The impact of economic development on carbon intensity of human well-being (CIWB): Evidence from lower middle-income countries

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ABSTRACT

The aim of sustainable development is to maintain and progress economic activities while protecting the environment in long run. Recent sustainability researches have focused on the relationship between stress placed on the environment by economic activity and human well-being, known as the Carbon Intensity of Well-Being (CIWB). To contribute to this endeavor, the authors employ two-way fixed effects which analyze the impact of economic and environmental variables on CIWB in 09 lower middle-income countries from 2000 to 2018. We find that economic development includes gross domestic product and annual foreign direct investment, which are significantly negative effects on CIWB. That means economic growth reduced human well-being in the overall sample in the study period. Nevertheless, this effect is unsteady which indicates these countries should wisely choose strategies for sustainable development. In addition, the effect of energy consumption on CIWB has a significant positive in this study.

1. Introduction

The term sustainability literally means "a capacity to maintain some entity, outcome, or process over time" (Jenkins, 2009, p. 380). That means current generations who have carried out activities and avoided running out of natural resources for future generations. In the early period of sustainable development in 1972, it has just only two pillars: economic growth and environmental stewardship. Then, this conception of sustainable development is motivated not only by economic development but also to take conservation of a resource that is limited and creates an idea of having a well-cared and healthy society. Thus, society has become one of the important pillars of sustainable development in 1992. Three pillars including economic growth, environmental stewardship, and social inclusion (Porter & van der Linde, 1995) have affected each other. There is no doubt that various activities from humans such as policies for social, economic, and public health adversely affect the environment. Consequently, humans have also suffered from several environmental issues such as pollution, global warming, and climate change. Therefore, questions concerning the relationship between economic activities and human well-being which is necessary for research to complete understanding of the dimensions of sustainability.

To answer this question, Dietz, Rosa, and York (2012) defined environmental effects on welfare (EIWB). Starting from that idea, Jorgenson (2014) introduced a ratio of Carbon emission on human welfare (CIWB) to explore the relationship between economic development and CIWB in 106 countries around the world (Africa, Asia, South and Central America North America,

Europe, and Oceania) from 1970 to 2009. The result showed that economic development affected positively CIWB with different magnitudes of impact across regions. After that, some research about CIWB is presented, such as Jorgenson and Givens (2015); Sweidan (2018); Givens (2018); Li, Luo, and Wang (2019); Greiner and McGee (2020). However, these previous studies focus on the CIWB of developed countries and underdeveloped countries. Thus, our approach asks how economic development affects CIWB in lower middle-countries.

2. Literature review

To uphold a certain level of human well-being, humans use fossil fuel energy in various activities to develop the economy. That causes the increase in carbon emissions and leads to depression in the environment. As a result, human well-being like physical health, happiness, welfare, and life satisfaction is affected by these actions. Prior researches have employed the ecological intensity of well-being tradition. Which is a well-known comprehensive measure of the consumption-based environmental demand-the ecological footprint of countries for measuring. It is recognized by the National Academy of Sciences (Wackernagel et al., 2002). Numerous studies used the ecological footprints of countries in comparative environmental sociology (Jorgenson, 2003, 2009; Jorgenson & Burns, 2007; Jorgenson & Clark, 2009; Rice, 2007; York, Rosa, & Dietz, 2003), human ecology (Dietz, Rosa, & York, 2007; Rosa, York, & Dietz, 2004) international relations (Ozler & Obach, 2009), and industrial ecology (Frey, Harrison, & Billett, 2006). Recently, some scholars such as Dietz et al. (2012), Knight and Rosa (2011), Steinberger, Roberts, Peters, and Baiocchi (2012), Jorgenson (2014) have researched the carbon intensity of well-being (CIWB) which presented the relationship between carbon emissions and human well-being. CIWB per capita is a useful tool that engages in the definition of sustainable development. It provides information about a specific nation will emit how much particular carbon dioxide in a given year, which is relative to the national life expectancy of individuals born in that year. For the purpose of this study, we define CIWB as the ratio of production-based data to measure carbon emissions to life expectancy at birth (LE). LE is a good measure of human well-being. It has presented the health conditions of society directly, such as infant mortality, life longevity, prenatal education, and high levels of literacy (Becker, Harris, McLaughlin, & Nielsen, 2003; Dietz et al., 2012)

