0)	-2.647(1)	-1.453(6)	-2.283(3)
First difference				
Δ <i>lnHE</i>	-7.075(0)***	-7.112(0)***	-7.007(4)***	-7.029(4)***
Δ <i>lnNR</i>	-6.256(0)***	-6.201(0)***	-6.286(7)***	-6.230(7)***
Δ <i>lnGDP</i>	-6.484(0)***	-6.691(0)***	-6.484(0)***	-6.705(3)***
Δ <i>lnCO₂</i>	-8.096(0)***	-7.998(0)***	-11.088(10)***	-10.952(10)***
Δ <i>lnTRD</i>	-4.970(1)***	-5.011(1)***	-5.751(8)***	-6.321(10)***

The optimal lag lengths in the ADF test are determined automatically using SIC. In the PP test, Newey and West (1994) method is used to determine the bandwidth. Values in parentheses represent the appropriate lag. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively

obtain more consistent findings, the stationarity of the series were also investigated with the test suggested by Narayan and Popp, which allows controlling for structural breaks.

The Narayan-Popp unit root test results are presented in Table 4. M2 (level and slope) findings demonstrate that health expenditure, natural resources, economic growth, and CO₂ emissions are found to be stationary at first differences. In addition, trade openness is determined to be stationary at level. The structural break dates generally indicate economic crisis and supply shocks. The structural breaks that appear in the Narayan-Popp level-only unit root test (M1) results for *lnHE* indicate the years 1984 and 1998 as breakpoints.

However, the test result with both level and slope (M2) signifies the years 1985 and 1998 as breakpoints. 1984–85 period represents a financial structural change in Turkish economy regarding the liberalization of trade and monetary exchange. 1998 is the year in which Turkish economy subjected to the negative supply shock stemming from 1997 Asian financial crisis. Consequently, we take the results of M2 (1985 and 1998) into account in break-dummy specification on the grounds that it captures both level and slope effects. We chose the break years indicated in M2 on the grounds of two reasons: first, the structural change in 1984 created a shift starting from 1985. Secondly, 1998 was the

Table 4 Narayan-Popp unit root test

Variables	M1 (Model 1): level			M2 (Model 2): level and slope		
	<i>t</i> -statistics	TB1	TB2	<i>t</i> -statistics	TB1	TB2
Level						
<i>lnHE</i>	-2.549(0)	1984	1998	-2.063(0)	1985	1998
<i>lnNR</i>	-2.701(0)	1997	2007	-3.219(0)	1997	2008
<i>lnGDP</i>	-4.134(0)	1993	2000	-3.783(0)	2000	2008
<i>lnCO₂</i>	-4.495(0)*	1986	2000	-3.314(0)	1987	2000
<i>lnTRD</i>	-2.564(1)	1983	1997	-7.647(1)***	1985	1993
First difference						
Δ <i>lnHE</i>	-10.21(0)***	1984	1998	-5.705(0)**	1985	1995
Δ <i>lnNR</i>	-6.811(0)***	1997	2008	-6.681(0)***	1997	2008
Δ <i>lnGDP</i>	-7.401(0)***	2000	2008	-7.167(0)***	2000	2008
Δ <i>lnCO₂</i>	-7.153(0)***	1987	2000	-8.015(0)***	1987	2000
Δ <i>lnTRD</i>	-5.836(0)***	1985	1997	-6.838(2)***	1984	1997

Values in parentheses represent the optimal lag. M1 critical table values are as -5.259, -4.514, and -4.143 at 1%, 5% and 10% significance levels, respectively. M2 critical table values are as -5.949, -5.181, and -4.789 at 1%, 5% and 10% significance levels, respectively. ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively

year that Turkish financial sector had been hit by a global shock that eventually spread to the real side of the economy and caused further economic crises in 1999 and 2001.

