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# Does Environmental Quality Drive Health Spending? A Cross Country Analysis

Maryam Ishaq[1], Furrukh Bashir[2], Ismat Nasim[3]

[1] Department of Economics, The University of Lahore, Lahore, Pakistan, Email: maryam.ishaq@econ.uol.edu.pk
[2] Assistant Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan
Email: furrukh@bzu.edu.pk
[3] Lecturer, Department of Economics, The Government Sadiq College Women University, Bahawalpur, Pakistan
Email: ismat.nasim@gscwu.edu.pk

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**ABSTRACT**

The paper aims at empirically investigating the long-run explanatory power of environmental quality and energy intensity towards aggregate health spending volumes for a set of 108 countries. The significance of CO2-related pollution and energy intensity levels as long-run determinants of health spending is well-evident, as proven from modern pooled data econometric procedures applied. Keeping in view the previous research on the subject, the sample set of countries is disaggregated into four distinct groups on the basis of Income The hypothesized relationship between health spending, environmental pollution and energy intensity is empirically verified. The obtained result reveal that plausible inter-relationship between Co2Emissions and the consequent rise in health spending is found to be existing more prominently for Upper-middle-income (UMI) and High-income (HI) countries, relative to low-income (LI)- and Lower-middle-income (LMI) countries, where the proposed relationships are found to be existing at less substantial levels. Energy intensity is a determinant of health expenditure. For upper middle and High-income (HI) country groups, the series bears a negative and significant coefficient. The negative coefficient value of energy intensity series implies that managing the levels of energy intensity up to optimal levels may contribute positively to reducing the growing volumes of public and private health spending.



Corresponding Author's Email: maryam.ishaq@econ.uol.edu.pk

## 1. Introduction

Health plays a vital role in attaining the economic development of a country (Boachie et al., 2014; WHO, 2019). The influence of health towards economic development comes from the health led growth hypothesis, suggesting investment in health can positively translate into higher levels of labor productivity, and thus increase in income and consequently increase in the wellbeing of population health (Bloom & Finlay, 2009; Piabuo & Tieguhong, 2017). Health system makes a significant contributor to economic development and inclusive growth, helping to bring benefits to the entire community. By analyzing and understanding their economic and social impacts, maintaining good health standards can serve as a highway towards meeting the Millennium Development Goals (MDGs) (WHO, 2019).

In present times, rising levels on environmental degradation has become the biggest challenge to this world. Environmental degradation is the deterioration of the environment through depletion of resources which includes deterioration/depletion of all varieties of natural resources from our surroundings i.e. Rising sea levels due to increasing temperature, speedy melt down of glaciers, depletion of ozone layer, deforestation, and many others. In addition to causing devaluation to natural environment, environmental degradation bears severely adverse effects on human health also. Environmental degradation may bring a variety of diseases to humans, respiration and skin-related diseases are most significant of them caused by growing volumes of air and water pollution, people are evidently found to be suffering from skin problems such as acne, hives and eczema (Drakaki, Dessinioti, & Antoniou, 2014; Maurya, Singh, Ohri, & Singh, 2020). Though, various forms of environmental pollution bring their own damages to environment and living-beings, Greenhouse Gases (GHGs) are one of the biggest concerns of modern day's environmental regulatory authorities (Zhang, Peng, Ma, & Shen, 2017). Carbon dioxide emission is a main source of environmental pollution which produces fossil fuel that damaged the ozone surface and leads to increase the environmental degradation which has harmful effects on human health (Jacobson, 2009). CO2is found to be responsible for constituting 76% of GHGs, whereas China is the main emitter of $CO_2$ emission in atmosphere which emits 30% of $CO_2$ emission globally. India and Russia also stand out in this respect with their respective contributions of 5% and 7% of global $CO_2$ emissions (IPPC, 2014; USEPA, 2017).

Environmental pollution poses serious threats to human health. It may cause different kinds of diseases like cardiovascular, respiratory diseases which can affect the human body when these environmental pollutions come into the lungs of body, they create the increasing risk of stroke and heart diseases and reduce life expectancy. Globally 2.5 million people are died due to stroke and heart diseases (H. Chen et al., 2017; Lu, Yao, Fung, & Lin, 2016; Siddique & Kiani, 2020; WHO, 2019). However, air and water pollution may be harmful for the human system, therefore, poses risks to health (Guan, Zheng, Chung, & Zhong, 2016; Li et al., 2015). According to WHO (2016), 12.6 million deaths per year occur due to environmental pollution which estimate the 24% of global disease burden worldwide.

