
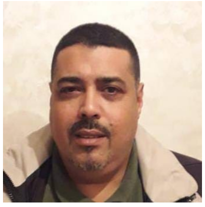


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THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION, FOREIGN DIRECT INVESTMENT, GROWTH, AND CO2 EMISSIONS: A TIME SERIES ANALYSIS WITH STRUCTURAL BREAKS FOR MOROCCO

Abstract: This Study investigates the nexus between energy consumption, foreign direct investment (FDI) inflows, growth and CO2 emissions in Morocco during the period 1971-2014. Given the period analyzed, we take into account the structural breaks that marked this long period. For this purpose, several tests of unit roots and cointegration with structural breaks and bootstrap causality tests are conducted. Our results show that there is a long-term relationship between the variables in the model. These results reveal that the pollution haven hypothesis meaning that FDI has positive effects on environment is valid for Morocco. Finally, we conclude with some recommendations for policy makers.
Keywords: Energy Consumption, Economic Growth, Foreign Direct Investment, Carbon Dioxide Emissions, Maki Cointegration Method.
Résumé : Cette étude examine le lien entre la consommation d'énergie, les flux d'investissements directs étrangers (IDE), la croissance et les émissions de CO2 au Maroc au cours de la période 1971-2014. Compte tenu de la période analysée, nous prenons en compte les ruptures structurelles qui ont marqué cette longue période. Pour ce faire, plusieurs tests de racines unitaires et de cointegration avec des ruptures structurelles et des tests de causalité bootstrap sont effectués. Nos résultats montrent qu'il existe une relation à long terme entre les variables du modèle. Ces résultats révèlent que l'hypothèse du "paradis pour les pollueurs", c'est-à-dire que les IDE ont des effets positifs sur l'environnement, est valable pour le Maroc. Enfin, nous concluons par quelques recommandations à l'intention des décideurs politiques.
Mots clés: Consommation d'énergie, Croissance économique, Investissements directs étrangers, Émissions de dioxyde de carbone, Méthode de cointegration de Maki.

1. Introduction

Climate change and its adverse effects, especially on the health and welfare, has been a one of the topics that has attracted the attention of scientists in recent decades. Conscious of the disastrous effects of this change, many countries have adopted new strategies to reduce CO2 emissions following the signing of the *Kyoto Accord in 1997*. Increasing concentration of greenhouse gases in the atmosphere leads to climate change and economic losses and consequent natural disasters. Of course, there are several environmental pollutants, which cause this climate change, but Carbone dioxide (CO2) is the one important contributor and the dominant gas of total GHG in the world and in 2010 was the highest in history (IEA, 2011). According to the Moroccan INDC's (**Intended Nationally Determined Contribution)** report submitted on June 2015, Morocco's commitment is to reduce its GHG emissions by 32 % by 2030 compared to "business as usual" projected emissions. To achieve these objectives, Morocco must naturally make a cumulative reduction of 401 Mt CO2eq over the period 2020-2030 and significant investments to support this policy. For Morocco, this new major issue probably leads to follow the anti-corruption reforms and adapt continuously these reforms to the various changes imposed by the global economy.

Before starting our work, it is important to point out that several studies have pointed out the failure to take into account structural breaks in periods marked by changes can lead to biased results in the estimates (Westerlund, J 2008, Hurlin C (2005). In the case of Morocco, it's well known that our economy has with stood internal and external economic shocks due to the adoption of structural reforms and global economic crises (the Asian crisis of 1997 and the crisis of 2007 in most countries). Among the reforms, we can highlight as an example: The decree of Moroccanization in 1973 eliminated in 1989, the Structural Adjustment Program (SAP) in 1983, the new code of investment in 1983 replaced in 1995, the use of several fiscal incentives introduced in the 1996, Finance law and the privatization program launched in 1989 and accelerated in 1993. In the most developing countries, FDI is one of the factors contributing to rapid growth and thereby creating employment, reducing debt pressure. However, despite the beneficial effects of these FDI on economic growth, it must be emphasized that research has shown that its impact on the quality of the environment is a subject of discussion (Baek (20016). In the literature, two opposing approaches have been suggested: The first one known as Pollution haven hypothesis which assumes that FDI moving towards the countries with less environment taxes, less environmental regulations and lower standards and no control CO2 emissions (Seker et al. 2015). This explains that these multinational companies are transferring their high pollution-level industries to developing countries to avoid high environmental charges in their countries (Koçak et al. 2017). The second approach Pollution halo hypothesis emphasizes that FDI invests in clean technologies by attracting investment in research and development. This assumption is that FDI increases the quality of the environment and reduces carbon emissions in developing countries. This paper tests the relationship between energy consumption, Foreign Direct Investment and CO2 emissions in Morocco for the period1971-2014.