When the residuals in a model do not fluctuate around a line, this indicates that the variance cannot be equally distributed among different levels of predictor variables. In other words, when residuals follow a curvy path, implementing a linear regression line renders the estimation results inconsistent. Thus, at the second stage, we apply the BDS test developed by Broock et al. (1996) to detect the presence of non-linearity. The findings presented in Table 5 indicate with a very high statistical significance that there exists non-linearity in the series.

In the third stage, the existence of a cointegration relationship between the dependent variable and explanatory variables is investigated through the NARDL model. The results are presented in Table 6. The NARDL model allows to determine the cointegration relationship by means of two different test statistics (F_{PSS} and t_{BDM}). Since the F_{PSS} and t_{BDM} statistics are higher than the upper critical limits at 1% significance level, the existence of a non-linear cointegration between the variables is validated. Therefore, this result means that there is a long-run asymmetric relationship between the variables included in the model.

The short- and long-term coefficients obtained from the NARDL model are presented in Table 7. At this stage of the analysis, the short- and long-run elasticities of the variables

are determined for both positive and negative shocks. In the long run, a positive shock to natural resources is negatively associated with health expenditures. Similarly, any negative shock to natural resources reduces health expenditures. However, the effect of positive natural resources shocks on health expenditures in the long run is greater than the impact of negative natural resources shocks. To put it another way, unit percent positive natural resource shocks reduce health expenditures by 0.325% and unit percent negative natural resource shocks reduce health expenditures by 0.265%. Therefore, it is concluded that the developments in natural resources will contribute to the reduction of health expenditures for Türkiye. Considering this situation for the Turkish economy, it allows the inference that the abundance of natural resources can contribute to the improvement of the health quality of individuals by minimizing the health risks and accordingly, reduce the health costs.

Our empirical result can be interpreted in conjunction with the findings of Cockx and Francken (2014). Although it is not an asymmetric analysis, they conduct a panel analysis and use two different natural resource data: natural resource income and natural resources per capita. According to their panel fixed effects estimation results, there are negative relationships between these variables with health expenditures. These results can be interpreted in the context of natural resource dependence implying that natural resource abundance recedes health expenditures. Zhan et al. (2015) reveal that resource dependency negatively affects health expenditures for 31 Chinese provinces. Hong (2017) finds that total natural resource rents have a negative effect on health expenditures in authoritarian regimes. On the other hand, Nikzadian et al. (2019) reveal that resource rent has a positive effect on government health expenditures for OPEC. Whereas Turan and Yanıkkaya (2020) analyze the total natural resource rent and related sub-indicators in the panel for more than 100 countries in the 1980–2015 period. They find that all kinds of resource rents have a negative effect on health expenditures.

While the effect of positive economic growth shocks on health expenditures is statistically insignificant, negative economic growth shocks are positively related to health expenditures. In other words, any negative shock to economic growth in the long run increases health expenditures. According to our findings, it can be deduced that negative developments in per capita income may lead to a decrease in the welfare of individuals, accelerate the occurrence of various health problems (psychological disorders, malnutrition etc.), and consequently increase the health expenditures. In addition, health expenditures may increase in the face of negative economic growth shocks, as it is an indicator that does not have a declining trend. In other words, as a negative shock to GDP directly increases the HE/GDP ratio, the effects of negative shocks to per capita GDP become

Table 5 BDS non-linearity test results

Variables	$m=2$	$m=3$	$m=4$	$m=5$	$m=6$
$\ln HE$	0.166***	0.287***	0.360***	0.405***	0.433***
$\ln NR$	0.129***	0.215***	0.248***	0.254***	0.248***
$\ln GDP$	0.177***	0.287***	0.356***	0.401***	0.431***
$\ln CO_2$	0.179***	0.304***	0.391***	0.452***	0.502***
$\ln TRD$	0.182***	0.308***	0.399***	0.472***	0.522***

The findings show the BDS test based on residual values of all series within VAR, with m dimension. *** indicates rejection of the null hypothesis of residuals iid at 1%

