Article

How is Mortality Affected by Fossil Fuel Energy, Economic Growth and Environmental Pollution in the CIS Region?

Ehsan Rasoulinezhad [1], Farhad Taghizadeh-Hesary [2,*]

[1] Faculty of World Studies, Tehran University; e.rasoulinezhad@ut.ac.ir
[2] Tokai University; farhad@tsc.u-tokai.ac.jp; farhadth@gmail.com
* Correspondence: farhad@tsc.u-tokai.ac.jp; farhadth@gmail.com; Tel.: (+81-80-4441-6860)

Abstract: It is widely discussed that growth of GDP has a vague impact on environmental pollution due to the emissions of carbon dioxide from consumed fossil fuels in production, transportation and power generation, and creation of required instruments to control environmental pollution as well. Due to the fact that environmental pollution can be a reason of mortality increase in a society, the main purpose of this study is to investigate the relationship between economic growth, fossil fuel consumption, mortality (from cardiovascular disease, cancer, diabetes and chronic respiratory disease) and environmental pollution using Generalized Method of Moments (GMM) estimation technique in the case of CIS member states over the period of 1993-2018. The major results revealed CO_2 emissions in in the region of CIS have a positive effect on increase of mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease. In regards to fossil fuel consumption, the estimation proved that this variable affects mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease positively. In addition, we found effect of economic growth, population growth and inflation rate positively, while any improvement in human development index (HDI) has a negative effect on increase of mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease in the CIS region. It is recommended that the CIS member states carry out different policies to improve energy transition indicating movement from fossil fuel energy sources to renewable ones. Moreover, we recommend the CIS member states to enhance various policies for easy access to the electricity from green sources and increase of renewable supply through improved technologies, sustainable economic growth, and increase of using green source in daily social life.

Keywords: economic growth; CO_2 emissions; cancer incidence; the CIS region; panel data estimation

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1. Introduction

Mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease has been linked economic growth and air pollution. It is widely discussed that clean energy unavailability in various countries, particularly those with developing level can potentially expose the population to various noxious gases raised from combustion of fossil fuels consumed for production, transportation and power generation. Furthermore, energy consumption can directly or indirectly affect human health by inducing air pollution, safe water shortage, or poor medical care infrastructures. Machol and Rizk (2013) argue that consumed fossil fuel energy in industries raises human health threats, future costs from climate change and other environmental damages which are totally considered as health security of a nation. However, due to ensure energy security issue (Le et al. 2019; Taghizadeh-Hesary et al. 2019), countries need to consume fossil fuel energy sources to ensure production of goods, power generation and having a proper transportation system.

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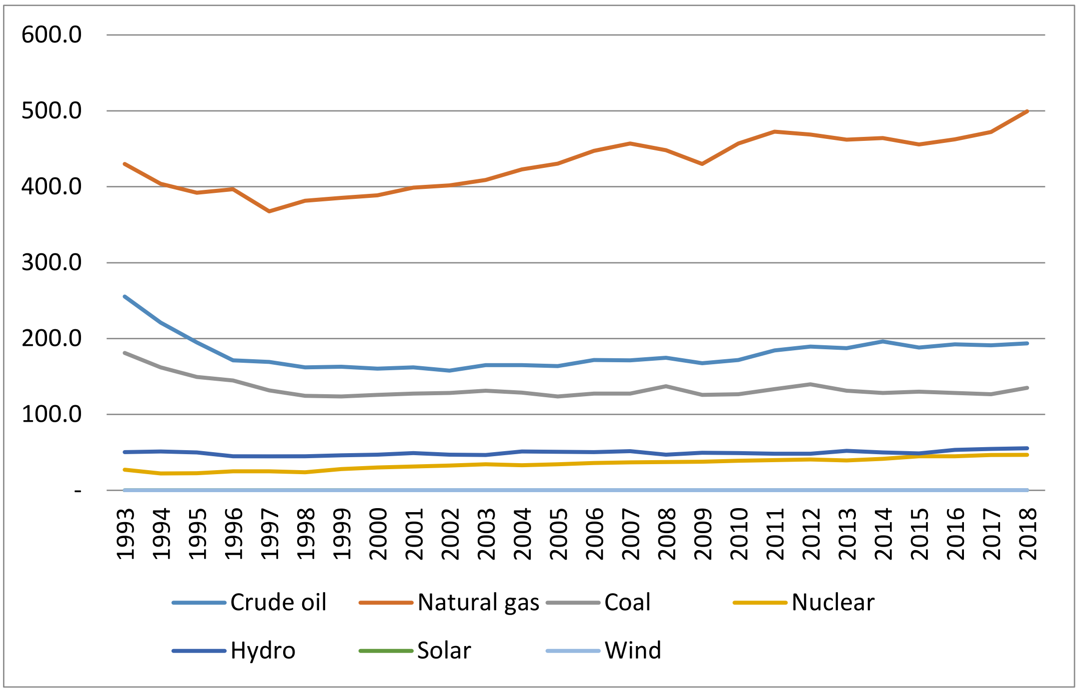
The problem of linking mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease with economic growth and environmental pollution is more crucial for developing nations such as the CIS member states because of their less developed health infrastructure and less contribution of renewable energy resources in economic sectors as well.