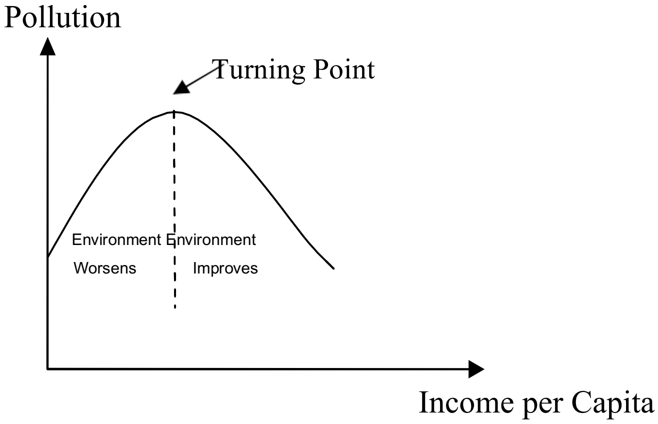
The remainder of the paper is organized as follows. In Section 2, presents reviews of theoretical and empirical literature. The data and estimation methodology are discussed in Section 3. Finally, the conclusion and policy recommendations are made in Section 4.

2. Literature Review

2.1. Theoretical Background

The literature on the relation between carbon emission, growth/income, energy use, and foreign investment is very theoretically documented but econometrically, the results are very mixed. The first one focuses on relationship between the carbon dioxide emissions, energy consumption, and economic growth. Most of these studies consider Environmental Kuznets Curve hypothesis developed by Kuznets. According to this hypothesis, in the first stage, as GDP rises, CO2 emissions also increase as this is due to the increase in energy consumption. This is called scale effect (Koçak, 2017). However, in the next step, any of the sensitivities and structural changes in the economy to reduce CO2 emissions begins to gain importance (structural effect). To do this, countries are adopting new technologies to ensure a quality environment (Bigilliet al.2016, Koçak, 2014). However, in the next step, any of the sensitivities and structural changes in the economy to reduce CO2 emissions begins to gain importance (structural effect). To do this, countries adopt new technologies to ensure a quality environment (Bigilliet al.2016, Koçak, 2014). When GDP per capita reaches a certain level, CO2 emissions decrease. This level is called turning point. This inverse relationship between environmental degradation and income can be described by the following Figure as an inverted U- shaped relationship.