Table 6 NARDL cointegration results

Model: $\ln HE / (\ln NR^+, \ln NR^-, \ln GDP^+, \ln GDP^-, \ln CO_2^+, \ln CO_2^-, \ln TRD^+, \ln TRD^-)$	
F_{PSS}	10.284*** Cointegrated
t_{BDM}	-5.706*** Cointegrated

F_{PSS} and t_{BDM} show the statistic of the Pesaran et al. (2001) bounds test and the statistic of Banerjee et al. (1998), respectively. *** indicates significance at 1% level

Table 7 NARDL model short-run and long-run results

	Coef	t-stat	Prob
$\ln HE_{t-1}$	-1.797***	-5.71	0.000
$\ln NR_{t-1}^+$	-0.584***	-5.86	0.000
$\ln NR_{t-1}^-$	0.476***	3.85	0.002
$\ln GDP_{t-1}^+$	0.042	0.08	0.939
$\ln GDP_{t-1}^-$	-4.823***	-3.64	0.003
$\ln CO_{2,t-1}^+$	2.287***	4.50	0.001
$\ln CO_{2,t-1}^-$	-0.166	-0.21	0.838
$\ln TRD_{t-1}^+$	-0.581***	-4.36	0.001
$\ln TRD_{t-1}^-$	-1.299***	-4.33	0.001
$\Delta \ln HE_{t-1}$	0.399*	2.06	0.059
$\Delta \ln NR_{t-1}^+$	-0.088	-0.60	0.561
$\Delta \ln NR_{t-1}^-$	0.207	1.30	0.216
$\Delta \ln NR_{t-1}$	0.197	1.40	0.184
$\Delta \ln NR_{t-1}^+$	-0.084	-0.75	0.468
$\Delta \ln GDP_{t-1}^+$	0.279	0.48	0.642
$\Delta \ln GDP_{t-1}^-$	-0.048	-0.10	0.925
$\Delta \ln GDP_{t-1}$	-4.415***	-3.05	0.009
$\Delta \ln GDP_{t-1}^+$	0.558	0.59	0.565
$\Delta \ln CO_{2,t-1}^+$	-0.041	-0.07	0.944
$\Delta \ln CO_{2,t-1}^-$	-1.150*	-2.14	0.051
$\Delta \ln CO_{2,t-1}$	0.951	1.16	0.266
$\Delta \ln CO_{2,t-1}^+$	0.462	0.58	0.569
$\Delta \ln TRD_{t-1}^+$	-0.986***	-4.31	0.001
$\Delta \ln TRD_{t-1}^-$	-0.276	-1.66	0.119
$\Delta \ln TRD_{t-1}$	0.756**	2.39	0.032
$\Delta \ln TRD_{t-1}^+$	1.288***	3.19	0.007
D_{1985}	-0.398***	-5.64	0.000
D_{1998}	0.574***	3.43	0.004
Constant	1.227***	4.57	0.000

Table 7 (continued)

Panel B: long-run coefficients			
	Coef	F-stat	Prob
$\ln NR^+$	-0.325***	61.99	0.000
$\ln NR^-$	-0.265***	31.78	0.000
$\ln GDP^+$	0.024	0.006	0.939
$\ln GDP^-$	2.683***	29.03	0.000
$\ln CO_2^+$	1.272***	21.5	0.000
$\ln CO_2^-$	0.092	0.043	0.838
$\ln TRD^+$	-0.324***	42.98	0.000
$\ln TRD^-$	0.723***	35.22	0.000

D_{1985} and D_{1998} represent structural breaks. ***, **, *, and * indicate significance at 1%, 5% and 10% levels, respectively.