In the present era, where clean environment is recognized as one of the fundamental pillars of sustainable development practices, global health spending continuously has risen over years. In 2017, it reported a volume of USD 7.8 trillion, equivalent to about ten percent of world GDP. The average health care spending reported by low-income (LI) countries is of USD41 per capita, while High-income (HI) countries spend USD2937 per capita, thus, representing a sharp contrast in the spending patterns of two regions. Amongst different regional territories of the world, Asia stand out in the context of population volumes and its growth rate, therefore, health and its related industries are of big concern for international health organizations of the world. According to (World Bank) East Asia spend USD 665 per capita on healthcare, or about 6% of GDP in 2017.

A vast number of studies have evidently proven that healthcare spending bears important implications on economic performance of a country, explained through labor force quality and its participation rates contributed to economy (Bedir, 2016; Boussalem, Boussalem, & Taiba, 2014; Jack & Powers, 2009; Schultz & Zelezny, 1999). Some commendable studies suggest that improvement in health can lead to increase in GDP and vice versa (Anand et al., 2000; Weil, 2014). In economic literature, healthcare expenditure is considered as an investment in human capital. Therefore, increase in health expenditure may impart significant improvements to national productivity levels and country's labor force participation rates (Bloom, Canning, & Sevilla, 2004; Kurt, 2015; Ozturk & Topcu, 2014).

By writing this research dissertation, the authors primarily aim at re-investigating (empirically) what significance does environmental quality holds for determining the health care spending volumes across an extensive range of countries. The study has attempted to validate (invalidate) the subject issue using extensive econometric procedures. Such a can be taken as worthwhile contribution to the existing research on this topic. So far, in the existing literature, no study has empirically tested the inter-relationship of environmental deterioration and health care expenditure using global data sets. For the purpose of statistical analysis, 108 countries of the world are including in our study sample. In this study, World Bank's classification has been taken to categorize the group of countries according to Income i.e. low-income (LI), Lower-middle-income (LMI), upper- middle income, and High-income (HI) countries. The disaggregation of our sample countries into distinct groups can be legitimize through the well-evident fact that disparity in income levels may have significant influence on link of environmental degradation with health care expenditure. The fact bears strong implications for researchers, studying environmental quality in relation to health care spending patterns across countries.

Keeping in view the growing importance of environmental quality for affecting the health care spending not only for developing countries but also for developed ones, the key objective of writing this research is to revisit (econometrically) what effects does CO2-related emissions (representing environmental quality) impart on health care expenditure at global level. Speaking formally, the key objective of conducting this research study is to acquire confirmation/validation of the much applauded linkage between CO2-based environmental contamination and health care spending volumes using modern econometric testing procedures. This broad study objective is served by below stated two sub-objectives, complementing our above given objective in their own distinct way.

- A rigorous empirical strategy is used to conduct a comprehensive research of the subject connection, which includes using many different testing techniques. This will help to verify the consistency and robustness of model estimates produced in comparison to other econometric techniques.
- A few studies report that the degree of association between environmental pollution, health expenditures and energy intensity may vary from region to region. This difference is mainly due to the country's income level. Therefore, this study will conduct a comprehensive analysis of 108 countries of the world to investigate whether the economic prosperity of a particular country group plays an important role in establishing the association between the model variables.

The country classification followed in this research is based on income level. This leads us to believe that each country group would be demonstrating a varying degree of association between our subject variables. This dissertation therefore holds an interesting analysis around 108 countries of the world, revealing the relative significance of group-specific economic properties in determining if to what extent environmental degradation (CO2-based) are proven to be determining the health care spending preferences in a global perspective.

## 2. Literature Review

The literature on the subject topic is quite vast, we therefore mainly focus on the empirical studies investigating the hypothesized relationship in the context of low-income (LI) and/or developing economies. However, conducting a comparative analysis between low-income (LI)- and High-income (HI) countries on the subject issue can be a very interesting activity, therefore, the later part of this section deals with reviewing some important studies done on Upper-middle-income (UMI)- and High-income (HI) countries.

