The Mediator Effect of GDP on the Relationship between Life Expectancy and Environment

Review of Integrative Business & Economics Research

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ABSTRACT

The research explored a mediator role of GDP on the relationship between life expectancy and environment based on data of twenty-three OECD countries for the period between 2004 and 2014. To provide empirical grounds for systematic research, the research employed two curve theories: Preston curve and environmental Kuznets curve. Then the research mapped out mediation model with four specific variables characterizing environment as predictor variables, life expectancy as an outcome variable, and GDP as a mediator variable. According to the findings, although the magnitudes of the effects which GDP mediates on relationships between each of four variables and life expectancy are different, it is clear that GDP mediates the relationships between life expectancy and each of the four specific variables. Given that the research exhibits a new approach to the study of the relationship between life expectancy and environment by setting up GDP as mediator, it is worthy of attention.

Keywords: life expectancy, environment, GDP, mediation.

Received 25 March 2019 | Revised 2 May 2019 | Accepted 31 May 2019.

1. INTRODUCTION

There has been a general recognition of the positive influence of economic growth on mortality rates (Acemoglu & Johnson, 2007; Banister & Zhang, 2005; Preston, 1975, 2007; Schnabel & Eilers, 2009). Preston (1975) examined the relationship between national income per head and life expectancy. He claimed that the rise in life expectancy is a response to the increase in national income per head (Preston, 1975, 2007). Preston curve illustrates that there is a significant relationship between economic growth and life expectancy (Banister & Zhang, 2005; Preston, 1975, 2007; Schnabel & Eilers, 2009). Economic growth has been related to general changes in society (Grossman & Krueger, 1995; Hagen, 1963; Kuznets, 1955; Lee & Kim, 2019; Panayotou, 1993). Grossman and Krueger (1991) studied how economic growth relates to environment. They claimed that economic growth involves pollution and exhaustion of natural resources but that the level of pollution would be lowered as old technologies causing pollution are replaced by new technologies that are less harmful to the environment (Bo, 2011; Grossman & Krueger, 1991, 1995; Panayotou, 1993). Starting from the concept of Preston curve, the research will explore environmental factor affecting life expectancy. The Preston curve shows that economic growth has a major influence on life expectancy (Banister & Zhang, 2005; Preston, 1975, 2007; Schnabel &

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Eilers, 2009). And given the environmental Kuznets curve, the economic growth has a significant relationship with environment (Beckerman, 1992; Bo, 2011; Grossman & Krueger, 1991, 1995; Panayotou, 1993; Suri & Chapman, 1998). It seems reasonable to assume that environment has a relationship with life expectancy via the mediating role of economic growth. With the mediating role of economic growth measured by GDP, the research proposes the relationship between the life expectancy and environment in accordance with the environmental Kuznets curve. For a better understanding, it is diagrammatized as Figure 1.

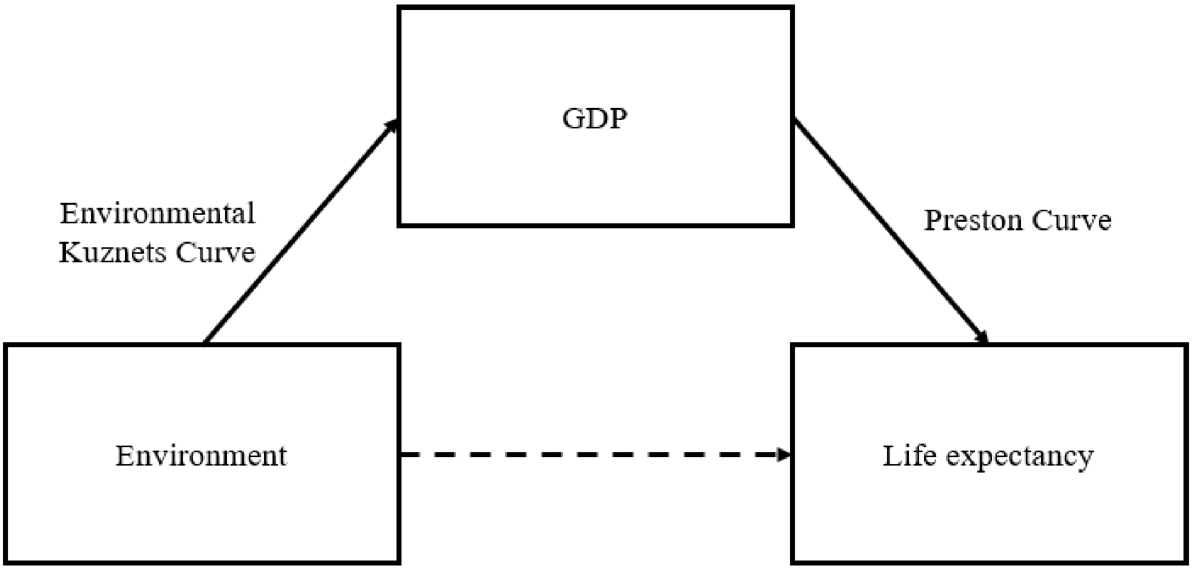

Figure 1. Proposed relationship based on the Preston curve and the environmental Kuznets curve.

While there has been a great deal of research on factors affecting life expectancy, the research on the mediating role of GDP on the relationships between life expectancy and the environmental factors remain under researched. The research outlines the structural connectivity mediated by GDP based on the two economic curve theories to impart a greater plausibility. This approach provides a new paradigm in understanding the effects of environment on life expectancy. Considering this fact, it is certainly worth inquiring.

2. LITERATURE REVIEW

To facilitate understanding of the research, it seems necessary to examine the two curve theories: Preston curve and environmental Kuznets curve. Thus, the research will firstly outline the background and nature of two economic curve theories and then attempt to examine the literature relating to the factors concerning the two theories.

2.1 Theoretical Background

2.1.1 Preston curve.

Preston (1975) examined the relationship between national income per head and life expectancy during the twentieth century. He supposed that income increase accessibility to various factors contributing to health (Preston, 1975, 2007). Considering the direct influence of income on health condition with increased affordability of services such as medical treatment, it is no less dubious to connect that income is one of strong indicator of life expectancy (Bloom & Canning, 2007). The Preston curve is a

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

cross-sectional relationship between life expectancy and national income for head (Preston, 1975, 2007). The x-axis is national income per head, and the y-axis is life expectancy at birth (Preston, 1975, 2007). The Preston curve shows a dramatic increase in the beginning. But the more income increase, the more the upward slope flattens out. The curvature of the Preston curve implies that in countries which show low levels of income, life expectancy is very sensitive to a change in income (Lutz & Kebede, 2018; Preston, 1975, 2007). But, it also means that life expectancy is less sensitive to a change in income in countries which show high levels of income (Lutz & Kebede, 2018; Preston, 1975, 2007).