much more apparent compared to positive shocks. We think that this is due to the fact that the period analyzed in this study includes many sharp drops in per capita GDP, but not as many sharp upswings. An example can be given as the expansion of health expenditures in many countries during the COVID-19 pandemic period in the world, while experiencing economic contraction. Thus, it is plausible for negative economic growth shocks to have a positive effect on health expenditures in Türkiye. At this point, it is crucial to note that it is not straightforward appropriate to compare our empirical findings with similar studies that are based on symmetrical analysis. However, most of the studies analyzing the symmetrical relationship between economic growth and health expenditures reveal that there is a positive relationship between the two variables (Murthy and Okunade 2016; Chaabouni and Saidi 2017; Qu et al. 2018; Barkat et al. 2019; Apergis et al. 2020; Yang et al. 2021). Contrary to these studies, Wang et al. (2019) determines that economic growth has a negative effect on health expenditures. We think that the positive relationship between economic growth and health expenditures, which is the prevalent tendency in the related literature, arises from the fact that none of the previous research takes advantage of a non-linear approach.

In the long run, a positive shock in CO₂ emissions is positively associated with health expenditures, despite the effect of negative CO₂ emissions shocks is insignificant. Therefore, the increase in environmental pollution causes an increase in health expenditures. That is, a one-percent positive shock in CO₂ emissions changes healthcare spending by 1.272%, which means that health expenditures respond to the increase in CO₂ emissions at a higher rate. In other words, the adverse effects on human health stemming from higher CO₂ emissions stimulate health expenditures even more. For this reason, every step to be taken to improve environmental quality in Türkiye will not only reduce health expenditures, but also relieve the load on the healthcare system. On the other hand, this situation brings to the agenda the increase in respiratory diseases due to the fact that individuals eat unhealthy foods and inhale lower-quality of air in countries like Türkiye, where rapid environmental degradation occurs due to air, soil and water pollution. Thus, an increase in health expenditures is inevitable in such countries. Examining the relationship between CO₂ emissions and health expenditures from a symmetrical perspective, Chaabouni et al. (2016), Apergis et al. (2018), Usman et al. (2019), Haseeb et al. (2019), and Shahzad et al. (2020)'s empirical findings support the existence of a positive relationship between the two variables. Again, we argue that the difference in significance regarding positive and negative shocks is due to the fact that CO₂ levels have been historically increasing and there has not been any strong breakdown in the trends until the recent COVID-19 pandemic.

The positive trade openness shocks on health expenditures have a negative coefficient, while negative trade openness shocks are positively associated with health expenditures. A one-percent positive trade openness shock reduces health expenditures by 0.324% in the long run, while a one-percent negative trade openness shock causes a 0.723% increase in health expenditures. This finding indicates that the developments in trade openness in the long run contribute to the decrease in health expenditures. This is an expected result in countries like Türkiye, where the focus on technology transfer through foreign trade is critical. It can be concluded that the implementation of more advanced and environment-friendly technologies via higher levels of trade openness creates statistically significant direct and/or indirect effects that reduce the health expenditures in the long run. Although it requires a careful approach to compare the findings of symmetric studies, Sagarik (2016) and Wang et al. (2019) detect the existence of a statistically insignificant relationship between trade openness and health expenditures. It is well-known that global integration via trade openness provides higher levels of welfare standards particularly to the individuals in developing countries by the introduction of more advanced technologies and products with higher quality. Thus, it is quite rational to expect positive effects of trade openness on health quality, which in turn decreases the health expenditures.

Table 8 shows the short- and long-term asymmetries of the NARDL model. At this stage of the empirical analysis, asymmetries in the relationship between natural resources, economic growth, CO₂ emissions, trade openness, and health expenditures are analyzed. The long-term relationships are found to be asymmetrical between the explanatory variables and health expenditures. On the other hand, the findings indicate that the short-run relationships between economic growth, trade openness and health expenditures are asymmetrical. The diagnostic tests for the estimated model are presented in Table 9. First, the independent variables explain