### 2.1 Reviewing the Inter-relationship between CO2 Emission and Health Expenditure for Low-income (LI)- and Lower-middle-income (LMI) Countries

Low-income (LI) countries are largely characterized by high public and private spending on provision of health care facilities. From Human Development Index (HDI), it is well evident that these countries are subject to low life expectancy ratio, therefore, indicating poor state of health requiring massive amounts of financing for health sector and the associated industries. This section of the chapter explores CO2 emissions as one of the plausible factor of increased volumes of health expenditures in low-income (LI)- and middle-income countries. A handful of studies will be reviewed in the hope of finding some substantial evidence in favor of CO2-related emission as one of the key explanatory variables of increased health spending for these countries.

Boachie et al. (2014) establish the causal relationship between $Co_2$ emissions and public health expenditure, with life expectancy, urbanization and economic growth as indicators of quality of life standards prevailing in the Ghana. The co-integration testing (through Engle-Granger procedure) results reveal long-run equilibrium linkage between public healthcare expenditure and $Co_2$ emission, with economic growth as most significant contributor from the side of control variables.

Yahaya, Nor, Habibullah, Ghani, and Noor (2016) select 125 developing countries of East- and Central Asia and found short-run causality amongst pairs of model variables is verified through error correction term (ECT). The panel OLS and the panel DOLS results validate long-run relationship between health expenditure and environmental quality. Khoshnevis Yazdi and Khanalizadeh (2017) conduct an empirical study on investigating the long-run factors affecting health expenditures in Middle Eastern and North Africa (MENA) region for a group of 11 member states. Employing per capita values of health expenditures, CO2 emission, air pollution and GDP. After confirming existence of valid long-run equilibrium relationship between air pollution, health expenditure and economic growth by Pedroni co-integration test, the long-run elasticities reveal positive effect of economic growth, CO2 emission and air pollution on health expenditures.

Zaidi and Saidi (2018) investigate positive effectiveness of economic growth on health expenditure while CO2 emission as negatively related with health expenditure while $Co_2$ emissions affecting negative health expenditures both over long- and short periods of time. Raeissi et al. (2018) confirm that CO2 emissions influence positively on the volumes of health spending. Speaking precisely, a (percentage) unit increase in CO2 emissions lead to 3.22 percent and 1.16 percent increase in public and private health expenditure, respectively.

Ullah, Rehman, Khan, Shah, and Khan (2020) contribute a commendable piece of research identifying the link between CO2 emissions and health expenditure for Pakistan. Health expenditures of the country are tested against CO2-related emission and renewable energy consumption with country's trade volume and economic growth in capacity of control variables. Using annual data points from 1998-2017, current values of health expenditures are tested against percentage of total fuel values of CO2 emissions and renewable energy through simultaneous equation technique and Granger causality test. The simultaneous equation testing results confirm that increased trade volumes induce increased levels of CO2 emission that ultimately result in increased heath spending. However, increase in renewable energy consumption brings reduction to health expenditure which are adversely affected due to CO2 emissions. As suggested by Granger causality test results, health care spending and GDP per capita have bidirectional causality, implying health care spending has strong implications for country's productivity. The study advocates the adoption of renewable energy as a powerful tool against CO2 emissions, ensuring a cut-down to health spending in longer-run.

Barkat, Sbia, and Maouchi (2019) worked out the long-run determinants of health expenditures for the 18 Arab countries. Health spending and income levels are measured through their per capita values and technological progress are proxied through life expectancy and mortality rate. Pooled mean group (PMG), common correlated estimator (CCE) results show that apart from income, population and mortality rate are also found to be significantly affect health expenditures. Alimi, Ajide, and Isola (2020) use income level, fertility rate, population, life expectancy, and inflation rate as control variables for Economic Community of West African States (ECOWAS) for a group of 15 countries using annual data set ranging from 1995-2014. The study concluded that environmental quality is inversely related with health expenditures while $Co_2$ emission has a positive and statistically significant effect on health care expenditure both (public and private) at 5% level.

Wang, Rasool, Asghar, and Wang (2019) conduct an empirical study on investigating the linkages of CO2 based pollution emissions and health expenditures for Pakistan. The bound testing results suggest the existence of valid cointegraion between CO2 emission and health expenditure, with trade, fixed capital formation and economic growth as significant contributors in establishing causal relationship. The short-run error correction based estimates also endorse the findings yielded through bound testing procedure. Zeeshan, Han, Rehman, Ullah, and Mubashir (2022) analyze the asymmetric dynamic relationship between household spending volumes, CO2 emission and the levels of environmental pollution in China. The study results are in line with earlier researches confirming the proposed nexus for the country revealing direct association between shock to CO2 emission and health spending volumes of the country.

