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Environmental quality, forestation, and health expenditure: a cross-country evidence

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Abstract

The study probes the relationship between health expenditures, forestation, and environmental quality using panel data of 87 countries, through 1999–2018. The empirical analysis is based on 16 high-income, 22 upper-middle-income, 18 low-middle-income, 13 low-income, and 18 partner countries of one belt one road (OBOR) project. The Chinese government initiated one belt one road (OBOR) project to enhance the level of cooperation among partner countries in different sectors of an economy. The study incorporates a difference and system generalized method of moments (GMM) to control the problem of endogeneity. Empirical findings reveal the positive and significant relationship between CO_2 emission and per capita health expenditure among the selected samples of all countries. However, forest area exhibits negative and significant association with per capita health expenditure in low-income and partner of one belt one road (OBOR) countries. The study incorporates different regression specification categories and amalgamation with different control variables such as per capita income, trade, and industrial value-added to ensure the robustness of estimates.

Keywords CO_2 emission · Per capita health expenditure · Per capita income · Trade · Industrial value-added

JEL Classification P18 · Q19 · Q20

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1 Introduction

The agenda of sustainable development 2030 and its goals are adopted by several economies that show the historical landmark for public health in general. However, it is explicitly considered that health plays an important role in sustainable development across the boundaries irrespective of their income level. Developing economies containing higher population growth rate needs quick action to attain a better standard of living. Higher population growth is more likely to deteriorate the resources of the environment such as forests, soil, air, and water. It also implies that denser air pollution causes many infectious diseases such as malaria, tuberculosis cholera, and dengue fever, leading to an increase in healthcare expenditures (Farooq et al., 2019; Racioppi et al., 2020; Sagarik, 2016). Moreover, air pollution is also a cost to the environment, as contamination of air with high toxic gases emitted by the industries leads to worsening the quality of the environment which damages the health of individuals and reduces labor productivity. This phenomenon will increase labor absenteeism and reduce the industrial and national output (Hansen & Selte, 2000; Jerrett et al., 2003).

Likewise, global health expenditures continue to increase rapidly from US$7.6 trillion to US$7.8 trillion from 2016 to 2017, whereas, among these spending, 40% are private and the rest are public. Health expenditure has been increased by 3.9% while the real income of the world increased by 3% from 2000 to 2017. Health spending has increased dramatically among low-income countries, increasing by 7.8% from 2000 to 2017, while their income increased by just 6.4%. Similarly, spending on health has been increased by more than 6% a year among middle-income countries. High-income countries account for 81% of global healthcare spending, though these high-income countries cover only 16% of the world's population. The share of global healthcare expenditure has been increased by 19% among upper and lower-middle-income countries since 2000. The upper-middle-income countries contribute 13% of global healthcare expenditure. The reason behind this upsurge is the increase in per capita income of the two most populated countries named as China and India while the health spending of other countries has been declined (World Health Organization, 2019, World Development Indicators, 2019). Furthermore, CO_2 emissions have been increased dramatically for the past few decades due to the usage of fossil fuels by several industries. Industries emit 37% of greenhouse gasses, while total energy consumption covers 80% of these emissions. The excess use of fossil fuels will diminish the natural assets on earth and additionally damage the quality of the environment. It is estimated that 1% of chest infections, 5% of cancer in the lungs, and 2% of heart diseases are caused by air contamination in the biosphere. World Health Organization elucidates that the 20 most polluted cities, due to high energy consumption, belong to low-income countries group (Worrell et al. 2009; Wang et al. 2016; IPCC, 2018).

This study discusses the impact of environmental degradation, captured by CO_2 emission, on human healthcare expenditure. Global warming can be curtailed to 2 degrees celsius and better health can be provided by controlling the emission of greenhouse gases, as these gasses further reduce healthcare expenditures. Greenhouse gases include methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), sulfur dioxide (SO_2), and fluorinated gases. Carbon dioxide accounts for 76% of greenhouse gas emissions in the atmosphere while methane and nitrous oxide contribute 16% and 6%, respectively, and other F-gases such as perfluorocarbons, hydrofluorocarbons, and sulfur oxide account for 2% (IPCC, 2014). However, recent literature Bakare and Sanmi (2011), Jerrett et al. (2003), Sagarik (2016), Yazdi and Khanalizadeh (2017) and Zhang (2017) studies the human activities to curtail environmental deterioration and air pollution, but the forestation role has been ignored among health and environment studies. However, plantation of forest can curtail the emission of CO_2 in the atmosphere with the help of sunlight by the phenomena of photosynthesis and later, consequently, to its alteration into trunks, leaves, branches, and roots and residues deposited as biomass till it degraded back to the atmosphere (Palmer, 2012). Moreover, Minnemeyer et al. (2017) elucidated that emission of CO_2 can be reduced by 7 billion, after stopping deforestation and reduction of 42% in CO_2 among total emissions can be achieved if grazing land can be reforested among forested eco-places. Forests are acting as carbon sink; therefore, the activities such as reforestation, afforestation, and forest restoration can easily remove carbon dioxide and other toxic gases from the atmosphere. Human activities of deforestation can increase the emission of greenhouses gases (which contains a major share of CO_2) and these emissions can create many health problems among the individuals of several economies which further burdens the healthcare expenditures (Ahmad, 2017; Beatty & Shimshack, 2014; Looi & Chua, 2007; Waheed et al., 2018). Moreover, the adverse effect of environmental degradation on the health of individuals disturbs labor productivity, which consequently impacts the production of industries, economic growth, and domestic output. This narrative climaxes the idea that the quality of the environment can be improved by planting more trees that control the amount of CO_2 emission in the atmosphere and reduces many human health problems. When forest investment and afforestation are encouraged, the level of CO_2 emission in the atmosphere will be decreased which resolve many health issues and reduce health expenditures (Chaabouni et al., 2016; Morin et al., 2013; Yazdi & Khanalizadeh, 2017).

This study evaluates the role of environmental quality in determining health expenditure at the global level with diverse income level economies such as low-, low-middle-, upper-middle-, and high-income, and partner of OBOR countries. However, many developed and developing economies experience an increasing trend of health issues and healthcare expenditures. Therefore, it is a need of the hour to identify the factors which can contribute to persuading health-related problems so that counter policies can be introduced to shield the development of humans. The current study contributes to the existing literature in several ways. Initially, the current study is the pioneer that discusses the impact of CO_2 emission on healthcare expenditures in several economies such as low-, low-middle-, upper-middle-, high-income, and partner of OBOR countries. Recently, many studies such as Beatty and Shimshack (2014), Chaabouni et al. (2016), Morin et al. (2013), Narayan and Narayan (2008) and Yazdi and Khanalizadeh (2017) discuss the adverse effects of environmental degradation on human health which further increases expenditure on health and reduces the growth of an economy. These studies discuss the direction of causality between the emission of CO_2 and health expenditure and also discuss several channels by which emission of CO_2 affects the health of individuals (Fernandoa et al., 2017; Tox Town, 2017). An increase in health-related problems forces states to spend more on the health of individuals and their treatment to safeguard the human and economic development of an economy. Secondly, the study also includes partners of OBOR (One Belt one Road) countries. The separation for partner countries of OBOR is important because the mega project of OBOR will increase the per capita income of partner countries of OBOR as well as the income of other countries at a global level due to dropping in the cost of a trade. It is estimated that income around the globe will upsurge by 0.7% with the instigation of project OBOR by 2030. However, this project will not increase, only China's real income but also the partner countries achieve 70% gain as well. Moreover, the partner countries of OBOR will contribute 45% in GDP in 2015 while partner countries of OBOR emit 54% of the world's CO2 emissions. Russia, India, and China account for 5%, 6%, and 28% of the world's CO_2 emission in 2015 (International Energy Agency (IEA), 2016; World Development Report (WDR), 2016; Belt and Road Initiative, 2015).