Figure 1: Environmental Kuznets Curve



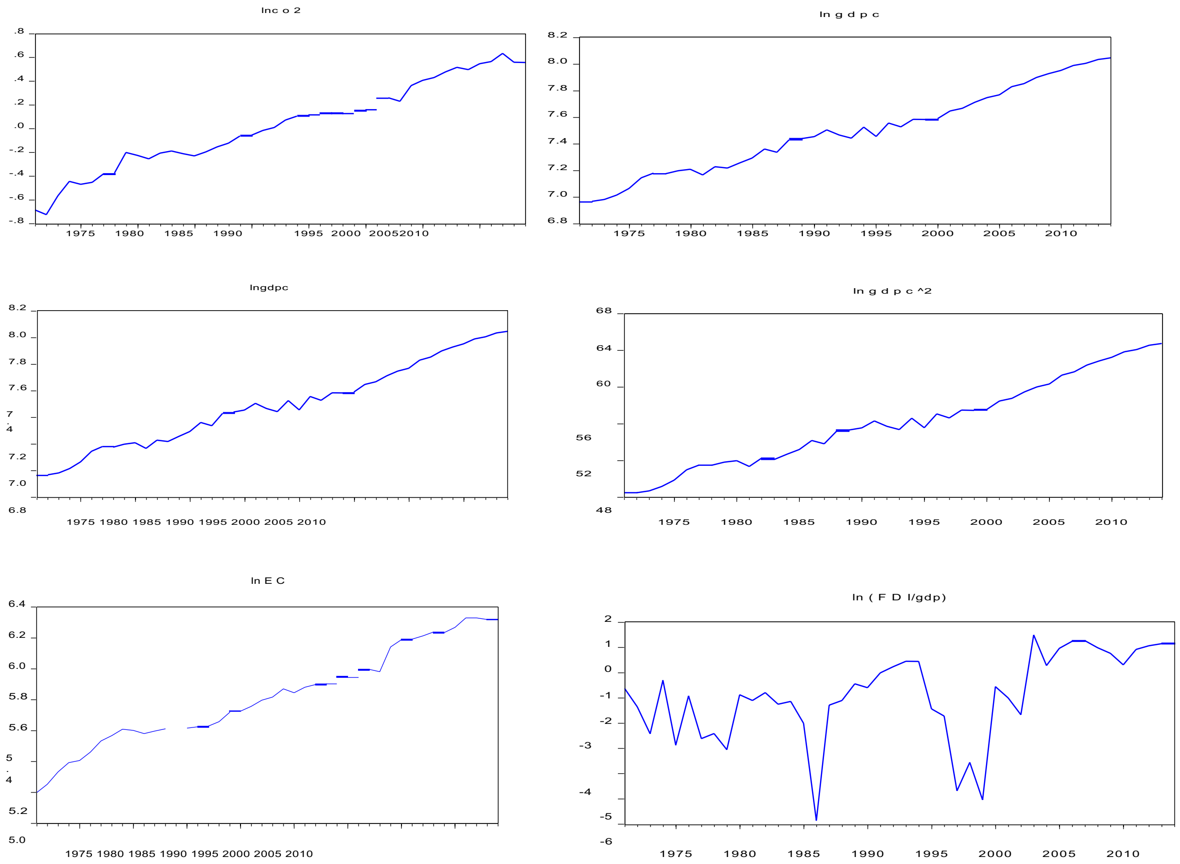
In the literature, some studies in this direction have tried to validate this EKC hypothesis, particularly with (Grossman and Krueger, 1991, Jalil and Mahmud, 2009). Other studies have found results that do not support this hypothesis (Koçak, 2014, Fodha and Zaghdoud, 2010). In the majority of these studies, only two variables were included in their models, notably CO2 emissions and GDP per capita. The relevant literature has also included new variables in the regression like energy consumption in order to test the EKC hypothesis (Apergis and Payne, 2010, Arouri et al, 2012), financial development (Farhani and Ozturk, 2015; Javid and Sharif, 2016), Urbanization (Kasman and Duman, 2015 ; Al Mulali and Ozturk , 2015), trade (Lau et al, 2014; Khler, 2013), institutional factors (Buitenzorgy and Mol, 2011 Leitao;, 2010), tourism (Devita et al. 2015, Ozturk 2016) and in the end, FDI (Acharya 2009; Lau et al. ;2014). These latest studies have led unclear results and remains ambiguous. In these studies, the methods used consider the linearity of the models and omit taking account of structural breaks during the period studied. In the case of Morocco, according to our knowledge, no study has addressed these aspects and this study aims to fill up this gap.

3.Empirical analysis

3.1. Data and EmpiricalSpecification

This study considers time series data set of The World Bank Database. The yearly data consists of FDI, GDP per capita used as a proxy of economic growth and CO2 emissions (metric tons per capita) for the sample period from 1974 to 2011. All variables were transformed into logarithms namely LCO2 , LFDI and LGDP. All empirical tests had been carried out by using the Eviews-10. The time series of CO2 , FDI and GDP are presented in Figure2.