Figure 1 illustrates the share of fossil fuel and various renewable energy consumptions in total energy consumption basket of the CIS region. According to the data, represented in Fig 1, the contributions of fossil fuels, particularly natural gas and crude oil to total energy consumption in the CIS region considerably are higher than the contributions of renewable ones. This fact clarities i) the dependency of economic production to fossil fuels (Rasoulinezhad, 2019) and ii) high role of fossil fuels in air pollution in this region.



Source: Authors' compilation from data gathered from BP

Figure 1. Energy consumption diversification in the CIS, 1993-2018, million tones oil equivalent.

Gathering and analyzing data from BP statistical energy review 2019 reveals that the amount of CO_2 emissions in the CIS has increased from 1794 million tons in 2000 to nearly 2100 million tons in 2018, indicating that over two last decades the problem of air pollution in the CIS region considerably rose. Comparatively, the amount of carbon dioxide emitted by the CIS is higher than total African countries, South and Central America and Middle East.

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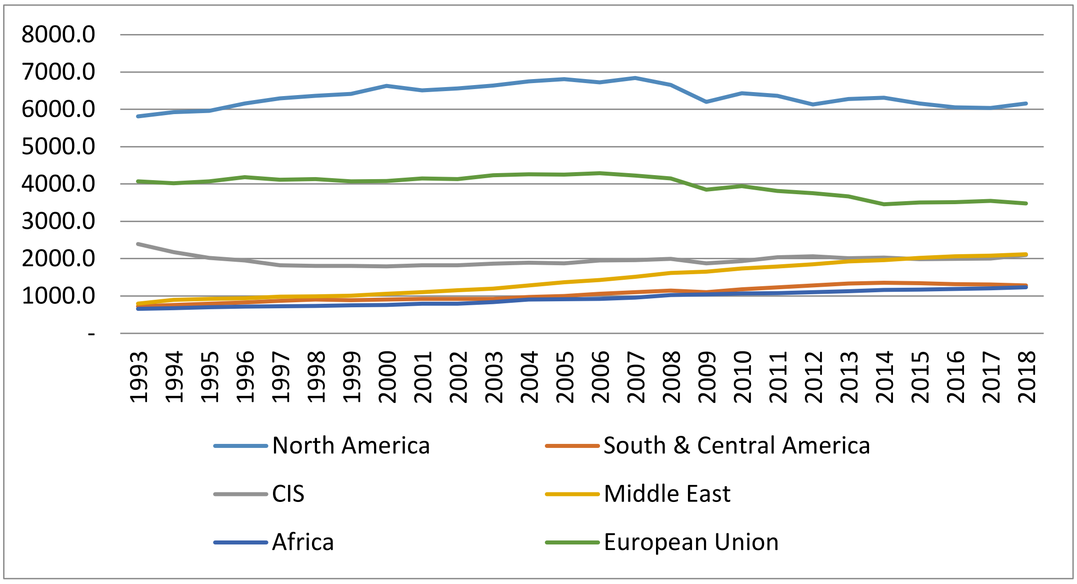

Source: Authors' compilation from data gathered from BP

Figure 2. CO_2 emissions in different regions, 1993-2018, million tons of carbon dioxide.

Since the region's economic life depends on fossil fuel consumption that leads to a higher economic growth and a more environmental pollution, an important question would be that is there any relationship between fossil fuel consumption, air pollution and mortality in this region?

Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) is a likely consequence of air pollution in a country. The CIS region characterizing with low national income and high poverty rate has different challenges to combat environmental pollution and improve the well-being of population. The analyses of Pearson correlation (Table 1) between economic growth, fossil fuel consumption, CO2 emissions, and mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) prove the primary linkage among these variables in the CIS region.

Table 1. Pearson correlation among variables.

	CO2 emissions	**Economic growth**	**Fossil fuel consumption**	**Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)**
CO2 emissions	1	0.140	0.095	0.025
Economic growth	0.140	1	0.146	0.533
Fossil fuel consumption	0.095	0.146	1	0.171
Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)	0.025	0.533	0.171	1

Source: Authors' compilation from SPSS.

Despite a number of earlier studies such as Newborough and Probert (1987), Lambert et al. (2014), Chaabouni et al. (2016), Nasre Esfahani and Rasoulinezhad (2016), Sirag (2017), Rasoulinezhad and Saboori (2018), Apergis et al. (2018) and Hanif (2018), we did not find any in-depth study focusing on relationship between energy consumption-air pollution and health issue in the CIS region. Hence, to our knowledge, this is the first study assessing effects of economic growth, fossil fuel consumption and air pollution on mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) in the CIS region.

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The remainder of paper is structured as follows: Section 2 discusses the related literature. Next Section represents data description and model specification. Section 4 argues empirical findings and the last Section concludes the paper.

2. Literature review

Human health can be impacted by non-renewable energy consumption in countries. Machol and Rizk (2013) and Nadimi and Tokimatsu (2017) believed that consumption of these kinds of energy sources by countries generates adverse human health impacts based on future cost of climate change and different environmental pollution. Martins et al. (2018) discussed that currently fossil fuels are the main economic engine of many countries which is in contrast with health issues in societies. This fact has been proved by other scholars such as Curtiss et al. (1996), Rosen (2009), McKenna (2011), Hendryx and Holland (2016). The highlight point of the mentioned studies is that fossil fuels consumption leads to spread of poisonous gases (Greenhouses gases=GHG) in atmosphere. Rafindadi et al. (2014) found out the positive relationship between air pollution and fossil fuel consumption. The major result revealed that the fossil fuel energy consumption has a dominating role in CO_2 emissions and air pollution, rather than other variables. The linkage between CO_2 emissions (Nejat et al. (2015) showed that CO_2 is the major gas responsible for climate change) and health issues has been drawn attention by numerous scholars. Chaabouni et al. (2016) proved a unidirectional causality from CO_2 emissions to health expenditures in a global panel of 51 countries over the period 1995-2013. In line with this result, Mohmmed et al. (2019) showed the relationship between CO_2 emissions and human health in the top ten emitting countries during 1991-2014. Abdul Shobande (2019) studied the impacts of energy use on infant mortality in Africa. The results revealed that any increase in carbon emissions has a considerable effect on infant mortality. This point also has been found out by Beach et al. (2019), Kotcher et al. (2019), Wang et al. (2019), and Apergis et al. (2020). Another crucial fact is that national production cannot be improved without consumption of fossil fuel energy as a major production input. Therefore, economic growth may have vague impact on human health due to the need of fossil fuel consumption to growth and likely positive effect of economic growth on health infrastructure. Chaabouni et al. (2016) found out bi-directional linkage between economic growth and health expenditures. They expressed that economic growth leads to increase of CO_2 emissions which consequently increases health expenditures of households (Janssen et al. (2006) found out the similar result for seven European countries over 1950-1999). In contrast, Zhang et al. (2001) argued that economic growth may be an important instrument to improve the health infrastructures of country which means mortality reduction. However, Lago-Penas et al. (2013) discussed that it depends on characteristics of health care system. They proved that health care systems with a higher share of private expenditure over total health care expenditure may have a faster speed of adoption with economic growth changes. In addition, Renton and Lintott (2012) viewed this vague effect from the aspect of income level of countries. They found out that for poorest nations, socio-economic change is a more influential source of health improvement than technical progress which is more important for richer countries and has a more tie with economic growth. Hence, economic growth-mortality reduction is likely seemed to be logical for richer nations.

Considering the above studies shows that the issue of relationship between fossil fuel energy consumption, economic growth, air pollution, and mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), particularly in the CIS region, has not been carried out in a serious study. Hence, our study will try to fill in this literature gap.