Table 8 NARDL model short-run and long-run asymmetry

	<i>F</i> -stat	Prob
Long-run		
W_{LR}^{lnNR}	73.14***	0.000
W_{LR}^{lnGDP}	20.6***	0.000
$W_{LR}^{lnCO_2}$	8.034**	0.013
W_{LR}^{lnTRD}	14.62***	0.002
Short-run		
W_{SR}^{lnNR}	0.0001	0.991
W_{SR}^{lnGDP}	3.34*	0.089
$W_{SR}^{lnCO_2}$	1.754	0.207
W_{SR}^{lnTRD}	14.34***	0.002

***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively

Table 9 NARDL model sensitivity analysis

Diagnostics		
R^2	0.922	
Adj. R^2	0.767	
	Stat	<i>p</i> value
Portmanteau test up to lag 19 (chi2)	25.25	0.152
Breusch/Pagan heteroskedasticity test (chi2)	0.057	0.810
Ramsey RESET test (<i>F</i>)	1.076	0.399
Jarque–Bera test on normality (chi2)	1.192	0.550

92% ($R^2 = 0.922$) of health expenditures. In other words, the power of the independent variables to explain the changes in the dependent variable is very high. Moreover, diagnostic tests show that the model does not suffer from heteroskedasticity and autocorrelation. It reveals that the error terms exhibit normal distribution, which is required in order for the estimated values to be robust. Also, the diagnostics show that there is no misspecification in the model. Thus, the findings of the diagnostic tests are satisfactory and indicate that the model is suitable.

At the last stage of NARDL procedure, we conduct the dynamic multiplier analyses to find out the dynamic effects of natural resources, economic growth, CO₂ emissions, and trade openness on health expenditure. The dynamic multipliers are presented in Fig. 1 which depicts the adjustment pattern of the health expenditure with negative and positive unitary shocks in explanatory variables. For natural resources, there is a greater response of health expenditure for a positive unitary shock than for a negative unitary shock. The unitary positive and negative shocks to natural resources affect health expenditures in a negative manner, making the asymmetry curve significantly negative for all forecasting horizons. On the other hand, a positive shock to economic growth does not have a significant effect on health expenditures. However, a negative shock to economic growth has a positive effect on health expenditures, although it tends to decrease in the first years. Also, the asymmetry curve is distinctly positive in all forecasting horizons and draws a trend with a negative economic growth shock curve. In addition, the impulse of positive CO₂ emissions shocks on health expenditure is positive. Yet, negative CO₂ emissions shocks tend to have a positive trend on health expenditures in the first years and then become ineffective. Thus, there appears to be a greater response of health expenditures to positive CO₂ emissions shocks. Also, the asymmetry curve is significantly positive and draws a similar movement to the positive CO₂ emissions shock curve. Finally, any positive shock to trade openness on health expenditures has a negative effect, while the response of health expenditures to any negative shock to trade openness is positive. Although the asymmetry curve is in the negative region in the first