Figure2 : Time series evolution



Following the literature, the model estimated is defined below as:

$$LnCO2_t = \beta_0 + \beta_1 LnY_t + \beta LnY_t^2 + \beta_2 LnEC_t + \beta_3 LnFDI_t + \varepsilon_t \quad (1)$$

Where CO2 represents CO2 emissions, Y represents GDP per capita, Y2 represents square of GDP per capita, EC represents energy consumption, FDI represents Foreign Direct Investment (% of GDP), and ε denotes stochastic error term, normally distributed with zero mean and constant variance. The stochastic error term is assumed to capture all other variables that may influence CO2 emissions that are not in the model. β1, β2, β3, and β4 are the slopes of the explanatory variables while β0 is the drift parameter. Before to carry on this study, we start by checking the order of integration of the variables using the Carrion-I- Silvestre(2009) Unit Root Tests with Breaks. To estimate if there is a long-term relationship between the variables of the model, we use the Maki (2012). In this study, this long-term relationship seems to be confirmed and the model is estimated with the method of Fully Modified least square. Finally, the direction of causality between variables is also verified with a Bootstrap causality test, recent by Hacker and Hatemi-j (2012).

3.2. Unit Root Test under Multiple StructuralBreaks

It is known that in the time series, if there are structural breaks due for example to changes in regulations, economic crises or policies and not taken into account, the standard unit root tests lead to spurious and incorrect results. In this case, Hurlin and al., (2005) noted that the failure to consider structural breaks when they exist may create a bias in favor of non-rejection of the unit root hypothesis. Therefore, it is important to conduct unit root tests allowing these structural breaks. There are several unit root tests with breaks including those of Perron (1989), Zivot and Andrews (1992), Rodriguez (2007) and Carrion-i-silvestre et al, (2009). This last test (CS) accepts break points as endogenous and it is the most developed one since the test can suppose up to 5 structural breaks. The break points are founded by using Bai&Perron (2003) algorithm and quasi GLS method by minimizing residual sum of squares. Another benefit of CS test, it can also be used for small samples (Carrion-i-Silvestre et al., 2009). The results of CS test are summarized in Table 1.

Table 1: Carrion-i-Silvestre et.al. (2009) Unit Root Test with Multiple Structural Break

	P_T	MP_T	MZ_α	MSB	MZ_T	**Break dates**
$LnCO_2$	16.11 (7.60)	15.44 (7.60)	-16.16 (-32.49)	0.17 (0.12)	-2.79 (-4.02)	1974; 1978; 2003
$LnGDPC$	14.52 (8.27)	14.77 (8.27)	-20.8 (-36.48)	0.15 (0.12)	-3.18 (-4.25)	1980; 1992; 2000
$LnGDPC^2$	14.63 (8.15)	13.79 (8.15)	-20.68 (-35.41)	0.204 (0.17)	-3.21 (-2.90)	1980; 1991; 1995
$LnEC$	15.28 (8.07)	14.68 (8.07)	-20.6 (-36.17)	0.15 (0.12)	-3.14 (-4.18)	1979; 1988; 2003
$LnFDI$	12.99 (7.67)	13.13 (7.67)	-20.45 (-35.08)	0.16 (0.12)	-3.19 (-4.14)	1984; 1992; 1999
$\Delta LnCO_2$	4.98** (5.54)	4.53** (5.54)	-20.41** (-17.32)	0.15** (0.17)	-3.18** (-2.9)	-
$\Delta LnGDPC$	5.72* (6.78)	5.87* (6.78)	-15.64* (-13.99)	0.18** (0.17)	-2.79* (-2.61)	-
$\Delta LnGDPC^2$	10.06** (6.75)	10.21** (6.75)	-20.22** (-31.34)	0.16** (0.13)	-3.18** (-3.92)	-
$\Delta LnEC$	4.25** (5.54)	4.38** (5.54)	-20.93** (-17.32)	0.15** (0.17)	-3.23** (-2.90)	-
$\Delta LnFDI$	5.22** (5.54)	5.42** (5.54)	-16.83** (-13.99)	0.17* (0.18)	-2.90* (-2.60)	-

Note: Break years and critical values in brackets are obtained through using the quasi GLS-based unit root tests of Carrion-i- Silvestre et al. (2009).** and * denotes the rejection of the null hypothesis at the 5 % and 10% significance level. In view of the fact that the time period in analysis is short, it has been let 3 structural breaks.