Based on CIWB ratio, a higher CIWB value is indicative of more carbon intensive, then the stress on the environment is high. This means that the sustainability of these countries really exists. While a lower CIWB value indicates a lower carbon intensity has been emitted by socio-economic processes, the stress is minor in the environment. That indicates the economy is toward more sustainability. Besides that, some researchers (Jorgenson & Clark, 2012; Jorgenson & Givens, 2015; Knight, 2014; York, 2012) have confirmed the influence of the country sample and the time horizon on economic performance and carbon emissions. As a result, in this study, the authors corrected CIWB for a specific group of the country in a specific period.Environmental devastation results from the way how human behaviour, a culture of mass consumption, and the failure of governments to adequately address environmental problems (Jänicke, 1990). After economic growth, globalization contributes to the deterioration of the environment, which also causes environmental disparities between developed and developing countries. In addition, the healthy environment in particular, and the environment, in general, is seen as luxury good. It is not infinite. Hence, the social interest will change to displace self-interest. The "green" demand for products and services will place pressure on governments to apply policies in choosing and investing in "eco-friendly" technologies. This is also the concept of ecological modernization based on the understanding that environmental protection is a precondition of long-term economic development (Grossman & Krueger, 1995). Ecological Modernization Theory (EMT) has

emphasized the possibility of a process policies for economic development and environmental protection can be combined. This result can help to apply efficiently the relationship between economics and innovation to achieve desired environmental outcomes (Gouldson & Murphy, 1997). Accordingly, if the relationship between economic development and environmental stress is negative, which will help to increase the energy intensity of human well-being and vice versa. Therefore, a conflict between the economic process and the environment is generated. Many studies (Dietz, Rosa, & York, 2009; Dietz et al., 2012; Jorgenson & Clark, 2012; Jorgenson & Givens, 2015; Mazur & Rosa, 1974; Rosa & Dietz, 2012; Sweidan, 2016; Venhoeven, Bolderdijk, & Steg, 2013; York, 2012) have found the economic development impacts of human well-being. Conventionally, in economics and policy, well-being (measures of affluence) is measured by Gross Domestic Product (GDP). And the relationship between affluence and well-being is curvilinear, the higher level is, the less well-being is contributed by affluence (Dietz, York, & Rosa, 2001; Goldstein, 1985; Inglehart & Klingemann, 2000; Preston, 1975).

3. Methodology and data

3.1. Data and research model

This study comprises panel data for 09 countries in a lower middle-income group (Algeria, Bangladesh, Egypt, India, Morocco, Pakistan, Philippines, Uzbekistan, and Vietnam) in the period from 2000 to 2018. The data extracted CIWB as a ratio between per capita anthropogenic carbon dioxide emissions and human well-being. Carbon emission (CO_2) per capita measured in metric tons per capita, taken from Countryeconomy (n.d.). Average Life Expectancy (LE) is measured by the number of years taken from World Bank (2020). Gross Domestic Product (GDP) per capita (measured in constant 2010 US dollars) and annual Foreign Direct Investment (FDI) per capita (in constant 2010 US dollars as same as GDP) which are from United countries Conference on Trade and Development. Energy consumption (EPC) per capita, measured in thousand kWh, are from Ourworldindata (Our world in data, n.d.).

The average number of years a newborn infant would expect to live, whether he or she were able to pass through life if current death rates do not change, which is defined as life expectancy at birth (LE). This study applies LE for the denominator and carbon emissions for the numerator in the CIWB ratio. In our datasets, the coefficient of variation of CO_2 is 0.64, and for average life expectancy, the coefficient of variation is 0.049. Thus, a CIWB ratio is dominated by carbon emissions data, which is much more than the average life expectancy.

Here we use a method like an approach pioneered by Dietz et al. (2012) and Jorgenson (2014) to resolve this complication. Thus, the authors add a correction factor[1] to carbon emissions per capita and shift its mean without changing the variance. And so, this process allows the study to equalize the coefficient of variation of the numerator and denominator. For our analysis, the correction factor of average life expectancy and carbon emissions per capita can be made equal by adding 21.98.