2.1.2 Environmental Kuznets curve.

Grossman and Krueger (1991) mentioned the relationship between economic growth and pollution. In the early phase of economic growth, as the scope of economic activities expands, environmental degradation caused by severe depletion of natural sources occurs (Grossman & Krueger, 1991, 1995; Panayotou, 1993). But beyond a certain level of economic growth, as environmental regulations are introduced and implemented, the previous upward trend in environmental degradation turns downward (Grossman & Krueger, 1991, 1995; Panayotou, 1993). At the a low level of economic growth, economic structure is focused on agriculture and exploitation of minerals and other natural resources, and it accelerates environmental degradation (Grossman & Krueger, 1991, 1995; Magnani, 2000, Panayotou, 1993; Stern, 2004). But economic growth is gradually attenuating the effects of environmental degradation with the introduction of environmental policies (Grossman & Krueger, 1991, 1995; Panayotou, 1993; Stern, 2004). The environmental Kuznets curve illustrates the implication of economic growth as exemplified by income per capita on environment (Panayotou, 1993; Stern, 2014). The overall pattern of environmental Kuznets curve shows an inverted-U shape with income per capita graphed on the x-axis and environmental degradation graphed on the y-axis (Panayotou, 1993; Stern, 2014). According to the environmental Kuznets curve, as the income per capita increases, the environmental degradation shows a positive tendency to begin with but after the income per capita passes through a certain level, it shows a negative tendency (Panayotou, 1993; Stern, 2014).

2.2 Factors Related to Each of the Two Curves

2.2.1 Factors related to the Preston curve.

2.2.1.1 Income.

Economic growth leads to an increase in employment and the consequent increase in individual disposable income facilitates an access to timely healthcare and nutritious food (Bloom & Canning, 2000; Chetty et al., 2016; Kabir, 2008; Preston, 1975, 2007; Rogot, Sorlie, & Johnson, 1992; Wilkinson, 1997). Economic growth measured by GDP leads to a reduction in diseases affecting survival (Bulled & Sosis, 2010; Preston, 1975, 2007). GDP is closely linked with public health service (Baltagi & Moscone, 2010; Cervellati & Sunde, 2011; Lago-Peñas, Cantarero-Prieto, & Blázquez-Fernández, 2013; Preston, 1975, 2007). It signifies that high levels of economic growth facilitate investment in the public health and the consequent improvement in national health status brings an increase in life expectancy (Bulled & Sosis, 2010; Cervellati & Sunde, 2011; Lago-Peñas et al., 2013; Preston, 1975, 2007).

2.2.1.2 Health expenditure.

In order to keep the good health, it costs more for medical treatment and preventive treatment (Gundgaard, Nielsen, Olsen, & Sørensen, 2003; Wright &

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Weinstein, 1998). Expenditure on health means consumption of health goods and services to keep a good health. (Xu et al., 2003). Thus, health expenditure is intimately linked with income (Xu et al., 2003). A number of previous research studied about the relationship between health expenditure and economic growth which is measured by GDP (Bakare & Olubokun, 2011; Hitiris & Posnett, 1992; Lago-Peñas et al., 2013). It shows that health expenditure is positively associated with economic growth and that the movement of health expenditure is highly susceptible to economic factor (Bakare & Olubokun, 2011; Bloom, Canning, & Sevilla, 2004; Hitiris & Posnett, 1992; Huber, 1999; Lago-Peñas et al., 2013).

2.2.2 Factor related to the environmental Kuznets curve.

2.2.2.1 Environment.

Environmental pollution is mostly caused by numerous anthropogenic activities (Kampa & Castanas, 2008; Künzli et al., 2000; Pope III & Dockery, 2006). Pollution from various industrial facilities and other related activities has adversely affected human health (Dominici, McDermott, Zeger, & Samet, 2002; Gryparis et al., 2004; Kampa & Castanas, 2008; Künzli et al., 2000; Neuberger, Rabczenko, & Moshammer, 2007; Pope III & Dockery, 2006). Pollutants are substances which exerts an undesirable influence on human, animals, and nature (Dominici et al., 2002; Gryparis et al., 2004; Kampa & Castanas, 2008; Künzli et al., 2000; Neuberger et al., 2007; Pope III & Dockery, 2006). Thus, exposure to pollutants could damage health (Gryparis et al., 2004; Kampa & Castanas, 2008; Künzli et al., 2000; Neuberger et al., 2007; Pope III & Dockery, 2006). The effects of pollution on health range from physical illness such as breathing difficulties to fatal diseases (Gryparis et al., 2004; Kampa & Castanas, 2008; Künzli et al., 2000; Neuberger et al., 2007; Pope III & Dockery, 2006).

3. DATA DESCRIPTION AND METHODOLOGY

3.1 Data Description

The research will draw on statistical data of twenty-three OECD countries collected from the World Bank databank and observe a relationship between life expectancy and environment. Twenty-three OECD countries selected for the research are Republic of Austria, Kingdom of Belgium, Czech Republic, Kingdom of Denmark, Republic of Estonia, Republic of Finland, French Republic, Hellenic Republic, Hungary, Republic of Iceland, Ireland, Republic of Latvia, Republic of Lithuania, Grand Duchy of Luxembourg, Kingdom of the Netherlands, Kingdom of Norway, Portuguese Republic, Slovak Republic, Republic of Slovenia, Kingdom of Spain, Kingdom of Sweden, Republic of Turkey, and United Kingdom of Great Britain and Northern Ireland. A period for data analysis is set between 2004 and 2014 because data for the period are mostly available, and data for a period since 2014 are including missing observations. The research will employ the specific variables for analysis. Three specific variables for the Preston curve are life expectancy at birth, total (years), GDP per capita, PPP (current international dollar), and current health expenditure per capita, PPP (current international dollar). Four specific variables for the environmental Kuznets curve are CO2 emissions (metric tons per capita), electricity production from nuclear sources (percentage of total), electricity production from natural gas sources (percentage of total), and electricity production from hydroelectric sources (percentage of total). The following descriptions of each specific variable rely on definitions of World Bank databank.

3.1.1 Specific variables related to the Preston curve.

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3.1.1.1 Life expectancy at birth, total (years).

Life expectancy at birth refers to the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. It reflects the overall mortality level of a population, and summarizes the mortality pattern that prevails across all age groups in a given year. In the process of analysis, the term *le* will stand for life expectancy at birth, total (years).