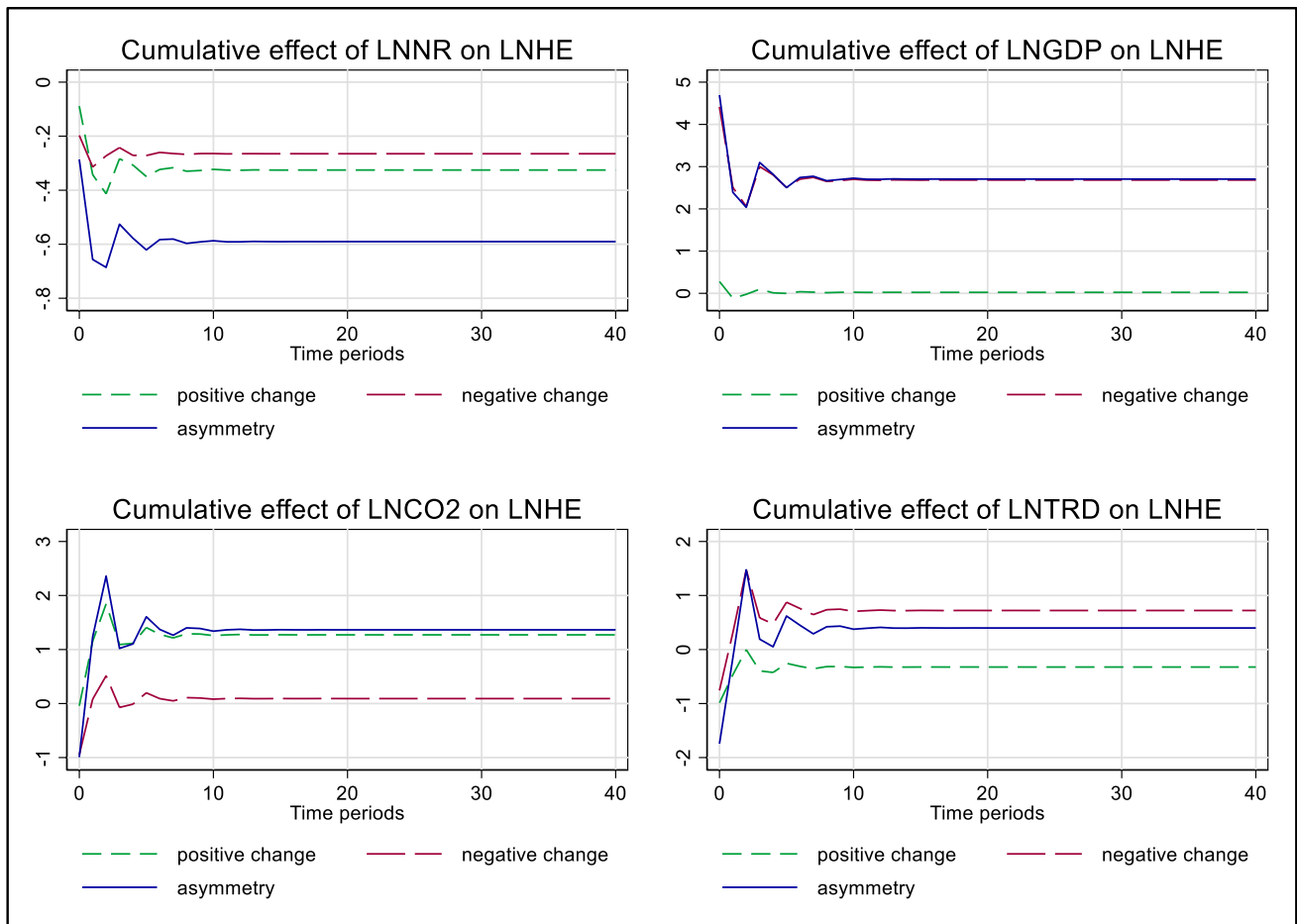


Fig. 1 Dynamic multipliers

years, it shows a positive trend in later periods. Hence, the asymmetry curve is generally located in positive forecasting horizons. All these findings are in line with the long-term coefficient estimates.

Conclusion and policy recommendations

This study provides a new perspective on environmental quality-health expenditures relation by controlling for the natural resources in the model. Moreover, another motivational source of this study is that it is the first study to analyze the relationship between natural resources and health expenditures in the context of the Turkish economy using the NARDL technique. Economic growth and trade openness variables are also included in the model as key determinants of health expenditures. The interactions are analyzed using annual data for the period of 1975–2019 for Türkiye. The unit root analysis of the series is determined by the Narayan-Popp two structural break tests as well as the conventional unit root tests of ADF and PP. The existence of asymmetrical

cointegration between the series is investigated by applying the NARDL approach. By doing so, the asymmetries between the variables and the effect of negative and positive shocks on the variables on health expenditures are also investigated.