As the result, the measure of the carbon intensity of human well-being (CIWB) is:

$$\mathbf{CIWB = ((CO_2 + 21.98) / LE) * 100} \quad (1)$$

3.2. Methodology

In order to review the relationship between economic development, environment, and human well-being variables such as GDP, FDI, and EPC. Our general model is as follows:

[1]According to Sweidan (2017), using subscripts CO_2 and LE to indicate CO_2 emissions and life expectancy, respectively, the correction factor is $\mathbf{CF = ([S_{CO2} * M_{LE}]/S_{LE})- M_{CO2}}$with S is standard deviation, M is mean

$$\mathbf{CIWB_{it} = f\ (GDP_{it},\ FDI_{it},\ EPC_{it}\ )} \quad (2)$$

Panel data has the disturbances such as heteroskedastic and contemporaneously correlates across panels (Sweidan, 2016). To solve these problems, the study applies the first-order autocorrelation - AR(1) for the estimated mode. After that, we use the time-series cross-sectional Prais-Winsten regression model with Panel-Corrected Standard Errors (PCSEs). This method has been recommended by Beck and Katz (1995). Beside that, the relationship between economic activities and the environment may change over time. To capture this dynamic change over time, Jorgenson (2014) and Jorgenson, Alekseyko, and Giedraitis (2014) proposed the two-way fixed-effect model. Thus, we employ the two-way fixed effects which is being able to simultaneously adjust for unit-specific and time-specific unobserved disturbances at the same time (Imai & Kim, 2019). In addition, our study researched CIWB of a group of Middle-Income Countries (MICs) which are defined by their income. These countries are aligned with their level of income as belonging to a rapid increase in GDP, population, and life expectancy at birth, as well as a high rate of increasing CO_2 emissions in the world (Ritchie, Roser, & Rosado, 2020). As with a fixed effects model, this technique estimates effects within countries over time, rather than between countries, and controls for variation between countries. For this reason, we access the two-way fixed effects technique on interaction variables between GDP per capita and time to access the extent to which the effect of economic development and CIWB changes through time from 2000 to 2018.

With the independent variables for economic development (GDP and FDI), for the environment (ECP), and dependent variables for the carbon intensity of human well-being (CIWB), the estimated model of study is:

$$\boldsymbol{CIWB_{it} = \beta_1 GDP_{it} + \beta_2 GDP_{it} year2001 + \ldots + \beta_{18} GDP_{it} year2018 + \beta_{19} year2001 + \ldots + \beta_{37} year2018 + \beta_{38} EPC_{it} + \beta_{39} FDI_{it} + u_i + e_{it}} \quad (3)$$

Where *i* denotes each country; *t* represents the time period;

Subscript ($\beta_{19} year2001 + \ldots + \beta_{37} year\ 2018$) is the year-specific intercepts;

With 2000 is the reference category, ($\beta_2 GDP_{it} year2001 + \ldots + \beta_{18} GDP_{it} year2018$) is the interaction through the time which impacts on CIWB;

The control variable is annual foreign direct investment per capita (FDI_{it}) and energy consumption per capita (EPC_{it});

Subscript u_i is the country-specific disturbance term and e_{it} is the unique disturbance term associated with each country at each point in time.

Ecological modernization theory and environmental economic perspectives suggest that economic growth's impact on the environment tends to diminish. Besides that, the applied research of Sweidan (2016), Greiner and McGee (2020), these studies have employed control variables in the estimated model. Therefore, to make our results sound logical, we also included 02 time-variant control variables which are FDI as the economic variable and ECP as the environment variable in our model.

To check if the time-fixed effects are needed, we perform the "testparm" command in the estimated model with and without both variables FDI and ECP. If the dummies for all years are equal to 0, then no time-fixed effects are needed. The results presented in **Table 1** show we can reject the null that the coefficients for all years are jointly equal to zero. This means the estimated model for our study with or without two control variables FDI and ECP have not affected to result of GDP on CIWB through time.

Table 1

Testing for time-fixed effects in Model with and without FDI and ECP

	Model with FDI and ECP	**Model without FDI and ECP**
The value of the Chi2 (18)	3359.13	5635.07
Pro > chi2	0.0000	0.0000

Source: The researcher's data analysis

4. Results and discussion

4.1. Descriptive statistics

The paper chooses variables that include the carbon intensity of human well-being (CIWB), Gross Domestic Product (GDP) per capita, annual Foreign Direct Investment (FDI) per capita, and energy consumption (EPC) per capita in the period 2000 - 2018. With skewness > ± 3 and kurtosis > ± 10, the data of this study have problems with the normal distribution (Kline, 2015). However, the distribution for all our variables was within the acceptable ranges, we do not need to use the natural logarithm to convert the data.