3.1.1.2 GDP per capita, PPP (current international dollar).

GDP per capita, PPP is gross domestic product per person converted to international dollars using purchasing power parity rates. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. In the process of analysis, the term *GDP* will stand for GDP per capita, PPP (current international dollar).

3.1.1.3 Current health expenditure per capita, PPP (current international dollar).

Current health expenditure per capita, PPP (current international dollar) refers to current expenditures on health per capita expressed in international dollars at purchasing power parity (PPP). Data for health expenditure used in the research refer to the sum of public and private health expenditures. In the process of analysis, the term *he* will stand for current health expenditure per capita, PPP (current international dollar).

3.1.2 Specific variables related to the environmental Kuznets curve.

3.1.2.1 CO2 emissions (metric tons per capita).

Carbon dioxide emissions, largely by-products of energy production and use, account for the largest share of greenhouse gases, which are associated with global warming (Aycaguer, Lev-On, & Winer, 2001; Glaeser & Kahn, 2010; Marland & Rotty, 1984; Wilkinson et al., 2009). Data for carbon dioxide emissions include gases from the burning of fossil fuels and cement manufacture, and also include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. But it excludes emissions from land use such as deforestation. In the process of analysis, the term *CO2* will stand for CO2 emissions (metric tons per capita).

3.1.2.2 Electricity production from nuclear sources (percentage of total).

Electricity production from nuclear sources (percentage of total) is the share of electricity produced by nuclear power plants in total electricity production which is the total number of gigawatt hours generated by power plants separated into electricity plants and combined heat and power plants. In comparison with other sources used in producing electricity, the amount of greenhouse gas emissions from nuclear power are much smaller than those related to coal, oil, and gas (Bickerstaff, Lorenzoni, Pidgeon, Poortinga, & Simmons, 2008; Rashad & Hammad, 2000). But a major environmental concern over nuclear power is the creation of radioactive waste (Palfrey, 1974; Slovic, Layman, & Flynn, 1991). Any mishandling of the processes can impact the environment and pose health risks to human body (Palfrey, 1974; Tsuda, Tokinobu, Yamamoto, & Suzuki, 2016). And the cooling system used in keeping nuclear power plant from overheating afflicts aquatic plants and animals living in the environs of nuclear power plant (Reutter & Herdendorf, 1976). In the process of analysis, the term *nuclear* will stand for electricity production from nuclear sources (percentage of total).

3.1.2.3 Electricity production from natural gas sources (percentage of total).

Electricity production from natural gas sources (percentage of total) is the share of natural gas, which is natural gas but not natural gas liquids, in total electricity

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production which is the total number of gigawatt hours generated by power plants separated into electricity plants and combined heat and power plants. Natural gas is considered as a good source of electricity supply for a number of economic, operational and environmental reasons: It is technically and financially of low-risk; lower carbon relative to other fossil fuels; gas plants can be built relatively quickly in around two years, unlike nuclear facilities, which can take much longer (Pascoli, Femia, & Luzzati, 2001). But recent research papers show that natural gas itself has its own serious environmental hazards (Colborn, Kwiatkowski, Schultz, & Bachran, 2011; Rashad & Hammad, 2000; Werner, Vink, Watt, & Jagals, 2015). Methane gas which is the second-most prevalent greenhouse gas is generated from the drilling and extraction of natural gas (Werner et al., 2015). And the drilling also produces hazardous air pollutants such as particulate matter, which cause adverse health outcomes (Colborn et al., 2011; Werner et al., 2015). In the process of analysis, the term *natural_gas* will stand for electricity production from natural gas sources (percentage of total).

3.1.2.4 Electricity production from hydroelectric sources (percentage of total).

Electrical energy from hydropower is derived from turbines being driven by flowing water in rivers, with or without man-made dams forming reservoirs. Since global warming is becoming a serious issue, hydroelectric energy is counted as green energy sources due to its characteristics: renewable and mostly nonpolluting (Kaygusuz, 2001, 2002). But hydroelectric power has some significant disadvantages (Balzannikov & Vyshkin, 2011; Rashad & Hammad, 2000). Hydroelectric power leads to changes in reservoir and stream water quality (Balzannikov & Vyshkin, 2011). And a process of operating hydroelectric power plant alters temperature and flow of water (Balzannikov & Vyshkin, 2011; Rashad & Hammad, 2000; Zhong & Power, 1996). It harms plants and animals in the river and on land (Balzannikov & Vyshkin, 2011; Biswas, 1982; Zhong & Power, 1996). In the process of analysis, the term *hydro* will stand for electricity production from hydroelectric sources (percentage of total).

3.2 Mediation Model

Mediator is an intervening variable which acts on a causal relationship between predictor and outcome (Baron & Kenny, 1986; Fitrianto & Midi, 2013; Gunzler, Chen, Wu, & Zhang, 2013). Mediation model is to evaluate causality and directionality in the relationship between predictor and outcome by testing for the existence of mediator variable (Baron & Kenny, 1986; Breitborde, Srihari, Pollard, Addington, & Woods, 2010; Gunzler et al., 2013; Judd & Kenny, 1981; Li, 2011; Rijnhart, Twisk, Chinapaw, de Boer, & Heymans, 2017).

There are a series of regression equations to estimate mediation model (Baron & Kenny, 1986; Fitrianto & Midi, 2013; Rijnhart et al., 2017).

$$Y = i_1 + cX + e_1 \tag{1}$$

$$M = i_2 + aX + e_2 \tag{2}$$

$$Y = i_3 + c'X + bM + e_3 \tag{3}$$

Where Y is the outcome variable as the dependent variable, X is the predictor variable as the independent variable, and M is the mediator (Fitrianto & Midi, 2013). The coefficient c denotes the overall effect of the predictor variable X on the outcome variable Y in equation (1). The coefficient a denotes the effect of the predictor variable X on the mediator variable M in equation (2). The coefficient c' denotes the direct effect of the predictor variable X on the outcome variable Y, and the coefficient b denotes the effect of the mediator variable M on the outcome variable Y in equation (3). According to Baron and Kenny (1986), the following conditions should be

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met in order to build a causal relationship with mediator: First, the predictor variable X with the coefficient c should show statistical significance in equation (1); second, the predictor variable X with the coefficient a should show statistical significance in equation (2); third, in equation (3), if the predictor variable X with the coefficient c' does not show statistical significance and the mediator variable M with the coefficient b shows statistical significance and the value of the coefficient c' is close to 0, then the findings support full mediation model; fourth, in equation (3), if both the predictor variable X with the coefficient c' and the mediator variable M with the coefficient b show statistical significance and the absolute value of the coefficient c' is less than the absolute value of the coefficient c, then the findings support partial mediation model. According to Rijnhart, Twisk, Chinapaw, de Boer, and Heymans (2017), the indirect effect can be computed by the product of the coefficients a and b or the difference between the coefficients c and c' based on the coefficients of the three equations. And the proportion mediated can be computed by either $ab/(ab + c')$, ab/c, or $1 - (c'/c)$ (Baron & Kenny, 1986; Fitrianto & Midi, 2013; Freedman, Graubard, & Schatzkin, 1992; MacKinnon, Lockwood, Brown, Wang, & Hoffman, 2007; MacKinnon, Warsi, & Dwyer, 1995; Rijnhart et al., 2017).