Thirdly, the inclusion of forestation is a noteworthy contribution to the existing literature of health studies. Previously, the researchers and scientists of forests such as Achard et al. (2004), Brown et al. (2004), Stern (2006), Thuy et al. (2014), Chaabouni et al. (2016) and Waheed et al. (2018) pay less attention to the economy and environment. This study tries to bridge this gap by including forest areas to curtail health-related issues and expenditures. Trees and plants can play a role as a carbon sink by producing carbohydrates and oxygen after utilizing carbon from the environment during photosynthesis phenomena. However, the carbohydrates are again splitting down into energy and carbon which is again provided to the atmosphere after the process of decomposition (Farooq et al., 2019; Griggs, 2017). The activities of deforestation also emit carbon in the environment especially when trees are employed for burning purposes. However, reforestation helps to alleviate the emission of CO_2 which consequently reduces health-related issues and healthcare expenditures (Beatty and Shimshack, 2014; Lathrop, 2017; Joyce, 2017; Yazdi & Khanalizadeh, 2017). Taking account of all discussed concerns few investigators such as Narayan et al. (2008), Wang et al. (2016), Sarwar et al. (2019) and Tambo et al. (2019) discussed the relationship between quality of environment and healthcare expenditure for a particular region. However, the main objective of the discussed study is to empirically investigate the relationship between emission of CO_2, forest area, and per capita health expenditure.

The study utilizes the Generalized Method of Moments (GMM) to resolve the problem of endogeneity and stationarity. However, several structures of lag have been incorporated in the case of system and generalized method of moments to apprehend the static and dynamic effect of the related variable. The long-run relationship has been extracted by using one and two steps of difference and system GMM to guarantee the robustness of findings. The empirical findings expose that increase in the emanations of CO_2 will lead to an increase in the per capita health expenditure while the increase in forest area will decrease the per capita health expenditure among the samples of BRI and low-income economies. However, the relationship between per capita industrial value-added and health expenditure is positive except for low-income economies. Moreover, the study objects to formulate noteworthy policy implications for the state and policymakers to regulate effective strategies regarding health and ecological change.

2 Literature review

The debate for the association between quality of the environment and economic growth was initially discussed by Grossman et al. 1991 which is further termed as the "Environmental Kuznets Curve (EKC) hypothesis". EKC elucidates that at an initial stage, escalation in economic growth will damage the quality of the environment at the initial stage, but after a certain point, an increase in economic growth will improve the value of the environment. However, strategy creators try to initiate environmentally friendly strategies such as providing facilities for the consumption of renewable energy, installing treatment plants for manufacturing sectors, and providing a mechanism for energy efficiency. These policies will help us to improve the quality of the environment by decreasing the emission of CO_2 in the sky, which will further improve the health of individuals and reduce healthcare expenditure. Many researchers such as Sarwar et al. (2019), Ullah et al. (2019), Shahbaz

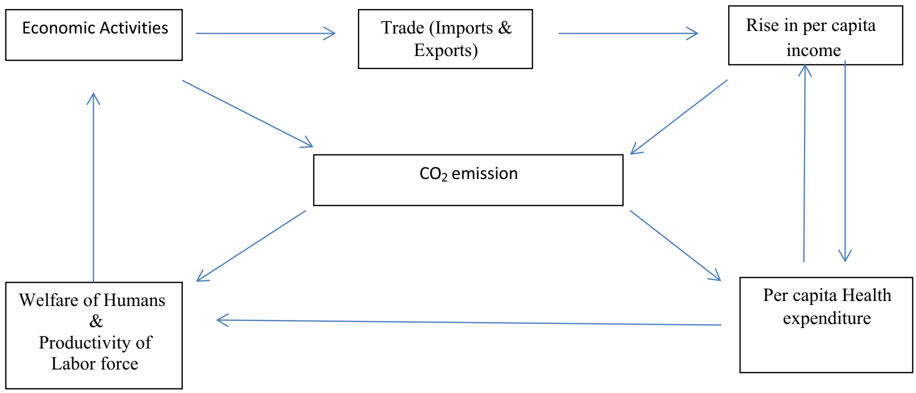

Fig. 1 Relationship between CO_2 emission and per capita health expenditure

et al. (2013), Wagner (2008), Akbostanci et al. (2009), Narayan et al. (2008) empirically explore the connection between environmental quality and above discussed variables.

The state of healthy individuals can be derived from the provision of better health facilities such as an improved healthcare system and devotion of time to household associates. This type of demand for health care is known as derived demand (Odusanya et al., 2014). Many studies such as Dreger et al. (2005) and Muhlbacher et al. (2004) estimate the demand for healthcare expenditure by employing per capita income as the explanatory variable and other non-income variables. However, Fig. 1 shows the theoretical framework for the association between the emission of CO_2 and expenditure on health. Figure 1 reveals that an increase in emission of CO_2 will lead to raising the expenditure on health. It also indicates that an increase in economic activities due to a rise in trade activities will also increase per capita income. The rise in per capita income will increase CO_2 emission due to massive industrialization which produces many toxic chemicals and emits greenhouse gases. The effect of such atmospheric pollution will put an adverse effect on human health and increase healthcare expenditures. The emission of CO_2 and production of toxic materials such as lead, chromium, and mercury are also dangerous for children's health (especially the age from 5 to 14) and pregnant women (Blacksmith Alimi et al., 2019; Institute, 2011).

Moreover, United Nation (2002) outlined many health problems derived from environmental quality damage such as neurological damage, IQ reduction, anemia, kidney disorder, tiredness, retardation, and headache. Ensure the existence of healthy living needs huge spending. There is also a need for government policy for environmental quality to reduce health-related issues which further reduce health expenditure and produce a quality of human capital. Moreover, Apergis et al. (2019) empirically explore the association between healthcare expenditure and quality of the environment by using different groups of 178 economies. The empirical results clarify that a 1% rise in economic growth will induce to surge in the emission of CO_2 and healthcare expenditure by 7.5% and 2.5%, respectively. However, a decrease in CO_2 emission will significantly decrease healthcare expenditures as well among the discussed sample. Moreover, Hao et al. (2018) scrutinize the affiliation between the emanation of CO_2 and healthcare expenditure by incorporating regional panel data in China from 1998 to 2005. They utilized the difference and system generalized method of moments for the estimation of discussed variables. Their findings reveal that at early phases, an increase in emission of SO_2 will significantly increase healthcare expenditure while an increase in economic growth will significantly increase healthcare expenditure, but after a certain point, an increase in national income will decrease per capita healthcare expenditure. This shows converse U-formed association among economic growth and healthcare expenditure.