Data description and model specification

Following from the review of the fossil fuel energy consumption, economic growth, environmental pollution and mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), the empirical specification to capture the relationship in the case of 12 CIS region member states, namely, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan over the period of 1993-2018 is based on the following function:

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Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) = F (influential factors on health of society)

Influential macroeconomic factors on health of a society based on the earlier studies (e.g. see Janssen et al. (2006), Gross (2012), Lago-Penas et al. (2013), Pervaiz and Faisal (2017), Wang et al. (2019) and Apergis et al. (2020)) are fossil fuel energy consumption, CO_2 emissions, economic growth as main explanatory variables and population growth, inflation rate, and human development index (HDI). All these variables are gathered from World Bank, BP statistical review and UNDP databases.

Table 3 represents the primary descriptive characteristics of our data. In regards to economic growth (%), our sample of 12 CIS member states has a mean of 2.6 percent over the period 1993–2018. The mean of our sample' fossil fuel energy consumption (% of total energy consumption) is 82.32%. It has a maximum and minimum of 100 and 26 percent during 1993–2018, respectively. The CO2 emissions and inflation rate in the 12 CIS member states during the period of 1993–2018 take the mean of 7.83 metric tonnes per capita and 78.23%, respectively. The average of morality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) and population growth in our selected sample are 19.53% and 1.92%, respectively, whereas HDI takes the maximum of 0.717 and minimum of 0.482 from 1993 to 2018.

Table 3. Variables' Descriptive Statistics.

Variables	Unit	Obs.	Mean	Std. Dev.	Max.	Min.
ECO	%	312	2.6	1.53	9.23	-7.32
FOS	%	312	82.32	26.42	100	26
CO2	Metric tonnes per capita	312	7.83	6.90	13.05	3.87
MOR	%	312	19.53	4.22	26.43	15.66
INF	%	312	78.23	1434.2	893.08	5.98
POP	%	312	1.92	0.03	2.78	-0.23
HDI	-	312	0.431	1.33	0.717	0.482

Notes: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Source: Authors' compilation.

We empirically investigate the following model based on the six mentioned explanatory variables as well:

$$LnMOR_{it} = \alpha_1 LnECO_{it} + \alpha_2 LnCO2_{it} + \alpha_3 LnFOS_{it} + \alpha_4 LnPOP_{it} + \alpha_5 LnINF_{it} + \alpha_6 LnHDI_{it} + \varepsilon_{it} \tag{1}$$

The coefficients $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ and α_6 indicate the long-run elasticity estimates mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)) problems with respect to economic growth, CO_2 emissions per capita, fossil fuel energy consumption, population growth, inflation rate and Human Development Index (HDI). Based on related literature, we expect that any increase in CO_2 emissions, fossil fuel consumption, inflation rate and population growth lead to an increase in mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)), while the impacts of human development index (HDI) on mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)) is negative. Moreover, the effect of economic growth is expected to be vague. Table 4 represents the expected coefficients of the variables:

Table 4. Expected signs of variables.

Variable	Expected sign of coefficient
CO2 emissions per capita	+
Fossil fuel consumption	+
Economic growth	+/-
population growth	+

Inflation rate	+
HDI	-

Source: Authors' compilation.

In order to carry out the estimation of our econometric equation (1), the Generalized Method of Moments (GMM) is applied in a panel-gravity framework among 12 countries in the CIS region. The reliability of the GMM method has been proved by many scholars such as Arellano and Bond (1991), Martinez-Zarzoso et al. (2009), Kahouli and Maktouf (2015) and Lin (2015). Arellano and Bond (1991) believed that the GMM estimator including the lagged endogenous variable as an explanatory variable is more convenient for panel data because it makes more consistent and robust results in the presence of arbitrary heteroskedasticity. In general regression model in the form of GMM is written as follows:

$$Y_{it} = \alpha + \beta Y_{it-1} + \gamma X_{it} + \eta_{it} + \varepsilon_{it} \quad (2)$$

Where Y indicates the dependent variable (mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD))) and X represents all explanatory variables (CO_2 emissions per capita, fossil fuel consumption, economic growth, population growth, inflation rate, and HDI). η_{it} represents the country-specific effects and ε_{it} is the error term.

To have reliable empirical estimations, we need to conduct some preliminary tests. As the first pre-estimation test, the Variance Inflation Factor (VIF) will be performed to find out whether there is any multicollinearity among the series. The second preliminary test is the Hausman test to check out the existence of heterogeneity that clarify the presence of random or fixed effects.in our panel. Since the economies of the selected sample experienced various exogenous and endogenous shocks, the next pre-estimation test will be checking cross-section dependency among series. 2nd generation unit root test will be the last preliminary test to find out whether series are I(1) stationary or I(0) non-stationary.