### 2.2 The Case of Upper-middle-income (UMI)- and High-income (HI) Countries

It is important to see up to what extent the linkage of $Co_2$related emissions with health spending in the case of Upper-middle-income (UMI)- and High-income (HI) countries may sustain. At the outset, the story seems to be substantially different from that of low-income (LI)- and middle-income countries, particularly in the sense of choice of proxy variables, magnitude of proposed relationship, its direction and the significance of key control variables. Nevertheless, nothing can be acclaimed with certainty without conducting a detailed review of earlier works on this subject. For studying the inter-relationship between degree of environmental degradation and health spending Narayan and Narayan (2008) investigated the proposed relationship for eight OECD countries (UK, Austria, Iceland, Norway, Spain, Ireland, Switzerland, and Denmark). Using annual data set from 1980-1999, the study establishes causal linkage of income per capita, a variety of pollution emissions (including nitrogen oxide, Sulphur oxide, carbon monoxide) with per capita health expenditures. After validating from Pedroni co-integration test about long-run co-movement, the results show that income, sulphur oxide and carbon oxide and bear positive effect on health expenditure while nitrogen oxide has negative impact on health expenditure.

J. Yang and Zhang (2018) studied China for exploring the interrelationship between air pollution and health expenditure. Using the China Urban Household Survey data, the authors employ air pollution and per capita family health expenditure to confirm the validity of hypothesized relationship between model variables. The OLS testing results show that 1% increase in yearly levels of air pollution corresponds to 0.536% increase in household health expenditure on the average. The results yielded through instrumental variable analysis depict even graver picture, suggesting that 1% increase in yearly air pollution brings 2.94% increase in household health expenditure. Hao, Liu, Lu, Huang, and Zhao (2018) used Generalized Method of Moments (GMM) to estimate the results which show that rise in sulphur dioxide and $Co_2$ emissions per capita result in significant rise in Chinese public health expenditures.

L. Chen, Zhuo, Xu, Xu, and Gao (2019) conduct a very interesting empirical study on investigating the determinants of health care expenditure for 30 provinces of China. Through test results, CO2 emissions turn out to be significantly important determinant of health care expenditure for all quantiles. Siddique and Kiani (2020) carried an empirical study on devastating effects of industrial pollution on health. Taking life expectancy and infant mortality rate as indicators of the state of human health, the damaging effects of CO2 Nitrous oxide ($N_2O$)-related emissions are tested through a sample data set from 1990-2016. The panel fixed-effect test results confirm the adverse effects of CO2 and $N_2O$-related emissions. Furthermore, the positive relationship between two types of emissions and high rate of infant mortality are also confirmed.

Majeed and Ozturk (2020) conduct a thorough analysis around the impact of environmental degradation on population-health outcomes in a global perspective of 180 Middle East and Latin America regions. Employing life expectancy and infant mortality value as health indicators, and per capita value of CO2 emissions, the results strongly suggest that environmental pollution bears negative impact on population health. Saleem, Khan, Shabbir, Khan, and Usman (2022) investigate the dynamic relationship between fossil-fuels based non-renewable energy production, health spending and CO2 emission for OECD countries. Employing a panel of 32 member states, the research confirms that energy production bears direct unidirectional causal association with CO2 emission. For health spending and CO2 emission, there holds a bidirectional relationship.

The review of literature conducted shed light on plausible inter-relationship between CO2-related emissions and the consequent rise in health spending. Fairly large number of studies support the notion, rendering CO2 emissions a credible determinant of health spending volumes, both over shorter- and longer horizons of time. This is particularly true for two groups of Upper-middle-income (UMI)- and High-income (HI) countries. Nevertheless, for low-income (LI)- and middle income groups of countries, the evidence is rather mixed. On one hand, a handful number of studies prove CO2 imparting positive impact on health-related expenditures in these countries, whereas, a few important studies also report a negative and/or statistically insignificant relationship between two variables. Altogether, the existing empirical evidence on this issue provides sufficient ground for revisiting the subject relationship but from a different perspective. The forthcoming section of the paper is dedicated to this purpose, where the hypothesized relationship between CO2 emissions and health spending volumes will be empirically investigated for four distinct group of countries, differing from each other based on their income levels and economic prosperity.