3.2.1 Mediation model for the relationship between life expectancy and environment with a mediator variable of GDP.

What follows is mediation analysis that examines the relationship between life expectancy and environment with a mediator variable of GDP. Four specific variables representing environment are CO2 emissions (metric tons per capita), electricity production from nuclear sources (percentage of total), electricity production from natural gas sources (percentage of total), and electricity production from hydroelectric sources (percentage of total). The mediation model is built with the four specific variables as predictor variables, GDP as a mediator variable, and life expectancy as an outcome variable, as illustrated in Figure 2.

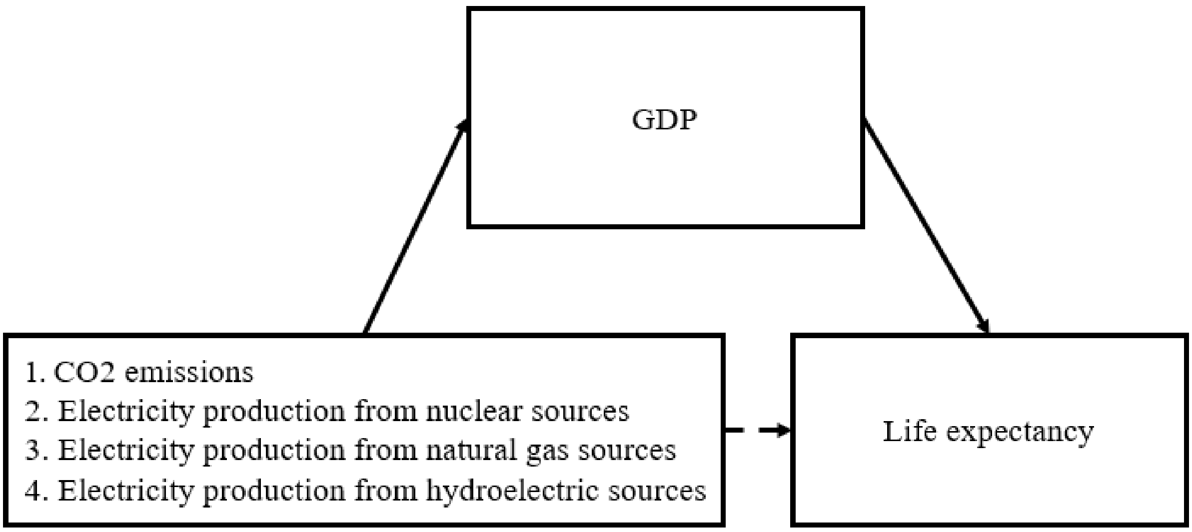

Figure 2. Proposed mediation model of the relationship between life expectancy and the specific variables representing environment.

Based on the foregoing regression approach, the mediating role of GDP on the effect of the four specific variables on life expectancy is examined as follows:

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$$le_{it} = \beta_{1,0} + \beta_{1,1}CO2_{it} + \beta_{1,2}nuclear_{it} + \beta_{1,3}natural\_gas_{it} + \beta_{1,4}hydro_{it} + \varepsilon_{1,it} \quad (4)$$

$$GDP_{it} = \beta_{2,0} + \beta_{2,1}CO2_{it} + \beta_{2,2}nuclear_{it} + \beta_{2,3}natural\_gas_{it} + \beta_{2,4}hydro_{it} + \varepsilon_{2,it} \quad (5)$$

$$le_{it} = \beta_{3,0} + \beta_{3,1}CO2_{it} + \beta_{3,2}nuclear_{it} + \beta_{3,3}natural\_gas_{it} + \beta_{3,4}hydro_{it} + \beta_{3,5}GDP_{it} + \varepsilon_{3,it} \quad (6)$$

4. EMPIRICAL RESULTS

4.1. Mediation Analysis

To figure out the relationship between environment and life expectancy, being mediated by GDP, Mediation model is composed of four variables specified for environment as predictor variables, GDP as a mediator variable, and life expectancy as an outcome variable. The estimated regression equation for the overall effect of four predictor variables specified for environment on life expectancy is formed as follows:

$$le_{it} = 86.8218 + (-0.5244)CO2_{it} + (-0.0665)nuclear_{it} + (-0.0578)natural_{gas_{it}} + (-0.0622)hydro_{it} + \varepsilon_{1,it} \quad (7)$$

The overall effect denotes the relationship between four predictor variables specified for environment and life expectancy with no consideration for the mediator variable of GDP.

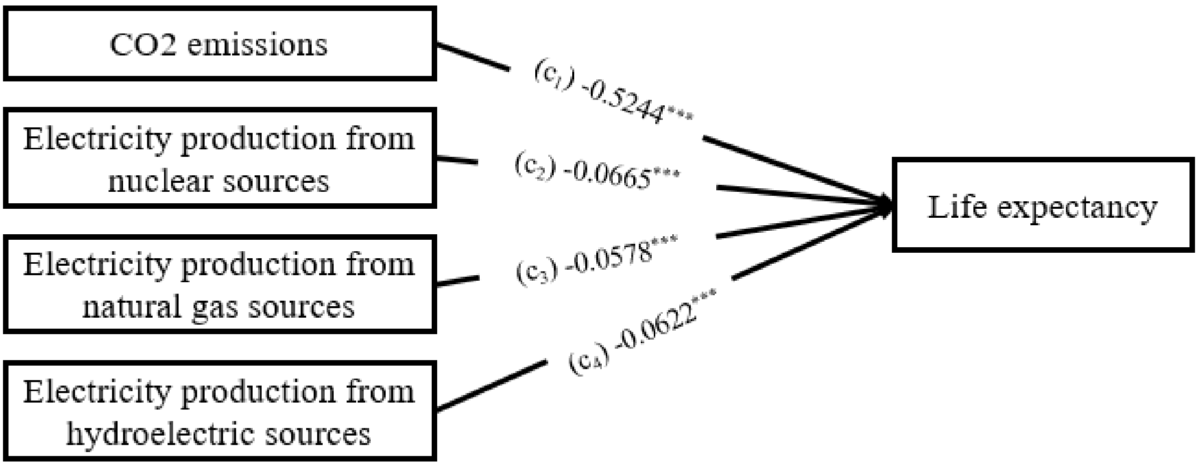

Figure 3. The overall effect of four variables specified for environment on life expectancy.

* indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level, respectively. *n.s.* corresponds to not significant.

Figure 3 shows that *le* is accounted for by each of *CO2*, *nuclear*, *natural_gas* and *hydro*. The overall effects of the respective variables on *le* are quantified by the coefficient corresponding to each variable: -0.5244 (t = -9.0748, $p < 0.0000$), -0.0665 (t = -5.6688, $p < 0.0000$), -0.0578 (t = -3.6980, p = 0.0003), and -0.0622 (t = -3.2297, p = 0.0014) in the order of *CO2*, *nuclear*, *natural_gas* and *hydro*. Other two regression equations in the mediation model are used to illuminate the direct and indirect effects of four predictor variables on life expectancy.

$$GDP_{it} = 73141.6296 + (-2149.2868)CO2_{it} + (-313.2324)nuclear_{it} + (-293.9740)natural_{gas_{it}} + (-351.7983)hydro_{it} + \varepsilon_{2,it} \quad (8)$$

In equation (8) where *GDP* is the outcome variable, each of -2149.2868 (t = -

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8.2642, $p < 0.0000$), -313.2324 ($t = -5.9281$, $p < 0.0000$), -293.9740 ($t = -4.1770$, $p < 0.0000$), and -351.7983 ($t = -4.0571$, $p = 0.0001$) shows the effect of each predictor variable corresponding to each coefficient on *GDP*.

$$le_{it} = 76.7478 + (-0.2283)CO2_{it} + (-0.0234)nuclear_{it} + (-0.0173)natural_{gas_{it}} + (-0.0138)hydro_{it} + 0.0001GDP_{it} + \varepsilon_{3,it} \quad (9)$$

In equation (9), each estimate of four predictor variables signifies the effect of the corresponding predictor variable on life expectancy while three other predictor variables and a mediator variable are held constant. Each direct effect of the four predictor variables on the outcome variable of *le* is quantified by the corresponding coefficient. The direct effects of *CO2*, *nuclear*, *natural_gas* and *hydro* on *le* are -0.2283 ($t = -4.4034$, $p < 0.0000$), -0.0234 ($t = -2.3586$, $p = 0.0192$), -0.0173 ($t = -1.3583$, $p = 0.1757$), and -0.0138 ($t = -0.8774$, $p = 0.3812$) respectively. 0.0001 ($t = 11.8505$, $p < 0.0000$) is the regression coefficient relating *GDP* to *le*, which is adjusted for each effect of the four predictor variables on the mediator variable of *GDP*.

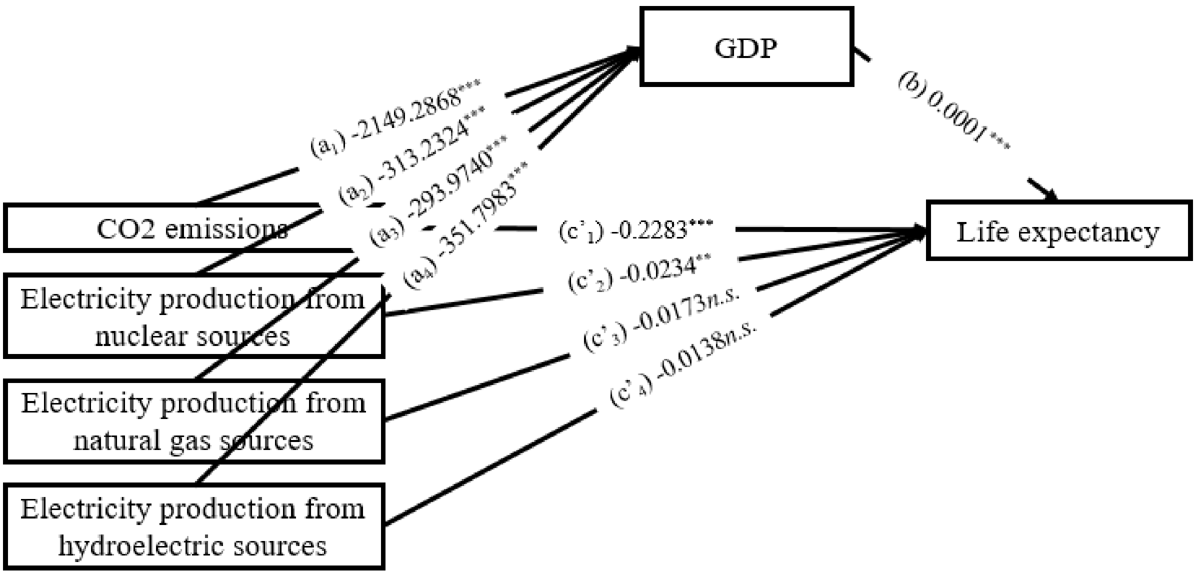

Figure 4. The direct and indirect effects of four variables specified for environment on life expectancy.

* indicates significance at the 10% level, ** at the 5% level, and *** at the 1% level, respectively. *n.s.* corresponds to not significant.

Figure 4 presents the mediation effects in a path diagram. On the outcome variable of *le*, the indirect effects of *CO2*, *nuclear*, *natural_gas* and *hydro* are quantified as each of $a_1 \cdot b$, $a_2 \cdot b$, $a_3 \cdot b$, and $a_4 \cdot b$ and the direct effects of those variables are quantified as each of c'_1, c'_2, c'_3, and c'_4. The indirect effect can be computed by using the form of $a_i \cdot b_i$. Based on the computation, each indirect effect of *CO2*, *nuclear*, *natural_gas* and *hydro* on *le* is -0.2960, -0.0431, -0.0405, and -0.0485. In Figure 4, the effect (b) of GDP on life expectancy indicates statistical significance. Based on the premise that b is significant, each significance level of c'_1, c'_2, c'_3, and c'_4 provide bases as to whether relationships between *le* and each of *CO2*, *nuclear*, *natural_gas* and *hydro* are fully or partially mediated by *GDP*. The coefficients of c'_1 and c'_2 are statistically significant, and then each absolute value of c'_1 and c'_2 is less

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

than each absolute value of c_1 and c_2. It indicates that each effect of CO2 emissions and electricity production from nuclear sources on life expectancy is partially mediated by GDP. By contrast, the coefficients of c'_3, and c'_4 are not significant, and it corroborates that the relationships between each of electricity production from natural gas sources and electricity production from hydroelectric sources and life expectancy are fully mediated by GDP. And with respect to each of four relationships mediated by GDP, the proportions mediated can be computed as follows: CO2 emissions is 56% (0.5645); electricity production from nuclear sources is 65% (0.6483); electricity production from natural gas sources is 70% (0.7002); electricity production from hydroelectric sources is 78% (0.7787). Considered in this findings, it is obvious that GDP mediates the relationship between life expectancy and four variables characterizing environment. Given this interpretation, it highly probable that the relationship between environment and life expectancy is mediated by GDP.