Furthermore, Alimi et al. (2019) investigate the association between eminence of environment and expenditure on public health by sorting out data of 15 economies of ECOWAS (Economic Community of West African States), covering the period from 1995 to 2014. The empirical findings exhibit that increase in the emanation of CO_2 will lead to an increase in expenditure on public health. However, an increase in the emanation of CO_2 will deteriorate people's health and this will lead to a rise in expenditure on health by the state for the provision of health facilities. However, the study does not find any significant relationship between environmental eminence and expenditure on private health facilities. Policymakers should initiate environmentally friendly policies such as green financing, carbon-free, and pollution reduction methods, which may reduce environmental degradation. Keeping in view the study of Alimi et al., (2019), and Haseeb et al. (2019) empirically inspect the association among emanation of CO_2, economic growth, energy consumption, and expenditures on R&D and health. The study utilizes the data of ASEAN (Association of Southeast Asian Nations) economies. The estimated findings confirm that an increase in the emanation of CO_2 will cause to increase in expenditure on R&D and health in the long run while in the long-run consumption of energy and expenditure on R&D verdicts a significant and positive association. However, the findings of the short run do not exhibit any significant relationship among discussed variables.

Furthermore, Gunduz (2019) empirically investigates the impact of environmental deterioration on healthcare expenditure for the USA from 1970 to 2016. The results of cointegration reveal the existence of the long-run relationship between environmental degradation and health expenditure. The empirical findings reveal that if environmental quality deteriorates by 1%, then healthcare expenditures will increase by 2.04% in the long run. These findings propose that curtailing environmental degradation will reduce the burden of health expenditures on budget. However, many researchers such as Karatzas (2000), Hansen et al. (2000), Jerrett et al. (2003), Neidell (2004) and Mead et al. (2005) reveal the significant connection between the eminence of the environment and people's expenditure on health. However, many pollutants such as nitrogen dioxide, sulfur, and carbon monoxide are the major ingredients for damaging respiratory systems, especially for children. Sulfur oxide has been originated from the burning of oil and coal. Sulfuric acid causes throat and nose infection which further creates breathing difficulties (Mead & Brajer, 2005; Murthy & Ukpolo, 1995; Shogren, 2001; Wordly et al., 1997). Siddique et al. (2020) confirm that a rise in pollution of industries will lead to deterioration of people's health among middle-income countries by using the fixed-effect model. Moreover, Moosa (2019) also shows a significant and positive connection between CO_2 emissions and public health expenditures. Ullah et al. (2019) scrutinized the affiliation among CO_2 emission, renewable energy consumption, and expenditure on health. The estimated results indicate that increase CO_2 emission will damage the health of individuals and further lead to an increase in health expenditures while an increase in renewable energy consumption will lead to a decrease in health expenditures.

The above-discussed studies review the relationship between quality environment, health expenditures, and health-related issues, and their findings are mixed and inconclusive. The reviewed studies conclude that the quality of the environment is considered an important factor of health expenditure. However, several studies neglected the impact of forestation on health expenditure because the increase in forestation will control the emission of CO_2 in the atmosphere which will improve the environmental quality and health-related issues among several individuals.[1] These phenomena will reduce the burden of health expenditure on the budget. There is a need for policy guidelines for the government regarding forestation, health expenditure, and environmental change.

3 Model and data description

The empirical investigation of the current study is composed of 16 high-income, 22 upper-middle-income, 18 low-middle-income, and 13 low-income economies. The study also includes 18 partner economies of the OBOR project based on the World Bank criteria. The study uses panel data from 1999 to 2018. Data of all variables have been extracted from World Development Indicators (WDI 2019). Moreover, keeping in view the famous quotation "Going Global through Bilateral Relationship", the mega venture of One Belt One Road (OBOR) was initiated by the Chinese government. However, more than 68 economies were intricate in this venture to understand supply and demand of energy consumption, which further leads toward the collaboration of trade, development of infrastructure, ecological sustainability, and business development. The induction of partner countries of OBOR is important because parallel to the development of infrastructure and business development, 65% of project's funds which have been utilized in the OBOR are coal-based while 1% fund is used for wind based for the generation of energy. Also, China utilized 40% of their public investment in the project, which is highly dependent on coal from 2007 to 2013. However, China will install 240 coal-based plants in 25 economies of OBOR while 92 additional coal-based plants have been fitted in more than 27 economies. These phenomena will increase the emission of CO_2 by 61.4% and further damage the health of individuals and increase healthcare expenditures among the companion economies of OBOR which contains the major population of the world (Pandya et al., 2003; Narayan et al., 2008; Akbostancı et al., 2009; Statistical Review of World Energy, 2017; Global Capital, 2015; Sarwar et al., 2019).

Keeping in view the studies of Apergis et al. (2019) and Sarwar et al. (2019), the influence of environmental quality along with other controlled indicators on health expenditures has been extended by using the following model

$$he = f(he_{t-1}, co_2, ind, tra, gdp, fr) \tag{1}$$

The current study has utilized all discussed variables into natural log due to linear specification. The linear specification provides us more consistent, efficient, reliable, and comparable findings in comparison with other specifications (Sarwar et al., 2017; Shahbaz et al., 2017; Waheed et al., 2018). Moreover, the value of coefficients becomes elasticities of homogeneous units which make a comparative analysis with each other. The converted equation can be written as follows

$$lhe = \beta_0 + \beta_1 lhe_{t-1} + \beta_2 lco_2 + \beta_3 lind + \beta_4 ltra + \beta_5 lgdp + \beta_6 lfr \tag{2}$$

Additionally, lhe, lhe_{t-1}, lco_2, $lind$, $ltra$, $lgdp$, lfr are symbolized as the natural logarithm of per capita health expenditure (constant 2010 US$), lag of per capita health expenditure

[1] Confirmed by Waheed et al. (2018).

Table 1 Description of variables

Variables	Description	Units	Source
he	Health expenditure	Per capita Health Expenditure (constant 2010 US$)	WDI
co_2	Carbon dioxide emission	Metric tons of CO_2 equivalent per capita	WDI
ind	Industrial value-added per capita	Industrial value-added per capita (constant 2010 US$)	WDI
tra	Trade openness proxies	Trade (% of GDP)	WDI
gdp	Per-capita income	GDP per capita (constant 2010 US$)	WDI
fr	Forestation	Forest area calculated in square kilometer (Sq.km)	WDI

(constant 2010 US$), CO_2 emission (metric tons per capita) as a proxy of environmental quality, per capita industrial value added (constant 2010 US$), trade as percent of GDP, per capita GDP (constant 2010 US$), and forest area calculated in square kilometer (sq. Km). Tables 1 and 2 show the description and descriptive statistics of each variable. However, the mean value of per capita health expenditure is 2527.8$, 286.02$, 78.19$, and 58.23$ in the case of the high, upper-middle-, low-middle-, and low-income countries, respectively. Moreover, partner countries of OBOR show 286.02$ average per capita health expenditure. High-income countries spend more on health facilities as compared to other discussed sample of countries. Similarly, the average forest area per square kilometer is higher among high-income countries while the mean value of per capita CO_2 emission is higher among partner countries of OBOR as compare to other high-, upper-middle-, low-middle-, and low-income countries.