Table 2

Descriptive statistics

Variables	**CIWB**	**GDP**	**ECP**	**FDI**
Mean	34.0878	1.9614	7.5651	38.2254
Std.Dev.	1.8747	1.1132	5.4536	36.1727
Min	31.16704	0.5249	1.0652	-14.7132
Max	39.9964	4.8301	24.0247	162.2256
Skewness	0.8131	0.9799	1.2178	1.157
Kurtosis	3.9103	3.2083	3.7254	3.7308

Source: The researcher's data analysis

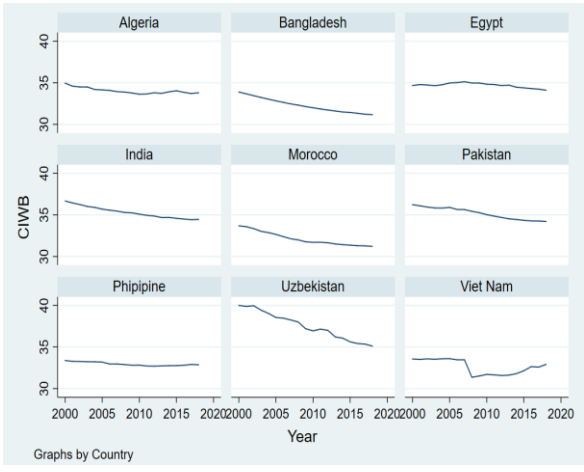

Figure 1. The CIWB measures for nine countries 2000 - 2018

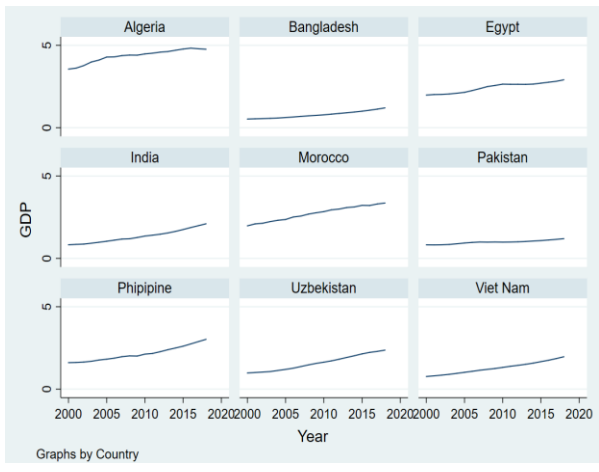

Figure 2. GDP per capita measures for nine countries 2000 - 2018

Source: The researcher's data analysis

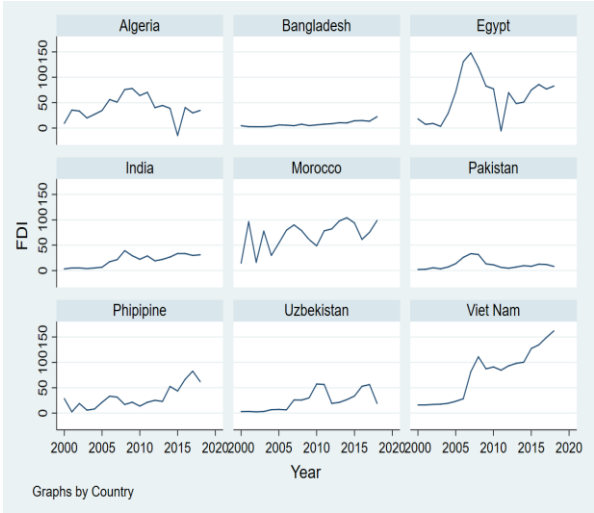

Figure 3. FDI per capita measures for nine countries 2000 - 2018

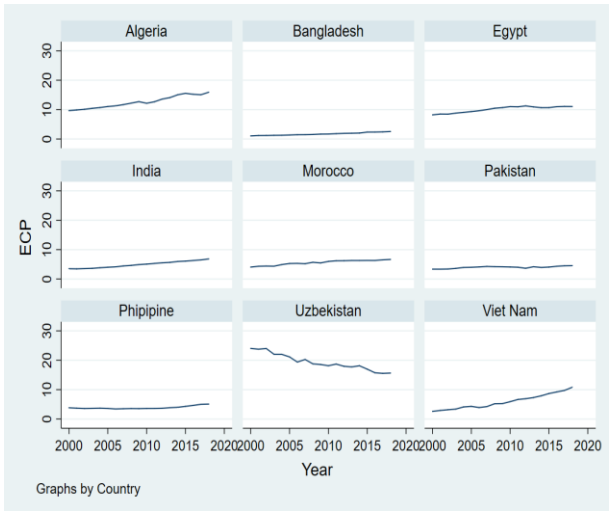

Figure 4. ECP per capita measures for nine countries 2000 - 2018

Source: The researcher's data analysis

The summary statistics of the model's variables are presented in **Table 2**. On average, nine countries in lower middle-income group which have 1.9614 USD gross domestic product per capita, receive 38.2254 USD annual foreign direct investment per capita. These countries use average 7.5651 thousand kWh of energy consumption per capita and reach 34.0878 CIWB.

For sustainable development, the smaller CIWB is, the better welfare of human well-being is. In **Figure 1**, the CIWB of the lower middle-income group has an overall downtrend in the research period. For Bangladesh, India, Morocco, Pakistan, and Uzbekistan, the level of CIWB are all deceased, but at different rates. From 2000 to 2018, the CIWB for Uzbekistan and Vietnam experienced increases and decreases in this period. Additionally, Uzbekistan is the one which has the highest CIWB in the early stage and a dramatic decrease over time. Besides, Vietnam has CIWB deeply decreased in 2008, followed by an upward trend beginning in 2015 and continuing until 2018. In addition, the CIWB for Algeria slightly decreased in value over time. However, The CIWB for Egypt which slightly increased during this period and downward trend at the final stage. Especially, the CIWB for Philippines hasn't changed almost through time.

Figure 2 represents the speed increase of GDP in this group, which is almost similar. Algeria has GDP per capita, which is the highest in lower middle-income group. On the contrary, Bangladesh is the nation that has the lowest GDP per capita of the 09 countries. While GDP per capita of India, Morocco, Philippines, Uzbekistan, and Vietnam experienced overall increases from 2000 - 2018. In addition, GDP per capita for Egypt slightly increased in the early stage, the downward trend from 2011 to 2014, and started an upward trend until 2018. Whereas, GDP per capita for Pakistan experienced modest increases.