5. DISCUSSION

Up to now the research has looked at the relationship between life expectancy and environment, being mediated by GDP. As seen in the mediation analysis, the main purpose of the research has been to explore the mediator role of GDP on the relationship between life expectancy and environment. The approach is to look at the structural regression model, where the relative magnitude and the significance level of each coefficient measure the effect of mediator variable on the relationship between predictor variable and outcome variable. The research employed two curve theories−Preston curve and environmental Kuznets curve−to provide empirical grounds for systematic research concept. And the connection of which GDP is a nexus was found between life expectancy and environment. Before delving into the mediation model with a mediator of GDP, four specific variables representing environment were chosen for analysis. The specific variables are CO2 emissions (metric tons per capita), electricity production from nuclear sources (percentage of total), electricity production from natural gas sources (percentage of total), and electricity production from hydroelectric sources (percentage of total). Then to ferret out mediator effect of GDP between life expectancy and environment, the research set up the mediation model with four specific variables characterizing environment as predictor variables, life expectancy as an outcome variable, and GDP as a mediator variable. According to the findings inferred from the significance level of each coefficient, the relationships between life expectancy and each of electricity production from natural gas sources and electricity production from hydroelectric sources are fully mediated by GDP. By contrast, the relationships between life expectancy and each of CO2 emissions and electricity production from nuclear sources are partially mediated by GDP. Partial mediation is more commonplace than full mediation (Preacher & Kelley, 2011). Namely, it identifies the probability which there would be additional mediators (Preacher & Kelley, 2011). By the same token, full mediation means that there is no possibility for another mediator (Preacher & Kelley, 2011). In this regard, the research provides a stepping stone for the possible existence of further mediator besides GDP. Furthermore, as an outcome, the mediation analysis offers the direct effect and indirect effect of each of four specific variables on life expectancy. But the indirect effect merely indicates the original scale in mediation analysis (Mackinnon & Dwyer, 1993; Preacher & Kelley, 2011). Thus the proportions mediated were computed to measure relative magnitude of mediation effect (Mackinnon & Dwyer, 1993; Sobel, 1982). With respect to each relationship between each of four

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specific variables and life expectancy, the proportions mediated by GDP are as follows: CO2 emissions is 56% (0.5645); electricity production from nuclear sources is 65% (0.6483); electricity production from natural gas sources is 70% (0.7002); electricity production from hydroelectric sources is 78% (0.7787). In the case of electricity production from natural gas sources and electricity production from hydroelectric sources, although the findings from the significance level of each coefficient suggest that there is full mediation between life expectancy and each of them, the findings from computation of proportion mediated show that there is the probability of the direct effect in the relationships: electricity production from natural gas sources is 30% (0.2998); electricity production from hydroelectric sources is 22% (0.2213) (Preacher & Kelley, 2011). Taking into account its findings, it shows that although the words full and partial connote a fundamental concept of the proportion, they are not the unit measured on numerical scale (Preacher & Kelley, 2011). Thus it should be viewed with reservation that the dichotomous terms are a lack of objectivity (Preacher & Kelley, 2011). However, it goes with saying that the terms provide a basis of judging the relative magnitude of the mediation effect on each relationship. More specifically, the findings substantiate the advisability of the assumption. When it comes to the proportion mediated by GDP on the relationship with life expectancy, each of electricity production from natural gas sources and electricity production from hydroelectric sources show higher numerical values than CO2 emissions and electricity production from nuclear sources. From the above, it is apparent that GDP mediates the relationships between life expectancy and each of four variables characterizing environment. It can be interpreted that the relationship between environment and life expectancy is mediated by GDP. This research sheds new light on the role of GDP in the relationship between life expectancy and environment. Quite a number of research papers are dedicated to the relationship between life expectancy and environment (Dominici et al., 2002; Gryparis et al., 2004; Kampa & Castanas, 2008; Künzli et al., 2000; Neuberger et al., 2007; Pope III & Dockery, 2006). Given that this research exhibits a new approach to the study of the relationship between life expectancy and environment by setting up GDP as mediator, it is certainly worthy of attention. Although the present research offered an initial contribution to the literature concerning the relationship between life expectancy and environment, more research is needed. Clearly, more research is needed to illuminate the diversity of mediator in the relationship between life expectancy and environment.

REFERENCES

[1] Acemoglu, D., & Johnson, S. (2007), "Disease and Development: The Effect of Life Expectancy on Economic Growth", *Journal of Political Economy*, 115(6), 925-985.

[2] Aycaguer, A.-C., Lev-On, M., & Winer, A. M. (2001), "Reducing Carbon Dioxide Emissions with Enhanced Oil Recovery Projects: A Life Cycle Assessment Approach", *Energy & Fuels*, 15(2), 303-308.

[3] Bakare, A. S., & Olubokun, S. (2011), "Health care expenditure and economic growth in Nigeria: An empirical study", *Journal of Emerging Trends in Economics and Management Sciences (JETEMS)*, 2(2), 83-87.