## 3. Empirical Framework and Model Variables

This section of the paper will be establishing the empirical framework to test the hypothesized relationship between health spending, environmental pollution and economic growth. The general form of the relationship will be constructed under investigation and subsequently its advanced econometric models of pooled data estimation will be used in forthcoming section to identify the (plausibly existing) relationship between health expenditures and environmental quality. For the model variables defined and discussed below, data series for analytical purpose are sourced with annual frequency from World Development Indicators (WDI, 2021), ranging from year 2000 to 2021.

## 3.1 Measuring the Model Regressand

### 3.1.1 Health Expenditure

This is our model regressand. Looking into the earlier studies on this subject, a variety of proxy variables have been used for representing the health spending like per capita health expenditure (Hao et al., 2018; J. Yang & Zhang, 2018). For the purpose of conducting empirical analysis, the proxy for health expenditure employed in this paper is the current health expenditures measured as percentage of national GDP.

$$Health\ Expenditure = he = \left(\frac{Current\ health\ expenditure}{GDP}\right) \times 100$$

## 3.2 Measuring the Model Regressors

Considering the objectives of the study and following the recent works of (Alimi et al., 2020; Sarwar, Alsaggaf, & Tingqiu, 2019; B.-Y. Yang et al., 2018), a vast majority of authors use carbon dioxide emission as a proxy of environmental pollution. Therefore, the same is chosen to reflect the status of environmental pollution for our sample country groups.

### 3.2.1 Environmental Pollution

Environmental pollution for this study is measured through CO2 emissions in terms of metric tons per capita.

$$Environmental\ Pollution = CO2 = C02\ emissions\ metric\ tons\ per\ capita$$

### 3.2.2 Energy Intensity

Energy intensity is taken as the second most important (plausible) determinant of health spending patterns. Numerous earlier researches have studied the patterns of CO2 based environmental pollution in connection to the degree of energy intensity demonstrated by each country (Apergis, Bhattacharya, & Hadhri, 2020; Ishaq et al., 2022; Ullah et al., 2020).

$$Energy\ intensity = ei = \left(\frac{energy\ supply}{GDP\ measured\ at\ purchasing\ power\ parity}\right)$$

### 3.2.2 Rate of Economic Growth

The rate of economic growth plays an imperative role in determining the inter-relationship of healthcare expenditure. Numerous earlier studies have shown that the improvement in country's income levels can lead to improving the levels of health spending. As proven from literature (Apergis et al., 2020; Hao et al., 2018; Ullah et al., 2020) economic growth holds an evident importance in ability of control variables. Looking through the previous research studies, while measuring economic growth, a common practice is to employ GDP growth rates or the growth rates of GDP per capita. For our study, the annual values of GDP per capita are employed to reflect the state of economic growth of a country.

$$Economic\ growth\ = gdppc = (GDP\ per\ capita, PPP\ (current\ international\ \$))$$

## 3.3 Developing an Empirical Framework for Estimating the Proposed Inter-Relationship between Health Expenditure, Environmental Pollution and Economic Growth

For empirical investigation, our estimable model comprises health expenditure ($he$)as model dependent variables, (plausibly) driven by environmental pollution ($CO2\ emission$) , energy intensity levels ($ei$) , and the rate of economic growth ($gdppc$) for my sample set of countries. The generalized form of the proposed relationship can therefore be stated as:

$$he = f(Co_2, ei, gdppc) \qquad (1)$$

And the econometric specification of equation (1) is:

$$he_t = \alpha + \beta_i X_t + \varepsilon_t \qquad (2)$$

Where, $t$ is time-series subscript and $t$ ranges from year 2000 to 2021, $X$ is Vector of model regressors and includes $Co_2, ei$ and gdppc and $\varepsilon_t$ is Error terms. Equation 2 is the starting point for investigating.$Co_2, ei$ and *gdppc* are serving as possible long-run determinants of $he$. For the purpose of establishing long-run cointegrating relationship between health expenditure against proposed set of model regressors, two distinct co-integration procedures are applied. These include single-equation residual- based co-integration test of Pedroni and the maximum-likelihood-based multivariate co-integration of Johansen-Fisher.The significance of utilizing two individual and distinctively different co integration estimators lies with their individual ability of recognizing the existence (inexistence) of valid Cointegration vector(s) in their own specific manner. Relative departures from the long-run connection between model variables determine how the Pedroni co-integration test behaves. The Johansen-Fisher panel co-integration estimator, on the other hand, uses maximum likelihood methods to determine the real (valid) number of co integrating vectors present in an equation system. Using the test, one may identify circumstances where more than one variable must change in order to restore long-run equilibrium. As a result, the condition of weak erogeneity is not forced.