In the study, NARDL approach is preferred since it is determined that the series are stationary at different levels and there are non-linear effects captured using BDS test. Empirical findings point to an asymmetric cointegration between natural resources, economic growth, CO₂ emissions, trade openness, and health expenditures. The findings also indicate the existence of asymmetries between all explanatory variables and health expenditures in the long run. Positive and negative natural resources shocks are negatively associated with health expenditures. This means that natural resources reduce health expenditures in the long run. In the study, while no statistically significant relationship could be determined between positive economic growth shocks and health expenditures in the long run, it is seen that a negative shock to economic growth positively affects health expenditures. This result may be associated with the decrease in real income per capita and

the inability of people to meet their most basic needs that results in malnutrition and lack of basic hygiene products, which in turn negatively affect health. In other words, the findings regarding negative shocks to economic growth increasing health expenditures might be the consequence of worsening health conditions due to welfare loss. On the other hand, negative shocks to CO₂ emissions do not create statistically significant effects on health expenditures, while positive shocks of CO₂ emissions have a positive effect on health expenditures. This means that a positive shock to long-term CO₂ emissions triggers healthcare spending. Finally in the long run, positive trade openness shocks have a negative effect on health expenditures, while negative trade openness shocks affect health expenditures positively.

The evidence that positive CO₂ emission shocks increase health expenditures indicates that health expenditures are triggered by increased environmental degradation. Therefore, policy-makers are suggested to remove the barriers to sustainable development goals. In addition, incentives for investments and low-carbon projects that comply with quality environmental standards must be supported by the government. Research and development activities aimed at improving environmental quality should be backed both financially and scientifically, as well. Various training programs should be created to increase environmental awareness among entrepreneurs. Finally, green and sustainable energy resources should be adopted to further accelerate environmental protection in the production and consumption behaviors of economic units. With all these aspects, slowing the environmental pollution down and ensuring sustainable economic growth will both increase the efficiency of health expenditures and protect human health. The finding that natural resources reduce health expenditures, which is another focus of this study, is a result that should be evaluated in detail in developing countries including Türkiye. Health expenditures have important effects on the budget deficit of governments and these expenditures need to be made effectively and efficiently. Despite being an important component of human capital, health expenditures will constitute an important cost element in budgets unless these expenditures are minimized by eliminating the negative effects on health. Based on the empirical results obtained in the light of these evaluations, the following policy recommendations can be implemented to reduce health expenditures through natural resources: (i) special attention should be paid to increasing the stock of natural resources. (ii) Deterrent measures should be taken against the excessive use of natural resources. (iii) Policies aimed at paying attention to forest fires and increasing green areas should be followed to prevent excessive reduction of the natural resource stock. (iv) Additional taxes must be imposed on the use of non-renewable energy resources, which significantly impair environmental quality.

In addition, subsidies should be provided for the production and investment of resources, such as renewable energy, that improve environmental quality. (v) Finally, special incentives must be provided to investments that can help recycle the natural resources used.

The first limitation of this study is the fact that the asymmetric causality technique cannot be conducted because the integration degrees of the series are not the same. The second limitation arises from the maximum explanatory variable count. Other determinants of health expenditures such as urbanization, inflation, unemployment, financial development, technological development, and renewable energy are excluded in this study. These variables can be included in the empirical models of future studies. In addition, this study may guide future studies in some respects. Comparative empirical findings can be obtained by including more than one country in the analysis using this methodology. As an indicator of environmental pollution, analysis can be performed with parameters such as ecological footprint, greenhouse gas emissions, in addition to CO₂ emissions. Moreover, the natural resources variable included in the study can be analyzed by dividing it into sub-parameters.

Authors' contributions Selin Demir: visualization, conceptualization, methodology, formal analysis, investigation, supervision, writing—review and editing, writing—original draft. Harun Demir: conceptualization, investigation, formal analysis, data curation, methodology, software, writing—review and editing. Caglar Karaduman: conceptualization, investigation, validation, visualization, methodology, formal analysis, writing—review and editing. Murat Cetin: conceptualization, investigation, methodology, validation, supervision, visualization, writing—review and editing. All authors read and approved the final manuscript.

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