Furthermore, we will conduct two different diagnostics tests after running the GMM estimations. The first is Arellano-Bond test for zero autocorrelation in the first-differenced errors, while Sargan test is the second diagnostic test to verify the overidentifying restrictions.

Empirical results

The VIF (checking multicollinearity among series) and Hausman (checking the nature of the panel data series) tests were carried out to identify the consistency of the GMM approach. Tables 5 represents the findings of these two tests:

Table 5. VIF and Hausman tests findings.

Sample	Independent variables	Explanatory variables					
		LECO	LCO2	LFOS	LINF	LPOP	LHDI
12 CIS member states	LECO	-	1.08	1.21	1.09	1.28	1.44
	LCO2	1.01	-	1.13	1.09	1.33	1.29
	LFOS	1.11	1.43	-	1.03	1.29	1.31
	LINF	1.09	1.23	1.40	-	1.11	1.39
	LPOP	1.17	1.46	1.39	1.28	-	1.09
	LHDI	1.19	1.58	1.38	1.12	1.17	-
	Mean VIF	1.11	1.35	1.30	1.12	1.23	1.30
	Chi2(5)	12.39					

Note 1: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Note 2: (L) indicates variables in the natural logarithms.

Source: Authors' compilation.

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Based on the report in Table 5, we can conclude that there is a low multicollinearity between the cross-sections. Moreover, the findings of the Hausman test (Chi2) depict the panel data with random effects. Next we should check out the existence of cross-section dependence in the series. Table 6 represents the results of the cross-section dependence (CSD) test for our variables:

Table 6. Cross-section dependence test results.

Samples	Variables	CSD test	Corr.	Abs. (corr.)	Significant at 1% level
12 CIS member states	LECO	9.52	0.388	0.387	Yes
	LCO2	10.28	0.429	0.429	Yes
	LFOS	9.88	0.369	0.369	Yes
	LINF	9.33	0.410	0.410	Yes
	LPOP	8.28	0.319	0.319	Yes
	LHDI	10.32	0.501	0.501	Yes

Note 1: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Note 2: (L) indicates variables in the natural logarithms.

Source: Authors' compilation.

The results of the CSD test, represented in Table 6, confirmed that cross-sections are present in all series, meaning that our samples share the same characteristics. Generally, in situations where there is low multicollinearity and cross-section dependence in the series, it is necessary to check the stationary of variables. Here, we conducted the second-generation panel unit root test (Pesaran's 2007 CIPS test) with the null hypothesis of all series being I(1). The findings of this test are reported in Table 7 and approve that all series are I(0).

Table 7. Pesaran (2007) panel unit root test results.

Samples	Variables	Without trend	With trend
12 CIS member states	LECO	0.492	1.417
	LCO2	0.466	1.404
	LFOS	0.413	-0.688
	LINF	0.452	-0.813
	LPOP	0.491	1.392
	LHDI	0.382	-0.707

Note 1: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Note 2: (L) indicates variables in the natural logarithms.

Source: Authors' compilation.

By considering the results of preliminary tests, the Arellano-Bond dynamic GMM estimations for our model are carried out. The results of the GMM estimations for 12 CIS member states are reported in Table 8 as follows:

Table 8. GMM estimation result.

Explanatory variables	Coefficients	Significant at 1% levels
Constant	0.28	No
LECO	0.29	Yes
LCO2	1.39	Yes
LFOS	0.11	Yes
LINF	0.04	Yes
LPOP	0.19	Yes
LHDI	-0.18	Yes

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No. of observations	360	
Range	1993-2018	
Cross-sections included	12	
Wald Chi2 (5)	632.18	Yes

Note 1: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Note 2: (L) indicates variables in the natural logarithms.

Source: Authors' compilation.