[4] Baltagi, B. H., & Moscone, F. (2010), "Health care expenditure and income in the OECD reconsidered: Evidence from panel data", *Economic Modelling*, 27(4), 804-811.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[5] Balzannikov, M. I., & Vyshkin, E. G. (2011), "Hydroelectric power plants reservoirs and their impact on the environment", *Environment. Technology. Resources. Proceedings of the 8th International Scientific and Practical Conference, Latvia*, 1, 171-174.
[6] Banister, J., & Zhang, X. (2005), "China, Economic Development and Mortality Decline", *World Development*, 33(1), 21-41.
[7] Baron, R. M., & Kenny, D. A. (1986), "The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations", *Journal of Personality and Social Psychology*, 51(6), 1173-1182.
[8] Beckerman, W. (1992), "Economic growth and the environment: Whose growth? Whose environment?", *World Development*, 20(4), 481-496.
[9] Bickerstaff, K., Lorenzoni, I., Pidgeon, N. F., Poortinga, W., & Simmons, P. (2008), "Reframing nuclear power in the UK energy debate: nuclear power, climate change mitigation and radioactive waste", *Public Understanding of Science*, 17(2), 145-169.
[10] Biswas, A. K. (1982), "Impacts of hydroelectric development on the environment", *Energy Policy*, 10(4), 349-354.
[11] Bloom, D. E., & Canning, D. (2000), "PUBLIC HEALTH: The Health and Wealth of Nations", *Science*, 287(5456), 1207-1209.
[12] Bloom, D. E., & Canning, D. (2007), "Commentary: The Preston Curve 30 years on: still sparking fires", *International Journal of Epidemiology*, 36(3), 498-499.
[13] Bloom, D. E., Canning, D., & Sevilla, J. (2004), "The Effect of Health on Economic Growth: A Production Function Approach", *World Development*, 32(1), 1-13.
[14] Bo, S. (2011), "A literature survey on environmental Kuznets curve", *Energy Procedia*, 5, 1322-1325.
[15] Breitborde, N. J. K., Srihari, V. H., Pollard, J. M., Addington, D. N., & Woods, S. W. (2010), "Mediators and moderators in early intervention research", *Early Intervention in Psychiatry*, 4(2), 143-152.
[16] Bulled, N. L., & Sosis, R. (2010), "Examining the Relationship between Life Expectancy, Reproduction, and Educational Attainment", *Human Nature*, 21(3), 269-289.
[17] Cervellati, M., & Sunde, U. (2011), "Life expectancy and economic growth: the role of the demographic transition", *Journal of Economic Growth*, 16(2), 99-133.
[18] Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., Bergeron, A., Cutler, D. (2016), "The Association Between Income and Life Expectancy in the United States", 2001-2014, *JAMA*, 315(16), 1750-1766.
[19] Colborn, T., Kwiatkowski, C., Schultz, K., & Bachran, M. (2011), "Natural Gas Operations from a Public Health Perspective", *Human and Ecological Risk Assessment: An International Journal*, 17(5), 1039-1056.
[20] Dominici, F., McDermott, A., Zeger, S. L., & Samet, J. M. (2002), "On the Use of Generalized Additive Models in Time-Series Studies of Air Pollution and Health", *American Journal of Epidemiology*, 156(3), 193-203.
[21] Fitrianto, A., & Midi, H. (2013), "Standardized Simple Mediation Model: A Numerical Example", *World Applied Sciences Journal*, 22(8), 1135-1139.
[22] Freedman, L. S., Graubard, B. I., & Schatzkin, A. (1992), "Statistical validation of intermediate endpoints for chronic diseases", *Statistics in Medicine*, 11(2), 167-178.
[23] Glaeser, E. L., & Kahn, M. E. (2010), "The greenness of cities: Carbon dioxide emissions and urban development", *Journal of Urban Economics*, 67(3), 404-418.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[24] Grossman, G. M., & Krueger, A. B. (1991), "Environmental Impacts of a North American Free Trade Agreement".
[25] Grossman, G. M., & Krueger, A. B. (1995), "Economic Growth and the Environment", *The Quarterly Journal of Economics*, 110(2), 353-377.
[26] Gryparis, A., Forsberg, B., Katsouyanni, K., Analitis, A., Touloumi, G., Schwartz, J., Samoli, E., Medina, S., Anderson, H. R., Niciu, E. M., Wichmann, H. -E., Kriz, B., Kosnik, M., Skorkovsky, J., Vonk, J. M., & Dörtbudak, Z. (2004), "Acute Effects of Ozone on Mortality from the "Air Pollution and Health: A European Approach" Project", *American Journal of Respiratory and Critical Care Medicine*, 170(10), 1080-1087.
[27] Gundgaard, J., Nielsen, J. N., Olsen, J., & Sørensen, J. (2003), "Increased intake of fruit and vegetables: estimation of impact in terms of life expectancy and healthcare costs†", *Public Health Nutrition*, 6(01), 25-30.
[28] Gunzler, D., Chen, T., Wu, P., & Zhang, H. (2013), "Introduction to mediation analysis with structural equation modeling", *Shanghai archives of psychiatry*, 25(6), 390-394.
[29] Hagen, E. E. (1963), "How Economic Growth Begins: A Theory of Social Change", *Journal of Social Issues*, 19(1), 20–34.
[30] Hitiris, T., & Posnett, J. (1992), "The determinants and effects of health expenditure in developed countries", *Journal of Health Economics*, 11(2), 173-181.
[31] Huber, M. (1999), "Health expenditure trends in OECD countries, 1970-1997", *Health care financing review*, 21(2), 99-117.
[32] Judd, C. M., & Kenny, D. A. (1981), "Process Analysis: Estimating Mediation in Treatment Evaluations", *Evaluation Review*, 5(5), 602-619.
[33] Kabir, M. (2008), "Determinants of Life Expectancy in Developing Countries", *The Journal of Developing Areas*, 41(2), 185-204.
[34] Kampa, M., & Castanas, E. (2008), "Human health effects of air pollution", *Environmental Pollution*, 151(2), 362-367.
[35] Kaygusuz, K. (2001), "Renewable Energy: Power for a Sustainable Future", *Energy Exploration & Exploitation*, 19(6), 603-626.
[36] Kaygusuz, K. (2002), "Sustainable Development of Hydroelectric Power", *Energy Sources*, 24(9), 803-815.
[37] Kuznets, S. (1955), "Economic growth and income inequality", *The American economic review*, 45(1), 1-28.
[38] Künzli, N., Kaiser, R., Medina, S., Studnicka, M., Chanel, O., Filliger, P., Herry, M., Horak Jr, F., Puybonnieux-Texier, V., Quénel, P., Schneider, J., Seethaler, R., Vergnaud, J-C., Sommer, H. (2000), "Public-health impact of outdoor and traffic-related air pollution: a European assessment", *The Lancet*, 356(9232), 795-801.
[39] Lago-Peñas, S., Cantarero-Prieto, D., & Blázquez-Fernández, C. (2013), "On the relationship between GDP and health care expenditure: A new look", *Economic Modelling*, 32, 124-129.
[40] Lee, C., & Kim, M. (2019), "The Relationship between Internet Environment and Life Expectancy in Asia", *Review of Integrative Business and Economics Research*, 8(2), 70-80.
[41] Li, S. D. (2011), "Testing Mediation Using Multiple Regression and Structural Equation Modeling Analyses in Secondary Data", *Evaluation Review*, 35(3), 240-268.
[42] Lutz, W., & Kebede, E. (2018), "Education and Health: Redrawing the Preston

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Curve", *Population and Development Review*, 44(2), 343-361.