## 4. Results and Discussion

Before performing the formal co-integration testing procedures, it is mandatory to confirm the order of integration of model's variables. Both the Pedroni and Fisher-Johansen Combined co-integration estimators necessitate the model participant series to be integrated of order one. Therefore, to ascertain the sequence of integration of our participant series, we use the unit root tests developed by Levin and Lin (1993) and Levin, Lin, and Chu (2002) (LLC afterwards). In contrast to conducting a separate unit root test for each unique entity, this technique imposes a cross-equation constraint on the first-order partial autocorrelation coefficients under the null.

**Table 1: Common Roots: Levin, Lin, Chu – Panel Unit Root Test**

| Variable | Deterministic Regressors | Sample Statistics | Deterministic Regressors | Sample Statistics | Decision |
|---|---|---|---|---|---|
| **Low-Income** | | | | | |
| | **At Level** | | **At First-Difference** | | |
| he | Intercept | -1.08 | Intercept | -14.67* | I(1) |
| $Co_2$ | Intercept | 1.64 | Intercept | -8.876* | I(1) |
| gdppc | Intercept | -0.46 | Intercept | -12.86* | I(1) |
| ei | Intercept | 3.18 | Intercept | -5.858* | I(1) |
| **Middle-Income** | | | | | |
| | **At Level** | | **At First Difference** | | |
| he | Intercept | -0.465 | Intercept | -12.34* | I(1) |
| $Co_2$ | Intercept | 5.725 | Intercept | -7.494* | I(1) |
| gdppc | Intercept | -0.293 | Intercept | -8.215* | I(1) |
| **Upper Middle-Income** | | | | | |
| | **At Level** | | **At First Difference** | | |
| he | Intercept | -0.633 | Intercept | -7.367* | I(1) |
| $Co_2$ | Intercept | 6.447 | Intercept | -2.737* | I(1) |
| gdppc | Intercept | 4.121 | Intercept | -16.18* | I(1) |
| ei | Intercept | 5.874 | Intercept | -3.240* | I(1) |
| **High-Income** | | | | | |
| | **At Level** | | **At First Difference** | | |
| he | Intercept | 5.542 | Intercept | -6.969* | I(1) |
| $Co_2$ | Intercept | 5.663 | Intercept | -10.67* | I(1) |
| gdppc | Intercept | 6.673 | Intercept | -14.66* | I(1) |
| ei | Intercept | 3.252 | Intercept | -9.933* | I(1) |

Note: * indicates statistical significance at 1% level

The panel unit root testing results are reported in table 1. It is obvious that all panel model series do not hold the time trend, thus, accordingly, our unit root regression equations comprise an intercept only as the deterministic regressors. In the view of given results, we tend to accept the null hypothesis of unit root for all variables and for all country groups. The variables used in the study i.e. Health Expenditure, Co2 Emission, GDP Per Capita and Energy Intensity are integrated of order one, such results indicate the fact that the subject variables are eligible to be modelled for co-integration testing.

Table 2 contains results of the Pedroni residual-based co-integration test for all panels. The Schwarz Information Criterion performs automated lag selection based on the test data received from the Pedroni co-integration test. The SIC recommended the addition of one lag for all income categories. According to Pedroni co-integration test, evidence is in support of co-integration between model variables. The obtained results are concluding as supporting the existence of valid co-integration between health expenditure, environmental quality and energy intensity against the cross-sectional data set.

**Table 2: Pedroni Panel Co-integration Test**

| Common AR Coefficients (Within Dimension) | | | | | Individual AR Coefficients (Between Dimension) | | | |
|---|---|---|---|---|---|---|---|---|
| Group of Countries | Panel v Statistics | Panel ρ Statistics | Panel PP Statistics | Panel ADF Statistics | Group ρ Statistics | Group PP Statistics | Group ADF Statistics | Does Co-integration Hold? |
| Low-income | -0.54 | 1.33 | -3.48*** | -3.42*** | 2.82 | -8.00*** | -5.02*** | Yes |
| Lower Middle-income | 0.78 | 0.47 | -3.49*** | -4.12*** | 1.12 | -6.69*** | -6.06*** | Yes |
| Upper Middle-income | 1.66** | 2.55 | -1.03 | -2.62*** | 4.19 | -1.51* | -3.09*** | Yes |
| High-income | 1.79** | 2.94 | -2.01*** | -4.54*** | 5.19 | -4.48*** | -6.05*** | Yes |

Note: * indicates statistical significance at 10% level, ** indicates statistical significance at 5% level and *** indicates statistical significance at 1% level.