According to the results of Table 1, all series exhibit unit root under multiple structural breaks that means they are non-stationary at their levels. On the other hand, they are stationary at their first differences. So that means that the series of the model are all integrated of order 1 and the long-term relationship between the variables can be studied. This long relationship is examined by Maki (2012) cointegration test considering multiple structural breaks.

3.3. Cointegration Analysis under Multiple Structural Breaks

As in the unit root, it's also plausible to consider the breaks in the long-term relationship between the variables in the regression. In the literature, different methods of cointegration were used considering that the parameters of the variables studied do not change in time. Among these tests, there is the Johansen test (1998,1991) and the Johansen and Juseluis test (1990), which are very well developed. However, these tests do not take into account the structural breaks into consideration and they can lead to a fallacious regression between the variables. The test developed in this work is the Maki cointegration test (20012), which takes into account four models under the assumption that there are several structural breaks:

Model 0: Level shift model (model with break in intercept, and without trend).

$$Y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t+} \beta' x_t + \mu_t \quad (1)$$

Model 1: Regime shift model (model with break in intercept and coefficients, and without trend)

$$Y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_i D_{i,t+} \mu_t \quad (2)$$

Model 2: Regime shift model with trend (model with break in intercept and coefficients, and with trend).

$$Y_t = + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_i D_{i,t+} \mu_t \ (3)$$

Model 3: Model with break in intercept, coefficients, and trend

$$Y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta_i' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t+} \mu_t \ (4)$$

Where t=1,2......T, represents observable variables I(1), μ_t is the error term and y_t is a numeral and an $(m\times1)$ vector. β is the slope coefficient, γ stands for the trend coefficient, and D_i presents dummy variables, also D_i =1 if t>TB, and D_i takes value of 0 otherwise. Also, TB stands for the break date.

Model 0 captures the changes in the level (1) only while model 1 accounts for structural breaks both in the level (l) and regressors (x). Model 2 has trend in additional to model 1. Model 3 captures structural breaks of levels, trends, and regressors (Maki, 2012). This test is based on the following hypotheses: H0: There is not any cointegration relation under structural breaks. H1: There is a cointegration relation under i number of structural breaks.

The rejection of the null hypothesis means that series are cointegrated under structural breaks. Results from Maki (2012) test in this study are summarized in Table 2.

Table 2: Maki (2012) Cointegration Test Results

	Test statistics	Critical values			Break point dates
		1%	5%	10%	
Model 0	-7.73***	-6.85	-6.3	-6.03	1973;1975;1978; 1986; 2006
Model 1	-8.13***	-7.05	-6.49	-6.22	1973;1975;1978; 1986; 2006
Model 2	-6.64	-9.44	-8.86	-8.54	1978; 1986;1997;2002; 2009
Model 3	-11.85***	-10.08	-9.48	-9.15	1979;1984;1992;1999;2008

Note: Critical values and test statistics are obtained from Maki (2012) test. Obtained results are the results of the test allowing for maximum 5 breaks. **, and *** denote 1%, 5%, level of significance respectively.

According to the results, there is a cointegration relation among series for model 0, model 1, and model 3, which means series in the model move together in the long run. In addition, obtained break point dates are meaningful for Morocco. In addition, these breakpoints coincide with the oil crises of the years 73- 75 and the adoption of the structural adjustment plan as well as the changes in reforms that followed this adjustment. In the next step, we will estimate the cointegration relationship with the FMOLS (Fully modified ordinary least square) technique to investigate the long run cointegration coefficients of model including dummy variables of break points. In case that the variables are non-stationary and cointegrated, estimation of the model by ordinary least squares method leads to obtain biased and inconsistent estimators. The Fully Modified Method (FM) originally proposed by Phillips and Hansen (1990), then extended by Phillips (1995), is a semi-parametric estimation procedure parameters of a cointegration relation that allows to correct the long-term endogeneity bias.