According to Table 8, economic growth in the CIS member states has a positive effect on increase mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD)). A 1% increase in the economic growth leads to increase of mortality by approximately 0.29%. This finding is in line with Chaabouni et al. (2016) who believe in negative relationship between economic growth and health improvement, while it is in contrast with Zhang et al. (2001) and Janssen et al. (2006) who proved the positive impact of economic growth on health issue. In regards to CO_2 emissions per capita, the estimation proves that this variable affects mortality (from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) positively (this finding is in line with Rafindadi et al. (2014), Nejat et al. (2015), Chaabouni et al. (2016) and Mohmmed et al. (2019) who found out the negative effect of CO_2 emissions on human health). A 1% increase in the CO_2 emissions per capita may accelerate mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) in this region by nearly 1.39%. As we expected, fossil fuel energy consumption and inflation rate positively affect mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease (this finding is in line with Curtiss et al. (1996), Rosen (2009), McKenna (2011), Machol and Rizk (2013), Hendryx and Holland (2016), Martins et al. (2018) who proved negative linkage between fossil fuel energy consumption and health issue), while HDI has a negative sign meaning that by a 1% increase in human development index, mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease in this region may decrease by nearly 0.18% (This result is in line with Pervaiz and Faisal (2017) who found out negative relationship between HDI and cancer incidence in Africa). In addition, population growth has a positive relationship with mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD) indicating that any a higher growth of population number in this region accelerates mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease. The finding is in line with Kibirige (1997) and Gross (2012) who argued about negative impact of population growth on human health.

Robustness analysis

To check out the reliability of estimation results, reported in Tables 8, we run alternative panel data technique namely Fully Modified OLS (FMOLS). As shown in Tables 9, estimation findings do not significantly differ suggesting the robustness of our results.

Table 9. Robustness check with FMOLS.

Samples	Independent variables					
	LCO2	LECO	LFOS	LINF	LPOP	LHDI
12 CIS member states	0.19 **	0.98**	0.28***	0.31**	0.19**	-0.29***

Note 1: ECO = Economic growth, FOS = Fossil fuel energy consumption, CO2 = CO2 emissions, MOR = Mortality from cardiovascular disease (CVD), cancer, diabetes and chronic respiratory disease (CRD), INF = Inflation rate, POP = Population growth and HDI= Human Development Index.

Note 2: (L) indicates variables in the natural logarithms.

Note 3: ** and *** indicate statistically significant at 1% and 5% levels.

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Source: Authors' compilation.

Concluding remarks

In this empirical study, we attempted to study how mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease is influenced by economic growth, non-renewable energy consumption, CO_2 emissions in 12 CIS member states, namely Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan, based on annual data over the period 1993-2018.

In regards to the methodology, the Generalized Method of Moments (GMM) was conducted to estimate the coefficients of independent variables (CO_2 emissions, fossil fuel consumption, economic growth, population growth, inflation rate and HDI).

Based on the results, we found out that CO_2 emissions in in the region of CIS had a positive effect on increase of mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease. In regards to fossil fuel consumption, the estimation proved that this variable affects mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease positively. In addition, we found effect of economic growth, population growth and inflation rate positively, while any improvement in human development index (HDI) has a negative sign meaning its negative effect on increase of mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease in the CIS region. Our finding about effects of CO_2 emissions on accelerating the mortality in countries is in line with Chaabouni et al. (2016), Chaabouni and Saidi (2017) and Apergis et al. (2018). Furthermore, positive linkage between population growth and spread of decease (mortality increase) has been confirmed by Moore et al. (2003), however this result is in contrast with findings of Geobel et al. (2010) who confirmed the role of population growth, especially urban population for women's health in a South African city. In regards to positive linkage between economic growth and health satisfaction, our result is in line with Ettner (1996) and Frijters et al. (2005), while it is in contrast with Pickett and Wilkinson (2015) who discussed the effects of income inequality, rather than economic growth and income.

Overall, we can suggest that the CIS member states need different policies to improve energy transition indicating movement from fossil fuel energy sources to renewable ones. Using fossil fuel energy sources destroys human living environment and leads to spread of terrible diseases such as cancer. Moreover, we recommend the CIS member states to enhance various policies for easy access to the electricity from green sources (e.g. see Taghizadeh-Hesary and Yoshino (2019)' suggestion to use green finance and investment) and increase of renewable supply through improved technologies, sustainable economic growth, and increase of using green source in daily social life. To this end, they need to receive scientific, financial and technological assistance from developed countries or countries with a success pattern in energy transition movement.

Notwithstanding its limitations, we believe that this paper contributes to existing literatures in related to health-energy-economic growth linkages in the CIS region. We recommend for future researches to employ different control variables such as trade openness and interest rate in econometric model, considering direct and indirect effects and carry out causality tests to distinguish short-run and long-run linkages between dependent and independent variables.

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