Many researchers such as Brunekreef et al. (2002), Mead et al. (2005), Narayan and Narayan (2008), Janke et al. (2009) and Beatty et al. (2014) investigate the connection between the quality of environment and expenditures on health care. The increase in environmental quality deterioration affects the worth of human life and increases healthcare expenditures. However, air pollution is the prime source for the degradation of the environment, which arises from the emission of greenhouse gases comprising of super dioxide, nitrogen dioxide, and carbon dioxide. Emission of these gases can directly or indirectly affect the health of individuals which further causes a bad impact on the development of humans in the future. Climate changes can also deteriorate the health of people by different means such as air pollution, extreme weather conditions, rise in temperature, and ultraviolet radiation (Jerrett et al., 2003; Yazdi & Khanalizadeh, 2017). Apergis et al. (2019) show the negative relationship between emission of CO_2 and healthcare expenditures. This relationship is more viable at the higher end of the provisional distribution of health expenditure. Keeping in view the states of the US, a lower level of CO_2 emission can provide tangible health-related advantages. The positive relationship between CO_2 emission and health expenditures is stronger in the case of low-income countries. Thus, the relationship between CO_2 emission and health expenditure depends on the technological advancement and income of a particular country.

Additionally, the consequences of adverse health can be reduced by exposure to more green land areas. Many studies such as Fong et al. (2018) and Kardan et al. (2015) reveal that increase in forest areas may increase individuals' mental and physical health through different ways such as forestation may help reduce stress and recuperate from attentional fatigue. Forest may also increase the physical and psychological restoration. Green areas also help establish social participation, personal and community identity (Karjalainen et al., 2010). Forest areas will provide oxygen to human beings by absorbing carbon

Table 2 Descriptive statistics

Variables	Mean	SD	Skewness	Kurtosis	Max.	Min.	Obs
High income							
he	2527.8	2222.6	0.629	2.66	9241.2	590.1	271
co_2	0.27	0.13	0.916	3.282	0.135	0.083	256
ind	8907.61	6320.06	1.986	9.232	39,063.44	792.48	286
tra	86.02	68.23	2.685	10.60	408.36	18.345	286
gdp	36,351.6	26,042.7	1.087	3.94	111,968.2	1002.2	288
fr	41.66	20.90	0.055	1.644	73.68	9.79	287
Upper middle income							
he	286.02	238.17	1.534	6.095	1301.11	8.52	371
co_2	0.617	0.329	0.722	2.591	1.471	0.178	352
ind	1811.1	1031.60	1.381	5.415	6572.21	454.21	391
tra	82.23	39.157	0.810	3.610	220.41	20.98	396
gdp	5525.0	2550.17	0.680	3.34	14,356.32	925.25	396
fr	24.06	24.27	0.256	2.079	90.07	0.651	396
Low middle income							
he	78.19	63.98	1.124	3.581	293.87	4.15	306
co_2	0.495	0.274	0.711	2.50	1.183	0.069	288
ind	544.27	413.57	1.667	7.101	2515.15	51.56	324
tra	63.524	29.385	1.209	4.232	165.64	19.102	324
gdp	1768.7	916.62	0.389	2.245	4140.59	355.172	324
fr	29.864	21.632	0.309	1.754	69.01	0.572	306
Low income							
he	58.23	61.52	0.362	4.521	276.98	5.12	236
co_2	0.324	0.621	0.871	3.217	1.321	0.082	236
ind	532.32	428.31	1.846	6.321	26,125.32	46.256	239
tra	61.25	28.12	1.652	3.214	152.32	17.56	240
gdp	1562.21	832.512	0.854	1.867	3654.23	293.65	236
fr	30.264	23.14	0.254	0.867	58.62	0.564	236
Partner of OBOR countries							
he	286.02	238.17	1.534	6.095	1301.1	8.511	371
co_2	0.617	0.329	0.722	2.591	1.470	0.178	352
ind	1811.1	1031.60	1.381	5.415	6572.43	454.42	391
tra	82.327	39.157	0.810	3.610	220.407	20.987	396
gdp	5525.03	2550.17	0.680	3.339	14,356.45	932.38	396
fr	34.06	24.272	0.2556	2.079	90.037	0.644	396

dioxide and emit oxygen as a by-product. Oxygen plays a key role in the functioning of the human lungs. However, forests also make water clean and purify for individuals because landscapes catch abundant runoff and permit them to penetrate the water under the ground. This strategy also helps to stop the adverse effect of flooding. The complex rooting system of several trees in forest areas keeps land firm at its place which curtails sediments from water pollution. Forests provide oxygen and clean water which are the main ingredients of human health. Provision of these two elements will make the life of individuals more healthy which will further reduce healthcare expenditures (Bahamondez & Thompson, 2016; Ramsfield et al., 2016). Similarly, deforested landscapes are more heated as compare to forested landscapes because the process of transpiration and evaporation make the earth cooler. However, human beings may experience an adverse impact on health such as illness and headache due to an increase in earth's temperature which further reduces human productivity (Bright et al., 2017; Ellison et al., 2017). Moreover, respiratory illness is also associated with deforestation because human beings often use fire for deforestation in tropical regions and the burning of these forests may create tinny particulate matter from the smoke of biomass. These tinny particulates penetrate the lungs of human beings and cause respiratory problems (Myers et al., 2013; Pienkowski et al., 2017).

Moreover, Sarwar et al. (2019) show that the lagged dependent variable has a positive and significant association with per capita health expenditure, which shows inertia such as the current per capita health expenditure positively and significantly association with the previous year per capita health expenditure. These findings imitate the importance of the expenses of long-term medical chronic diseases. Long-term chronic diseases require continuous medical input. This shows that the per capita health expenditure has long-term inertia. Moreover, a rise in the level of per capita income and environmental degradation is expected to have a positive relationship with health expenditure. A country will spend more on health if it experienced high economic growth and environmental degradation. That is why the increase in per capita income will increase per capita health expenditure (Narayan & Narayan, 2008; Yazdi & Khanalizadeh, 2017). Moreover, a rise in per capita income of a particular country forces people to place greater value for the quality of life and this will increase expectations regarding better health and medical facilities which will lead to an increase in health expenditure. The relationship between per capita income and health expenditure depends upon the development level of a particular country. However, to maintain the development level of any country, health expenditures play a vital role. An increase in per capita income will lead to an increase in health expenditure due to features of the social and economic development of a country (Bedir, 2016). Jie (2014) elucidates the association between SO_2 which is released by industries and the health of the public. The estimated results show that an upsurge in industrialization will increase the level of economic growth. This rise in industrialization will emit more SO_2 in the atmosphere and damages people's health while other results reveal that a rise in atmospheric pollution will not worsen people's health due to a surge in economic growth. Moreover, emission required for an additional unit of the product declines gradually in China (Ostro, 1996; Peng et al., 2001). Furthermore, trade liberalization can improve the health of individuals which further reduces health expenditure due to the dissemination of technologies such as distance-learning for individuals of remote areas and telemedicine can have optimistic consequences on health. However, increases in trade libralization also have negative repercussions on health due to the marketing and promotion of harmful commodities. Liberalization of trade also increases the risk of cross-border diffusion of diseases, which are very harmful to human beings (Adams & Kinnon, 1998; Bettcher et al., 2000).