Besides that, the changing in FDI for 09 countries from 2000 to 2018 is presented in **Figure 3**. Bangladesh, India and Pakistan experienced a slightly upward trend in this period. Particularly, Bangladesh is the one attracting FDI, which is the smallest in the lower middle-income group. In contrast, the FDI value of Algeria, Philippines, and Uzbekistan which grew markedly through time. However, starting 2015 to 2018, these countries had a fall in appealing to FDI. The countries which rapidly increased FDI are Egypt, Morocco, and Vietnam. Also, FDI of Egypt dramatically went down in 2011, but it went up in 2012 and continued until 2018. Whereas, the FDI of Morocco

experienced periods of increases and decreases in last 18 years. For Vietnam, at the beginning of this stage, FDI value remained stable. In 2007, the FDI of Vietnam suddenly rose and had an upward trend until 2018.

Energy consumption (EPC) per capita is reported in **Figure 4**. Most countries with lower middle-income had very modest increasing energy consumption from 2000 to 2018. The ECP of Algeria and Vietnam both rose slightly. On the other hand, Uzbekistan is the only one which had a downward trend in consuming energy in this period. This behavior is encouraged to reduce environmental pollution.

4.2. Estimated results

The paper provides the result of an estimated model in **Table 2**. It shows the effect of GDP per capita on the CIWB of nine countries from 2000 to 2018. The large R-square is close to perfect, which indicates the estimated model is significant. Besides, the Rho is 99.27% of variance due to differences across countries due to panel data of this study, which includes 09 countries in the lower middle-income group.

For the sample of 09 countries, in 2000, the GDP coefficient is negatively and significantly at 1% linked with CIWB. A negative coefficient of GDP would imply an increase in economic development leads to a reduction in CIWB. It shows the beneficial effect of sustainable development. The GDP coefficient is -0.7480 in 2000, indicating a 1 unit increase in GDP per capita led to a decrease of slightly less than 0.748 units in CIWB.

In 2001 and 2002, the coefficients of GDP per capita which are not statistically significant, have a negative effect on CIWB. It shows that a developing economy in that years would lead to a reduction in CIWB. Except in 2004, GDP has no significance. After that time, all interactions between GDP per capita and the year dummy variables are positive and statistically significant for the overall sample. In 2018, a 1 unit increase in GDP per capita led to a 0.543 units decrease in CIWB. Thus, the result proofs the effect of economic development on CIWB tends to increase, which means less sustainable.