**Table 3: Johansen-Fisher Panel Co-integration Test Result**

| Group of Countries | Fisher Stat (From Trace Stat) | Fisher Stat (From Max-Eigen Stat) | Does Valid Co-integration Hold? |
|---|---|---|---|
| **Low Income Countries** | | | |
| **Case 3:** Intercept (no trend) in co-integrating equation and VAR | | | |
| **Low Income** | 3 | 1*** | Inconclusive |
| **Case 4:** Intercept and trend in co-integrating equation-no trend in VAR | | | |
| **Low Income** | 2*** | 2*** | Yes |
| **Lower Middle Income Countries** | | | |
| **Case 3:** Intercept (no trend) in co-integrating equation and VAR | | | |
| **Lower Middle Income** | 2 | 2 | No |
| **Case 4:** Intercept and trend in co-integrating equation-no trend in VAR | | | |
| **Lower Middle Income** | 2 | 0 | No |
| **Upper Middle Income Countries** | | | |
| **Case 3:** Intercept (no trend) in co-integrating equation and VAR | | | |
| **Upper Middle income** | 2** | 1*** | Yes |
| **Case 4:** Intercept and trend in co-integrating equation-no trend in VAR | | | |
| **Upper Middle income** | 3 | 3 | No |
| **High Income Countries** | | | |
| **Case 3:** Intercept (no trend) in co-integrating equation and VAR | | | |
| **High Income** | 3 | 3 | No |
| **Case 4:** Intercept and trend in co-integrating equation-no trend in VAR | | | |
| **High Income** | 2*** | 2*** | Yes |

Note: ***, ** and * are representing significance of sample statistics at 1%, 5% and 10% levels respectively.

The Johansen-Fisher Panel co-integration test is also applied for checking Cointegration among the variables used in the model and their results are reported in table 3 which are similar to the ones obtained through Pedroni residual based co-integration test. The results are having mixed evidence of co-integration when the model is tested against two different test specifications.

The calculation of long-run coefficients (elasticities) of model regressors is necessary where is calculated by Panel Fully Modified OLS (PFMOLS) co-integration regression and their results are reported in table 4. The asymptotically unbiased estimators are effective enough to handle significant variability among the panel's individual members. Firstly, in the case of high- and upper middle income countries, the test shows that carbon dioxide emissions have a significant contribution to explain the trend deviations in health expenditure from its long-run equilibrium. The coefficient has positive value, 1.14 and 0.05 respectively, (for upper middle income and High-income (HI) groups) and a statistical significance is better than 10 percent, which means that a unit increase in CO2 emission may lead to 11 and 5 percent increase in health expenditures, respectively in upper middle and High-income (HI) countries.

Secondly, energy intensity (*ei*) is the most important long-run determinant of health expenditure. For Upper-middle-income (UMI) and High-income (HI) groups, energy intensity is statistically significant at one percent or better level of statistical significance. The coefficient has negative value indicating the fact that, in the long-run greater use of energy intensity can contribute positively to reducing the increasing level of spending on health. In addition, due to changes in structural and technological changes energy intensity reduces over a while which may reduce the level of CO2 emissions and health expenditures. However, the situation of low-income (LI) group is quite different. The long-run coefficient value of energy intensity is 0.08, with a statistical significance of better than one percent, indicates that a unit increase in energy intensity can lead to 8 percent increase in health expenditures.

Finally, *gdppc* have a positive and statistically significant impact on health expenditure from its long-run equilibrium. For all income groups, the series is statistically significant at better than one percent level except in the case of Upper-middle-income (UMI) countries where the series is not statically significant. However, in the case of low-income (LI)- and Lower-middle-income (LMI) countries, the CO2 emission have a statistically insignificant negative impact on health expenditures from its long-run equilibrium.