4 Estimation technique

The study incorporates the method of difference and system generalized method of moments to find the relationship between quality of the environment and per capita expenditures on health with other control variables. It might be discovered the presence of a two-way connection among CO_2 emission, expenditure on health, and economic growth due to which traditional OLS may cause biased results. Therefore, we incorporate difference and system GMM methods to resolve the problem of endogeneity. The difference GMM method is also recognized as an instrumental variable (IV) method in which lagged value of an independent and dependent variable is utilized to tackle endogeneity. The cross-sectional fixed effect can be removed using difference GMM that possibly affects the explained variable (Arellano & Bond, 1991; Dong & Hao, 2018; Halkos & Paizanos, 2013; Hayakawa, 2009; Huang, 2010). Moreover, Di Matteo et al. (1998) and Costa-Font et al., (2007) reveals that country-specific heterogeneity creates some restriction among cross-country study of health expenditure. We incorporate a cross-sectional dependence test due to the heterogeneous characteristics of our discussed panel in our study. Our study may ascend heterogeneity because of certain variations in energy policies and expenditure on health across each panel or due to some exterior shocks. This may affect the policies of carbon emission and health expenditure, directly or indirectly. Paramati et al. (2016, 2017) indicate the presence of cross-sectional dependence among each panel in the presence of heterogeneity. The study also evaluated the second-order serial correlation and condition of orthogonality by using a diagnostic test such as the Hansen test.

4.1 Cross-sectional dependence tests

The second-generation unit test has been applied in the occurrence of cross-sectional dependence; therefore, the initial section tests the occurrence of cross-sectional dependence. Following cross-sectional statistics has been proposed by Pesaran (2004)

$$CD = \frac{\sqrt{2t}}{[n(n-1)]} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \vartheta_{ij} \tag{3}$$

However, t and n represent time and country while the coefficient of pairwise correlation is represented by ϑ_{ij}. The null hypothesis represents the existence of cross-sectional dependency while the alternative hypothesis shows the absence of cross-sectional dependency. However, the cross-sectional dependence test follows the standard normal distribution of two-tailed.

4.2 Panel unit root tests

The presence of cross-sectional dependence prefers the application of second-generation unit root test by Pesaran (2007). Taking account of t statistics for the estimator $\alpha_i(\alpha_i)$ of (OLS) ordinary least square among the cross-sectional (CADF) regression. To proxy the common factor, Pesaran (2007) test of unit root builds test statistics and employs the mean of cross sections.

$$dy_{it} = \vartheta_i + \alpha_i y_{i,t-1} + \rho_i dy_t + r_{ij} \tag{4}$$

Moreover, the consideration of augmented IPS test is also an option through mathematical formulae as follows

$$CIPS(N,t) = T - bar = N^{-1} \beta_{i=1}^{N} T_i(N,t) \tag{5}$$

Table 3 Pesaran (2007) cross-sectional dependence

Variables	High income	Upper middle income	Low middle income	Low income	Partner countries of OBOR
llche	29.16***	40.67***	31.08***	24.64***	8.28***
lco_2	29.49***	11.19***	0.20	11.35**	18.19***
lind	17.94***	38.98***	38.90***	0.38	20.35***
ltra	15.57***	13.51***	8.33***	5.83*	5.95***
lg *dp*	31.25***	56.87***	45.31***	45.62*	38.46***
lfr	8.38***	6.66***	3.43***	2.23*	20.53***

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

Table 4 Cross-sectional dependence

Variables	High income	Upper middle income	Low middle income	Low income	Partner countries of OBOR
Pesaran CD (2004)	6.92***	5.53***	4.61***	3.83***	0.57
Breush–Pagan(LM)	174.3***	184.5***	145.36***	186.54***	162.54***
Friedman CD	39.53***	46.93***	19.46***	18.63***	23.27***

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

Moreover, the statistics of augmented dickey fuller across the country for i^{th} unit of the country is represented by $r_{ij}(N, t)$, which is settled by the coefficient $(y_{i,}T - 1)$ of t statistics in regression of CADF.

5 Estimation and discussion

The findings of cross-sectional dependence among the above-mentioned countries are reported in Tables 3 & 4. Pesaran's (2007) outcomes approve that the null hypothesis of cross-sectional independence has been rejected because values of probability are significant. The above statement confirms that all indicators show the occurrence of cross-sectional dependence. Similarly, the presence of cross-sectional dependence also confirms among the studied samples from Table 4. The values of probability in Table 4 are statistically significant which testifies the refusal null hypothesis for cross-sectional independence by incorporating Brush–Pagan (LM), Friedman, and Pesaran's (2004) test of cross-sectional dependence. Thus, our study incorporated a second-generation CIPS (Cross-sectional augmented IPS) stationarity test, presented by Pesaran (2007).

The inference for the inaccuracy of individual behavior of learning becomes noteworthy if the sample size of data is large, e.g., (t > 20). In these scenarios, the assumption of ordinary least square (OLS) for all variables has been rejected for independent mean and variance in time (Gujarati, 2009; Pedroni, 2008; Eberhardt et al., 2011). To evaluate the occurrence of the unit root problem, a panel stationarity test has been utilized. CIPS stationarity test is applied in Table 5. Mean and variance are not constant with time are characterized by null hypothesis while vice versa is represented as the alternative hypothesis. Table 5

Table 5 Unit root test

Variables		*lhe*	lco_2	*lind*	*ltra*	lg *dp*	*lfr*
High income							
Pesaran (2007)							
With trend	Level	0.96	1.82*	0.34	0.09	0.20	0.89
	1st Difference	4.69***	3.32**	3.22***	2.52***	3.65***	3.35***
Maddala & Wu (1999)							
With trend	Level	119.12	140.72*	226.63	204.7**	99.83	179.78
	1st Difference	153.92***	88.44***	184.98**	103.30***	199.58***	184.98***
Upper middle income							
Pesaran (2007)							
With trend	Level	1.35	1.75*	0.35	0.03	0.89	0.83
	1st Difference	2.21***	2.47***	2.97***	2.75***	2.33***	1.87**
Maddala & Wu (1999)							
With trend	Level	33.03	35.93*	57.29	39.22	17.23	91.20
	1st Difference	26.14***	26.42***	26.14***	41.81***	19.25***	79.05***
Low middle income							
Pesaran (2007)							
With trend	Level	2.39***	2.62	1.89	1.82	4.59*	1.37*
	1st Difference	2.87***	3.28***	1.23***	2.89***	2.97***	1.46***
Maddala & Wu (1999)							
With trend	Level	36.36*	68.50	21.60**	32.91	19.88	54.57
	1st Difference	25.45***	39.66***	132.40***	45.95***	51.79***	47.72***
Low income							
Pesaran (2007)							
With trend	Level	2.88**	1.68	2.47	1.47	2.23	1.38
	1st Difference	2.56***	3.86***	3.57***	2.54***	4.98***	6.78***
Maddala & Wu (1999)							
With trend	Level	34.26	31.28	21.54	25.74	34.56	31.25
	1st Difference	21.84**	35.74**	47.86***	34.85***	42.56***	35.26***
Partner countries of OBOR							
Pesaran (2007)							
With trend	Level	2.06**	0.81	1.68	2.33***	1.59	1.24
	1st Difference	2.57***	1.68***	1.89***	3.36***	2.48***	2.18***
Maddala & Wu (1999)							
With trend	Level	45.98	51.11	111.23	59.27	22.14	53.82
	1st Difference	51.55***	33.12***	83.05***	72.06***	51.86***	118.5***

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

Table 6 Difference GMM (DGMM)