The result in **Table 3** also proves that the effects of EPC and FDI on CIWB are statistically significant. As expected, the impact of energy consumption per capita (EPC) is positive on CIWB. This outcome suggests EPC is relevant and adds more stress to the environment over time. On the contrary, the impact of annual Foreign Direct Investment per capita (FDI) is negative. Hence, attracting investment from foreign countries, which contributes to reducing the stress on the environment by using more green technology for the lower middle-income group.

Table 3

The effects of GDP per capita on CIWB in 2000 - 2018

Independent variables	Coefficients	Panel-corrected standard errors
GDP	**-0.7480*****	**0.0389**
GDP_2001	-0.0090	**0.0174**
GDP_2002	-0.0023	**0.0142**
GDP_2003	**0.0510*****	**0.0164**
GDP_2004	0.0224	**0.0178**

Independent variables	Coefficients	Panel-corrected standard errors
GDP_2005	**0.0610*****	**0.0212**
GDP_2006	**0.0672****	**0.0282**
GDP_2007	**0.0476***	**0.0260**
GDP_2008	**0.1776*****	**0.0289**
GDP_2009	**0.1692*****	**0.0319**
GDP_2010	**0.1881*****	**0.0296**
GDP_2011	**0.2201*****	**0.0316**
GDP_2012	**0.2241*****	**0.0349**
GDP_2013	**0.2505*****	**0.0368**
GDP_2014	**0.2501*****	**0.0390**
GDP_2015	**0.2439*****	**0.0424**
GDP_2016	**0.2404*****	**0.0393**
GDP_2017	**0.2325*****	**0.0408**
GDP_2018	**0.2047*****	**0.0440**
ECP	**0.2482*****	**0.0221**
FDI	**-0.0022****	**0.0011**
Constant	**34.6683*****	
R^2	0.9927	
Rho	0.8711	
N	171	

Note: *: significant at 10%; **: significant at 5%; ***: significant at 1%
Source: The researcher's data analysis

Figure 5 shows the ultimate effect of GDP per capita on CIWB which is unstable in the research period. At the beginning of the period, from 2000 to 2003, the effect of GDP on CIWB is low and stable. CIWB level, which is low, indicates economic development enhances human well-being. This trend goes down in 2006 despite being at a negative level. This means the impacts of economic development on the environment continue to be negative with more fluctuations. At that time, the amount of carbon emissions has an uptrend in Alegria and Vietnam. Besides that, Vietnam continues to be ranked 4th in the Asia Countries about emitting carbon dioxide from 2003 to 2017. Until 2017 and 2018, this effect has reduced. The uptrend is a discouraging behavior; it causes more stress on the environment and decreases human well-being and welfare.

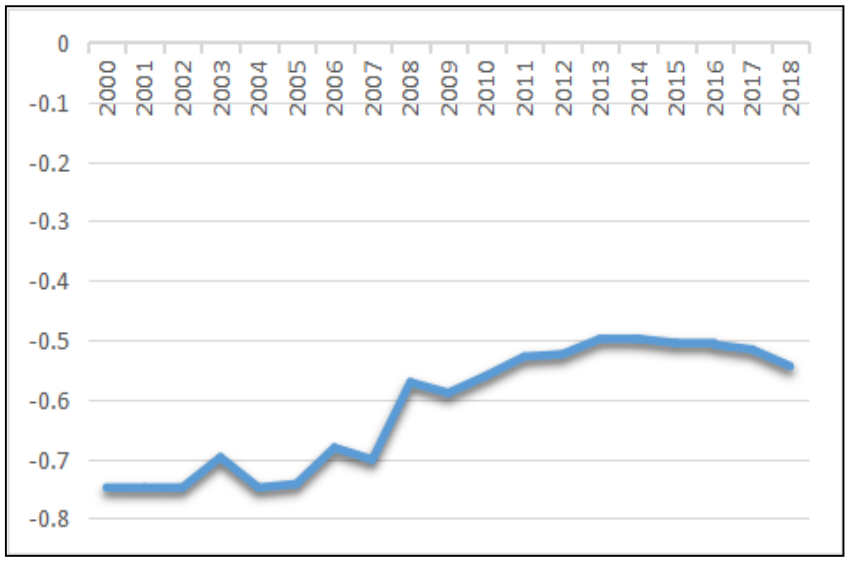

Figure 5. The elasticity coefficients of the effect of GDP on CIWB in 2000 - 2018