**Table 4: Estimating Long-Run Coefficients through Panel FMOLS**

| Income Group | Long-run Coefficient | | |
|---|---|---|---|
| | *CO2* | *gdppc* | *ei* |
| **Low-income** | -1.87 | 2.80*** | 0.08*** |
| | (2.06) | (1.04) | (0.03) |
| | [-0.90] | [2.68] | [2.79] |
| **Lower Middle-income** | -0.04 | 1.17*** | - |
| | (0.12) | (0.38) | |
| | [-0.33] | [3.03] | |
| **Upper Middle-income** | 1.14* | 0.00 | -0.20* |
| | (0.69) | (0.00) | (0.11) |
| | [1.65] | [1.53] | [-1.74] |
| **High-income** | 0.05*** | 0.00*** | -0.22*** |
| | (0.02) | (0.00) | (0.04) |
| | [2.64] | [3.52] | [-5.16] |

Note: ***, ** and * are representing significance of sample statistics at 1%, 5% and 10% levels respectively.

## 5. Conclusion and Policy Implications

The primary objective of producing this study is to explore the explanatory power of two (plausible) long-run determinants of health expenditures i.e. CO2-related environmental pollution and energy intensity. This paper entails a detailed research around two inter-related aspects of our research problem (a) does environmental pollution significantly affect the health care expenditures in long-run, and (b) can optimal levels of energy intensity mitigate the effects of environmental pollution on health care expenditures. In the hope of obtaining some meaningful relationship between our subject variables, the paper studies a panel of 108 countries, and the sample is disaggregated into four different income groups to determine the cross-regional dynamic effect of environmental pollution on health care expenditures.

To confirm the relationship between health expenditures and its long-run key determinants, different modern econometric methods are employed. For the sake of establishing long-run relationship, Pedroni co-integration and Fisher- Johansen Combined Panel co-integration tests are used. To check the reliability of obtained results, alternative models of panel co-integration are applied for consistency and robustness checking of model estimates. In general, we tend to accept the proposed relationship between health care expenditure, environmental quality and energy intensity. Valid statistical evidence is found in favor of proposed relationship between CO2-related emissions and the consequent rise in health spending. The main findings of our research support the notion, rendering environmental pollution as a credible determinant of health expenditure in long-run. This is particularly true for two country groups of Upper-middle-income (UMI) and High-income (HI) countries yielded through panel FMOLS estimator.

In the case of high and upper middle income countries, the test shows that carbon dioxide emissions extend a significant contribution to the trend deviations in health expenditures from its long-run equilibrium. The coefficient has positive value, 1.14 and 0.05 respectively, (for upper middle income and High-income (HI) groups) and a statistical significance is better than 10 percent, which means that a unit increase in CO2 emission may lead to 11 and 5 percent increase in health expenditures, respectively in upper middle and High-income (HI) countries. However, in the case of low-income (LI)- and Lower-middle-income (MI) countries, the CO2 emission have a statistically insignificant negative impact on health expenditures from its long-run equilibrium. Secondly, energy intensity is the most important long-run determinant of health expenditure. For upper middle and High-income (HI) groups, energy intensity is statistically significant at one percent or better level of statistical significance. The coefficient has negative value indicating the fact that in the long-run the greater use of energy intensity can contribute positively to reducing the increasing level of spending on health. However, the situation of low-income (LI) group is quite different. The long-run coefficient value of energy intensity is 0.08, with a statistical significance of better than one percent, thus, indicating that a unit increase in energy intensity can lead to 8 percent increase in health expenditures. Based on the results of our dissertation, following policy recommendations are made:

- At first, policy makers should use green technologies that helps to control the CO2-related environmental pollution without effecting economic development. As an example, East Asian and South Asian nations must encourage companies to support green finance and low-carbon industrial innovations.
- In addition, government should charge carbon taxes on industries, transportation and fuel production up to efficient levels which may prove to be of much help in reducing the levels of environmental pollution and control the excessive use of fossil fuels. In, 1991 Norway and Finland were first ones to introduce a tax on carbon emissions.
- While formulating policies related to the energy intensity, it seems necessary that policy makers adopt the energy efficient measures (like non-fossil energy and renewable energy sources) to reduce the level of energy intensity as well as CO2-related emissions.
- In this respect, countries should invest towards the exploration of renewable energy sources and clean energy production technologies to decrease the level of environmental pollution which positively effect on human health. For example, UK implemented the clean power plan to reduce the level of CO2-related environmental pollution to improve the quality of energy efficiency.
- In addition, government should focus the low-carbon emission policies and energy-saving technologies to maintain the quality of environment that minimize the health spending.
- Over the past three decades, Sweden, France and Canada are the three major countries that have made the greatest effort to introduce the carbon tax to increase manufacturing efficiency and improved the quality of environment.

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