Variables	Dependent variable: Per capita health expenditure				Partner countries of OBOR
	High income	Upper middle income	Low middle income	Low income	
One-step difference GMM					
llche	0.266*** (0.00)	0.284*** (0.00)	0.697*** (0.00)	0.548*** (0.00)	0.316*** (0.00)
lco_2	0.284*** (0.02)	0.471* (0.09)	0.49*** (0.00)	0.687* (0.10)	0.970* (0.10)
lind	0.723*** (0.02)	0.179* (0.09)	0.252* (0.09)	0.489*** (0.00)	−0.256** (0.07)
ltra	−0.285*** (0.00)	−0.146*** (0.00)	0.854** (0.08)	0.364*** (0.00)	0.362 (0.84)
lg *dp*	0.778*** (0.00)	0.635*** (0.00)	0.603*** (0.00)	0.647 (0.64)	−0.356*** (0.00)
lfr	−0.274 (0.21)	0.435*** (0.00)	−0.264 (0.42)	−0.547*** (0.00)	−0.112*** (0.00)
AR(2)	0.62	0.20	0.26	0.12	0.46
Hansen	0.97	0.22	0.34	0.36	0.96
Two-step difference GMM					
llche	0.330*** (0.00)	0.284*** (0.00)	0.953*** (0.00)	0.978*** (0.00)	0.599*** (0.00)
lco_2	0.619*** (0.00)	0.34*** (0.00)	−0.197 (0.13)	−0.348*** (0.00)	0.246*** (0.00)
lind	−0.295 (0.71)	0.171 (0.18)	0.134*** (0.00)	0.856 (0.34)	0.805*** (0.00)
ltra	−0.359*** (0.00)	−0.14 (0.98)	0.126*** (0.00)	0.458*** (0.00)	0.522 (0.92)
lg *dp*	0.964*** (0.00)	0.657*** (0.00)	−0.102 (0.47)	0.545 (0.36)	0.576 (0.35)
lfr	−0.136 (0.60)	0.47** (0.07)	−0.354 (0.26)	−0.874*** (0.00)	−0.737*** (0.00)
AR(2)	0.42	0.19	0.31	0.45	0.93
Hansen	0.98	0.22	0.44	0.18	0.94

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

confirms the refusal of the null hypothesis which approves that at the first difference, all indicators do not obligate the problem of a unit root in case of with trend. However, both specifications of trend and without trend show that all variables have constant mean and variance in time at the first difference among the selected sample of countries.[2]

Initially, we estimate the relationship between emission of CO_2 and per capita health expenditure with other controlled variables by using pooled ordinary least square (OLS) and fixed-effect model to ensure the presence of relationship among discussed variables.[3] The estimated findings of one & two-step difference GMM and one & two-step system GMM are stated in Tables 6 and 7 to ensure the robustness of findings. Table 6 shows

[2] The detailed results of unit root are presented in Appendix A1.

[3] The detailed results of pooled OLS and fixed effect model are shown in Appendix A2.

Table 7 System GMM (SGMM)

Variables	Dependent variable: Per capita health expenditure				Partner countries of OBOR
	High income	Upper middle income	*Low Middle Income*	High income	
One-step system GMM					
llche	0.424*** (0.00)	0.995*** (0.00)	0.992*** (0.00)	0.887*** (0.00)	0.316*** (0.00)
lco_2	0.113*** (0.00)	0.535*** (0.00)	0.631*** (0.00)	−0.364*** (0.00)	0.673** (0.07)
lind	0.325*** (0.00)	0.412** (0.04)	0.279** (0.08)	0.364 (0.45)	0.427* (0.10)
ltra	−0.203 (0.86)	−0.499 (0.34)	−0.602** (0.03)	0.842** (0.08)	−0.426* (0.10)
lg *dp*	0.365 (0.97)	−0.478 (0.13)	−0.327 (0.35)	0.842 (0.86)	−0.115
lfr	−0.243 (0.53)	−0.615** (0.06)	−0.103 (0.24)	−0.894*** (0.00)	−0.778*** (0.00)
AR(2)	0.18	0.46	0.22	0.24	0.54
Hansen	0.77	0.27	0.25	0.19	0.69
Two-step system GMM					
llche	0.788*** (0.00)	0.356*** (0.00)	0.931*** (0.00)	0.974*** (0.00)	0.215*** (0.00)
lco_2	0.571** (0.05)	−0.986*** (0.00)	0.672*** (0.00)	0.456 (0.78)	0.876*** (0.00)
lind	0.710 (0.11)	0.137*** (0.00)	0.264* (0.10)	0.368*** (0.00)	0.3679** (0.07)
ltra	−0.778* (0.10)	0.216 (0.48)	0.626** (0.08)	0.784*** (0.00)	0.456 (0.35)
lg *dp*	−0.234 (0.94)	−0.133 (0.34)	−0.299 (0.34)	0.842 (0.84)	0.647 (0.84)
lfr	0.29* (0.10)	0.419 (0.52)	0.931 (0.26)	−0.847*** (0.00)	−0.235*** (0.00)
AR(2)	0.54	0.61	0.41	0.36	0.69
Hansen	0.85	0.86	0.78	0.12	0.78

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

that lagged explained variables approve the significant and positive relationship with health expenditure among all selected samples of countries while the increase in CO_2 emission will increase the per capita health expenditure among all the nominated samples of countries except low-middle-income countries by using one & two-step difference GMM. However, forest area exhibits a significant and negative relationship with expenditure on health among low-income and partner countries of OBOR while upper-middle-income countries elucidate the significant and positive association between forest area and expenditure on health per capita in both specifications of one & two-step difference GMM. However, a rise in GDP per capita will upsurge health expenditure between high-income and high-middle-income economies.

Table 7 incorporates the estimates of one & two-step system GMM. Table 7 approves that lagged dependent variable exhibits significant and positive connection with per capita health expenditure. However, all nominated samples of economies show that rise in the emission of CO_2 will upsurge the expenditure on health except in low-income countries, by incorporating one-step system GMM, while results of two-stage system GMM clarify the significant and positive association among emanation of CO_2 and expenditure on health per capita between all nominated sample of economies except low- and upper-middle-income countries. Moreover, forest area approves negative and significant association with per capita health expenditure among upper-middle-income, low-income, and partner of OBOR countries employing one-stage system GMM while two-stage system GMM exhibits same outcomes among low-income and partner of OBOR economies. The estimated outcomes are steady with the results of (Farooq et al., 2019; Sarwar et al., 2019). Per capita industrial value-added also approves a significant and positive relationship with health expenditure among all samples of selected countries except low-income countries utilizing the one-step system GMM. Moreover, the lagged dependent variable approves a significant and positive association with expenditure on health per capita in all specifications. However, an increase in CO_2 emission also leads to an increase in per capita health expenditure among the majority of nominated sample economies. Most of the specifications show that forest area also exhibits a negative and significant relationship with per capita health expenditure.[4]