[43] Mackinnon, D. P., & Dwyer, J. H. (1993), "Estimating Mediated Effects in Prevention Studies", *Evaluation Review*, 17(2), 144-158.

[44] MacKinnon, D. P., Lockwood, C. M., Brown, C. H., Wang, W., & Hoffman, J. M. (2007), "The intermediate endpoint effect in logistic and probit regression", *Clinical Trials: Journal of the Society for Clinical Trials*, 4(5), 499-513.

[45] MacKinnon, D. P., Warsi, G., & Dwyer, J. H. (1995), "A Simulation Study of Mediated Effect Measures", *Multivariate Behavioral Research*, 30(1), 41-62.

[46] Magnani, E. (2000), "The Environmental Kuznets Curve, environmental protection policy and income distribution", *Ecological Economics*, 32(3), 431-443.

[47] Marland, G., & Rotty, R. M. (1984), "Carbon dioxide emissions from fossil fuels: a procedure for estimation and results for 1950-1982", *Tellus B: Chemical and Physical Meteorology*, 36(4), 232-261.

[48] Neuberger, M., Rabczenko, D., & Moshammer, H. (2007), "Extended effects of air pollution on cardiopulmonary mortality in Vienna", *Atmospheric Environment*, 41(38), 8549-8556.

[49] Palfrey, J. G. (1974), "Energy and the Environment: The Special Case of Nuclear Power", *Columbia Law Review*, 74(8), 1375-1409.

[50] Panayotou, T. (1993), "Empirical tests and policy analysis of environmental degradation at different stages of economic development (No. 992927783402676)", *International Labour Organization*.

[51] Pascoli, S. D., Femia, A., & Luzzati, T. (2001), "Natural gas, cars and the environment. A (relatively) "clean" and cheap fuel looking for users", *Ecological Economics*, 38(2), 179-189.

[52] Pope III, C. A., & Dockery, D. W. (2006), "Health Effects of Fine Particulate Air Pollution: Lines that Connect", *Journal of the Air & Waste Management Association*, 56(6), 709-742.

[53] Preacher, K. J., & Kelley, K. (2011), "Effect size measures for mediation models: Quantitative strategies for communicating indirect effects", *Psychological Methods*, 16(2), 93-115.

[54] Preston, S. H. (1975), "The Changing Relation between Mortality and level of Economic Development", *Population Studies: A Journal of Demography*, 29(2), 231-248.

[55] Preston, S. H. (2007), "The changing relation between mortality and level of economic development", *International Journal of Epidemiology*, 36(3), 484-490.

[56] Rashad, S. M., & Hammad, F. H. (2000), "Nuclear power and the environment", *Applied Energy*, 65(1-4), 211-229.

[57] Reutter, J. M., & Herdendorf, C. E. (1976), "Thermal Discharge from a Nuclear Power Plant: Predicted Effects on Lake Erie Fish", *The Ohio Journal of Science*, 76, 39-45.

[58] Rijnhart, J. J. M., Twisk, J. W. R., Chinapaw, M. J. M., de Boer, M. R., & Heymans, M. W. (2017), "Comparison of methods for the analysis of relatively simple mediation models", *Contemporary Clinical Trials Communications*, 7, 130-135.

[59] Rogot, E., Sorlie, P. D., & Johnson, N. J. (1992), "Life expectancy by employment status, income, and education in the National Longitudinal Mortality Study", *Public health reports*, 107(4), 457-461.

[60] Schnabel, S. K., & Eilers, P. H. (2009), "An analysis of life expectancy and economic production using expectile frontier zones", *Demographic Research*, 21,

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

109-134.
[61] Slovic, P., Layman, M., & Flynn, J. H. (1991), “Risk Perception, Trust, and Nuclear Waste: Lessons from Yucca Mountain”, *Environment: Science and Policy for Sustainable Development*, 33(3), 6-30.
[62] Sobel, M. E. (1982), “Asymptotic Confidence Intervals for Indirect Effects in Structural Equation Models”, *Sociological Methodology*, 13, 290-312.
[63] Stern, D. I. (2004), “The Rise and Fall of the Environmental Kuznets Curve”, *World Development*, 32(8), 1419-1439.
[64] Stern, D. I. (2014), “The Environmental Kuznets Curve: A Primer”, *Crawford School of Public Policy, Centre for Climate Economics and Policy, The Australian National University*.
[65] Suri, V., & Chapman, D. (1998), “Economic growth, trade and energy: implications for the environmental Kuznets curve”, *Ecological Economics*, 25(2), 195-208.
[66] Tsuda, T., Tokinobu, A., Yamamoto, E., & Suzuki, E. (2016), “Thyroid Cancer Detection by Ultrasound Among Residents Ages 18 Years and Younger in Fukushima, Japan”, *Epidemiology*, 27(3), 316-322.
[67] Werner, A. K., Vink, S., Watt, K., & Jagals, P. (2015), “Environmental health impacts of unconventional natural gas development: A review of the current strength of evidence”, *Science of the Total Environment*, 505, 1127-1141.
[68] Wilkinson, R. G. (1997), “Socioeconomic determinants of health. Health inequalities: relative or absolute material standards?”, *BMJ: British Medical Journal*, 314(7080), 591-599.
[69] Wilkinson, P., Smith, K. R., Davies, M., Adair, H., Armstrong, B. G., Barrett, M., Bruce, N., Haines, A., Hamilton, I., Oreszczyn, T., Ridley, I., Tonne, C., Chalabi, Z. (2009), “Public health benefits of strategies to reduce greenhouse-gas emissions: household energy”, *The Lancet*, 374(9705), 1917-1929.
[70] Wright, J. C., & Weinstein, M. C. (1998), “Gains in Life Expectancy from Medical Interventions—Standardizing Data on Outcomes”, *New England Journal of Medicine*, 339(6), 380-386.
[71] Xu, K., Evans, D. B., Kawabata, K., Zeramdini, R., Klavus, J., & Murray, C. J. (2003), “Household catastrophic health expenditure: a multicountry analysis”, *The Lancet*, 362(9378), 111-117.
[72] Zhong, Y., & Power, G. (1996), “Environmental impacts of hydroelectric projects on fish resources in China”, *Regulated Rivers: Research & Management*, 12(1), 81-98.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)