Source: The researcher's data analysis

In conclusion, the increase in GDP per capita contributes to decreasing CIWB in the lower middle-income group from 2000 to 2018. The result is in line with the findings of many studies (Jorgenson & Clark, 2012; Jorgenson & Givens, 2015), Jorgenson and Givens (2015) for Africa or non-high-income countries. However, the uptrend in the relationship between GDP and CIWB indicates the recent policies of lower middle-income group which could have some projects benefiting from the economic growth but based on natural resource extraction and the consumption of fossil. If these policies are continued, they will be the victims of ecologically unequal- exchange. For this reason, the uptrend change of GDP will cause the increase of CIWB which emits large amounts of CO_2 ino the air and decreases human welfare. Hence, the government of lower middle-income countries should take part in the environmental movement, which is an international movement, represented by a range of various organizations from country to country. Movement goals are conservation of the environment and preservation of the environment. This implies that humans should use the resources wisely and make sure not overused so they don't run out. Moreover, countries with lower middle-income should apply for a green certificate in industries such as ISO 14000, green building, and the green production certification program for all front-line production technicians in all sectors of manufacturing. Besides that, it is recommended that more strict environmental policies must be claimed and attached to a green strategy which includes green products, green firms, and green alliances to improve well-being.

5. Conclusion

Based on the results, it is clear that there is a linkage between economic development and the CIWB for a long time. We confirm that Gross Domestic Products per capita (GDP) has a significant negative effect on CIWB which means economic growth reduced human well-being in developing countries in the period 2000 - 2018, except in 2001 and 2002. This finding highlights important differences across the samples, comprising developing countries that have low income. In addition, this relationship in high-income countries has been confirmed by previous research recently (Dietz et al., 2009, 2012; Givens, 2015; Jorgenson & Clark, 2012; Mazur & Rosa, 1974; Rosa & Dietz, 2012; Sweidan, 2016; Venhoeven et al., 2013; York, 2012). While scholars haven't detected that linkage in developing countries yet.

On the policy implication side, our results showed that the current economic performance enhances human well-being, and maintains sustainable development through decreasing environmental stress in the lower middle-income countries. Practically, as economic activities reduce CIWB, it is more challenging for the governments that issue economic policies to protect and improve the environment in these countries. For this reason, green growth policies are a necessary part of a strong and sustainable economy. The government can enhance productivity by creating motivation for greater efficiency in using natural resources, reducing waste, and energy consumption. Besides, they need to focus on contributing to fiscal consolidation by mobilising revenues through green taxes and through the elimination of environmentally harmful subsidies. Especially, they will need to ponder how to manage any potential trade-offs and best exploit the synergies between green growth and poverty reduction.

In addition, the relationship between annual Foreign Direct Investment per capita (FDI) and CIWB is negative. The result indicates attracting foreign direct investment contributes to reducing stress on the environment and increasing human well-being in the long term. This supports policies at focusing on green reinvestment as a strategy for upgrading existing assets; choosing and developing green technological innovations and new market practices which are generating opportunities and expanding demand for green FDI.

Furthermore, the environmental impacts (EPC) on human well-being have been confirmed significantly positive in this study. This is discouraging behavior because human welfare is not improved and the consequence of using energy consumption is environmental degradation. As a result, we believe that the policymakers need to promote for using energy conversion and storage technologies from renewable sources such as wind, wave, solar, and thermal, ... in achieving sustainability. Particularly, policies aimed at undertaking renewable energy law about fiscal incentives and non-fiscal incentives, tradable certificates, renewable portfolio standards, and green energy option programs.

In sum, developing countries that have low income, have focused on developing economy. Hence, the government has exploited natural resources to enhance economic activities. The more stress on the environment, the more adverse effect on human well-being. Our main conclusion is advising countries with lower middle-income should apply green policies for economic growth. This will support a sustainable development strategy, especially in developing countries. Besides, our finding shows GDP has a negative effect on the CIWB of 09 countries in the lower middle-income group from 2000 to 2018. However, the effect is slight and hasn't pointed out the detail of each country in the group. Thus, this is also researching direction for our next studies.

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