5.1 Discussion

Estimated findings have evidenced the presence of an association between emanation of CO_2 and expenditure on health within selected samples of all countries. These findings are consistent with Farooq et al. (2019), Heutel and Ruhm (2016), Ogundari and Awokuse (2018), Saidi and Hammami (2016) and Sarwar et al. (2019). Many countries are constantly adopting several policies to curb CO_2 emanation. However, the surge in economic growth deteriorates the quality of the environment by instigating CO_2 emissions. The higher level of income has the effect of increasing carbon even after ignoring technological and composition effects. Taking account of the scale effect, an increase in income leads to an increase in healthcare expenditure. In the occurrence of structural and technological changes, many countries incorporate intensity of energy, capturing the changes of technology in sinking per capita emission. Due to changes in structural and technological changes, intensity of energy decreases over a while. These combinations of policies will further reduce the CO_2 emission and healthcare expenditures (Assadzadeh et al., 2014; Ozcan et al., 2018). Moreover, an increase in income leads to an increase in economic activity as a result of unobstructed foreign earnings and foreign investment from imports and exports. This will increase the income of countries, but this increase in income is associated with the problem of environmental quality due to the manufacturing of toxic material and chemicals (Clemente et al. 2004; Murthy & Okunade, 2009; Blacksmith Institute, 2011). Narayan et al. (2008) empirically investigated the connection between environmental eminence and healthcare expenditure by using a sample of 8 OECD economies. They employed an autoregressive distributed lag model (ARDL) from 1980 to 1999. The estimated findings reveal that the increase in emission of nitrogen and sulfur oxide will lead to a rise in healthcare expenditure. Moreover, Zheng et al., (2019) concluded that the improved quality of the environment has a positive and significant impact on healthcare expenditure, both in the short run and long run.

[4] Summary of detailed results are shown in Appendix A3.

An increase in forest area leads to a decrease in per capita health expenditure in all specifications of low-income and partner of OBOR countries. It is drawn from the above findings that higher forestation leads to a decrease in health issues due to an increase in rainfall which further reduces the level of temperatures. An increase in rainfall happens due to massive forestation through a round of recycling such as vapors are absorbed by the plants from the ground and emit in the atmosphere which further comes from the cloud in form of hail. The outcome of temperature changes due to the relationship between massive forestation and reduction in greenhouse gases, as it is an admitted fact that forest area plays an important role in controlling temperature due to the natural ability of plants to absorb carbon dioxide through photosynthesis which further reduces global warming. These verdicts are consistent with Badamassi et al. (2017) and Bernstein et al. (2008), which confirms that deforestation increases temperature. The reproduction of mosquitoes also depends upon the level of temperature and humidity which further affect the health of an individual. Generally, an increase in air pollution will surge the temperature level in the sky which causes many chronic diseases such as heart disease, respiratory infection, lung infection, and low birth weight (Kamila et al., 2014; Skoufias et al., 2011).

The nature of traded commodities plays a significant role in determining the relationship between trade liberalization and health. These types of commodities are classified into four groups such as legal and doubtful benefits, legal and beneficial, illegal and harmful, and legal and harmful commodities. The focus should be on legal and harmful goods such as cigarettes. It is estimated that 4 million people died due to usage of tobacco in 1998, which is predictable to reach up to 8.4 million by 2020, whereas 70% of these expiries belong to developing economies. However, 800,000 people died in China from 1999 to 2000 due to tobacco usage. Foreign investment and trade liberalization facilitate multinational companies and this will prevent the contrivance of tobacco control policy by the public health community (Murray et al., 1997; Chaloupka et al., 1998; Dollar & Kraay, 2001; Cornia et al., 2007).

6 Conclusion

The study elucidates the novel understanding of the relationship between CO_2 emission, forestation, and per capita health expenditure among 16 high-, 22 upper-middle-, 18 low-middle-, and 13 low-income economies. The study also includes 18 partner economies of OBOR from 1999 to 2018. The study uses pooled OLS, fixed-effect model, one and two-step difference, and system GMM to find the relationship between the above-discussed indicators to ensure the robustness of findings. We also incorporate the sample for the companion economies of OBOR which signifies 68% of the total world population. To renovate the industrial sector, the project of OBOR supports several economies to share their technologies, resources, and labor. This will increase the production of each country and leads to a surge in economic growth. The increase in economic growth due to massive industrial production may worsen the quality of the environment and the health of individuals. The major partners of the OBOR project are composed of developing economies that are keen to raise the speed of their development.

Empirical findings reveal the positive and significant association between emanation of CO_2 and per capita health expenditure among the selected samples of several economies except for low-income countries. However, an increase in forest area leads to a decrease in per capita health expenditure in the case of low-income and partner of OBOR countries.

Moreover, the per capita industrial value-added also exhibits a significant and positive relationship with per capita health expenditure among all selected samples of countries except low-income economies by using system GMM.

6.1 Policy implication

The empirical evidence suggested that policymakers should propose such policy reforms that can enhance the quality of the environment and minimize several health-related issues. Initially, local and state governments should cooperate to manage the area of forest regularly. Public sector investment in forests can reduce the emission of CO_2 in the atmosphere such as afforestation, forest management, and reforestation. Local residents should be involved in forest management and cleaning activities by providing them rewards and incentives. Moreover, the government should implement strict rules for deforestation and issue a limited amount of license for deforestation upon the condition of new planting trees.

Furthermore, an increase in pollution will deteriorate the environmental quality, leading to an increase in many health problems and expenditure on public health among the discussed regions. The situation reveals that maintaining the quality of the environment will be a great challenge if the government continues to fund the important sector of an economy like the health and education sector. There is a need to intensify the efforts for maintaining the quality of the environment by using carbon-free technologies such as renewable energy sources. However, those economies that are increasing their economic growth at the cost of the environment will increase the pollution and early deaths caused by health diseases. Moreover, the government should provide a healthy living environment to the rural and urban population by building parks, green belts, and better sewerage systems. Therefore, environmentally friendly policies among the discussed regions of the world would be valuable for the health sector and human welfare.

Appendix

See Tables 8, 9, 10.

Table 8 Unit root test

Variables			lhe	lco_2	$lind$	$ltra$	lg dp	lfr
High income								
Pesaran (2007)								
	Without trend	Level	0.29	0.99	0.88	0.29	0.09	0.20
		1st Difference	2.82***	3.36**	5.25**	2.06***	3.16***	4.36***
	With trend	Level	0.96	1.82*	0.34	0.09	0.20	0.89
		1st Difference	4.69***	3.32**	3.22***	2.52***	3.65***	3.35***
Maddala & Wu (1999)								
	Without trend	Level	117.28	147.6**	274.86	257.62*	118.95	235.13
		1st Difference	89.83***	97.103**	202.15***	125.25****	96.76***	166.76***
	With trend	Level	119.12	140.72*	226.63	204.7**	99.83	179.78
		1st Difference	153.92***	88.44***	184.98**	103.30***	199.58***	184.98***
Upper middle income								
Pesaran (2007)								
	Without trend	Level	0.55	1.69*	0.67	0.79	0.64	0.51
		1st Difference	2.76**	1.69***	3.65**	1.35***	2.09***	1.35***
	With trend	Level	1.35	1.75*	0.35	0.03	0.89	0.83
		1st Difference	2.21***	2.47***	2.97***	2.75***	2.33***	1.87**
Maddala & Wu (1999)								
	Without trend	Level	79.21*	35.14	37.36	66.50	34.82	97.82
		1st Difference	25.95***	32.15***	27.25***	44.90***	52.66***	85.93***
	With trend	Level	33.03	35.93*	57.29	39.22	17.23	91.20
		1st Difference	26.14***	26.42***	26.14***	41.81***	19.25***	79.05***
Low middle income								
Pesaran (2007)								
	Without trend	Level	3.73***	1.46	0.80	1.20	4.05**	1.18
		1st Difference	4.06***	2.03***	2.27***	2.23***	3.05***	0.69***
	With trend	Level	2.39***	2.62	1.89	1.82	4.59*	1.37*
		1st Difference	2.87***	3.28***	1.23***	2.89***	2.97***	1.46***
Maddala & Wu (1999)								
	Without trend	Level	26.14	41.91	17.59	26.93	5.67	63.54
		1st Difference	23.07***	58.06***	13.82***	22.81***	7.94***	49.90***
	With trend	Level	36.36*	68.50	21.60**	32.91	19.88	54.57
		1st Difference	25.45***	39.66***	132.40***	45.95***	51.79***	47.72***
Low income								
Pesaran (2007)								
	Without trend	Level	3.86	2.38	0.82	1.34	4.08**	0.25
		1st Difference	4.38***	6.86***	5.84***	3.86***	2.56***	6.67***
	With trend	Level	2.88**	1.68	2.47	1.47	2.23	1.38
		1st Difference	2.56***	3.86***	3.57***	2.54***	4.98***	6.78***
Maddala & Wu (1999)								
	Without trend	Level	35.86	25.12	27.21	26.17	29.74	21.45
		1st Difference	41.38***	36.86***	31.24***	35.86***	36.86***	35.67***
	With trend	Level	34.26	31.28	21.54	25.74	34.56	31.25
		1st Difference	21.84**	35.74**	47.86***	34.85***	42.56***	35.26***

Table 8 (continued)

Variables		lhe	lco_2	$lind$	$ltra$	$\lg dp$	lfr
Partner countries of OBOR							
Pesaran (2007)							
Without trend	Level	3.39***	0.41	2.96	0.82	0.67	1.67
	1st Difference	3.16***	0.34***	3.45***	1.95***	1.87***	2.26***
Without trend	Level	2.06**	0.81	1.68	2.33***	1.59	1.24
	1st Difference	2.57***	1.68***	1.89***	3.36***	2.48***	2.18***
Maddala & Wu (1999)							
Without Trend	Level	56.98**	62.62	84.10	51.97	67.67	89.69
	1st Difference	57.70***	26.26***	65.02***	70.06***	33.57***	65.07***
Without trend	Level	45.98	51.11	111.23	59.27	22.14	53.82
	1st Difference	51.55***	33.12***	83.05***	72.06***	51.86***	118.5***

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

Table 9 Pooled ordinary least square & fixed effect model

Variables	Per capita health expenditure				Partner countries of OBOR
	High income	Upper middle income	Low middle income	Low income	
Pooled OLS dependent					
$llche$	0.134*** (0.00)	0.996*** (0.00)	0.992*** (0.00)	0.846*** (0.00)	0.316*** (0.00)
lco_2	0.142** (0.07)	−0.478 (0.11)	0.634** (0.07)	0.542** (0.08)	0.673* (0.09)
$lind$	0.012 (0.26)	0.435*** (0.00)	0.279 (0.23)	0.244 (0.26)	0.427* (0.10)
$ltra$	0.201 (0.42)	−0.786 (0.19)	0.607*** (0.00)	0.364 (0.45)	−0.423*** (0.00)
$\lg dp$	0.202 (0.19)	−0.489*** (0.00)	−0.327 (0.17)	0.865*** (0.00)	−0.115 (0.30)
lfr	0.074 (0.25)	0.652 (0.14)	−0.103 (0.23)	0.654 (0.84)	−0.778** (0.07)
Fixed effect model					
$llche$	0.475*** (0.00)	0.642*** (0.00)	0.856*** (0.00)	0.965*** (0.00)	0.887*** (0.00)
lco_2	0.203 (0.98)	0.465 (0.59)	−0.148 (0.89)	0.578*** (0.00)	−0.442 (0.78)
$lind$	0.894*** (0.00)	0.985*** (0.00)	0.245*** (0.00)	0.364 (0.56)	0.427 (0.57)
$ltra$	0.707 (0.12)	−0.426 (0.42)	0.56* (0.10)	0.874*** (0.00)	0.464 (0.68)
$\lg dp$	0.528*** (0.00)	0.301*** (0.00)	0.765 (0.14)	0.647*** (0.00)	0.600* (0.10)
lfr	−0.064 (0.77)	−0.517 (0.34)	−0.346 (0.17)	0.862 (0.97)	−0.57 (0.83)

*, ** and *** denotes the significance level of 0.10, 0.05 and 0.01 level

Table 10 Summary of results

	Pooled OLS	Fixed effect	One step diff. GMM	Two step diff. GMM	One step syst. GMM	Two step syst. GMM
High income						
llche	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lco_2	**+ ve Sig**	+ ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lind	+ ve insig	**+ ve sig**	**+ ve sig**	– ve insig	**+ ve sig**	+ ve insig
ltra	+ ve insig	+ ve insig	**– ve sig**	**– ve sig**	– ve insig	**– ve sig**
lg *dp*	+ ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	+ ve insig	– ve insig
lfr	+ ve insig	– ve insig	– ve insig	– ve insig	– ve inisg	**+ ve sig**
Upper middle income						
llche	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lco_2	– ve insig	+ ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	**– ve sig**
lind	**+ ve sig**	**+ ve sig**	**+ ve sig**	+ ve insig	**+ ve sig**	**+ ve sig**
ltra	– ve insig	– ve insig	**– ve sig**	– ve insig	– ve insig	+ ve insig
lg *dp*	**– ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	– ve insig	– ve insig
lfr	+ ve insig	– ve insig	**+ ve sig**	**+ ve sig**	**– ve sig**	+ ve insig
Low middle income						
llche	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lco_2	**+ ve Sig**	– ve insig	**+ ve sig**	– ve insig	**+ ve sig**	**+ ve sig**
lind	+ ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
ltra	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	– ve insig	**+ ve sig**
lg *dp*	– ve insig	+ ve insig	**+ ve sig**	– ve insig	– ve insig	– ve insig
lfr	– ve insig	– ve insig	– ve insig	– ve insig	– ve insig	+ ve inisg
Low income						
llche	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lco_2	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**– ve sig**	**– ve sig**	+ ve insig
lind	+ ve insig	+ ve insig	**+ ve sig**	+ ve insig	+ ve insig	**+ ve sig**
ltra	+ ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lg *dp*	**+ ve sig**	**+ ve sig**	+ ve insig	+ ve insig	+ ve insig	+ ve insig

Table 10 (continued)

	Pooled OLS	Fixed effect	One step diff. GMM	Two step diff. GMM	One step syst. GMM	Two step syst. GMM
lfr	+ ve insig	+ ve insig	**– ve sig**	**– ve sig**	**– ve sig**	**– ve sig**
Partner countries of OBOR						
llche	**+ ve Sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lco_2	**+ ve Sig**	– ve insig	**+ ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
lind	**+ ve sig**	+ ve insig	**– ve sig**	**+ ve sig**	**+ ve sig**	**+ ve sig**
ltra	**– ve sig**	+ ve insig	+ ve insig	+ ve insig	**– ve sig**	+ ve insig
lg *dp*	– ve insig	**+ ve sig**	**– ve sig**	+ ve insig	– ve insig	+ ve insig
lfr	**– ve sig**	– ve insig	**– ve sig**	**– ve sig**	**– ve sig**	**– ve sig**

The bold letter {(**sig+**) and (**sig-**)} shows the significance of each variable in selected of countries

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