3.4. Estimation of Long TermCoefficients

In this study, we estimate the long run cointegration coefficients by FMOLS method, and results summarized in Table 3.

Table 3. The long run FMLOS estimation Results of Cointegration Coefficients

Regressor	Model 0	Model 3
$LnGDPC$	2.15* (0.10)	2.01** (0.05)
$LnGDPC^2$	-0.15* (0.08)	-0.14 (0.04)
$LnEC$	1.11*** (0.000)	0.982* (0.000)
$LnFDI$	0.003* (0.06)	0.004* (0.06)
DU73	0.075*** (0.000)	-
DU75	-0.087*** (0.000)	-
DU78	0.093*** (0.000)	0.06** (0.05)
DU86	0.051*** (0.001)	-
DU06	0.05*** (0.005)	-
DU09	-	0.016 (0.37)
C	-14.21*** (0.007)	-13.05** (0.001)
@TREND	-	0.005** (0.03)
Turning point	**US $ 1296**	**US $ 1311**
R^2	0.996	0.994
$\bar{R}^2$	0.995	0.993

The results in Table 3 clearly show that the parameters are estimated by the FMOLS method. The parameter $LnGPC$ standing for Economic growth is positive and significant at 10% and the parameter $LnGDPC^2$ is highly negative and statically significant at 10%. Therefore we remark that $LnGPC > 0$ and $LnGDPC^2 < 0$, this means that the EKC hypothesis is valid for Morocco during the period 1971-2014. In addition, we calculated the turning point τ ($\tau = \exp(-\beta_1/2\beta_2)$ as defined by Stern (2004). This point reached US$ 1296 for the model0 and US$ 1311 for the model. This means that while economic growth increases CO2 emissions until our economy reaches US these income levels. Another result is related to the effect of FDI on CO2 emissions. According to these results, FDI ($LnFDI$) impacts positively CO2 emissions during the period studied in Morocco for the two selected models. This finding support Pollution haven hypothesis between FDI and CO2 emissions in Morocco. For the last parameter $LnEC$ standing for Energy use, ort Pollution haven hypothesis between FDI and CO2 emissions in Morocco. For the last parameter $LnEC$ is positive and statistically significant at 1% significance level whatever the chosen model. This explains while energy consumption increases by 1%, CO2 emissions increase by 1.11% for model 0 and 0.98% in model 3. Finally, all variables dummies are statistically and significant. These structural breaks are positive excepted the year 1975, which has a negative effect on carbon dioxide emissions. The previous tests carried out do not make it possible to inform us on the direction of causality between the variables. So, we conducted the bootstrap test causality test of Hacker and Hatemi-J (2012). The

following table reports the results.

We deduce that there is only one-way causality of the variables to CO2 emissions and that there is no feedback causality between CO2 emissions to the growth, energy use and FDI. These results support the idea that these variables are candidate variables explaining CO2 emissions in the case of Morocco for the period 1971-2014.

Table 4. Hacker and Hatemi-J (2012) Bootstrap causality test results

Null hypotheses	MWALD statistic	Bootstrap critical values			Decision
		1%	5%	10%	
LnY does not cause lnCO2	7.20**	9.168	5.433	3.865	Reject
Ln CO2 does not cause lnY	2.452	9.321	5.160	3.611	Fail to reject
Ln FDI does not cause lnCO2	3.855*	7.958	4.253	2.913	Reject
LnCO2does not cause lnFDI	2.368	7.784	4.269	2.881	Fail to reject
Ln EC does not cause lnCO2	13.233***	12.307	7.023	4.818	Reject
LnCO2does not cause lnEC	0.707	7.446	4.109	2.879	Fail to reject

Note: Critical values are calculated through bootstrap approach. ***, **,* illustrates respectively statistical significance at 1%, 5% and 10%.

4.Conclusion and policy suggestions

The aim of this study is to investigate the link between the energy consumption, income, Foreign Direct Investment inflows, and CO2 emission in Morocco over the period 1974-2014. Unlike previous studies and considering the period examined, we used different tests taking into account structural breaks. In comparison with the standard unit root and cointegration tests, these tests lead to unbiased results because they take into account the changes that affected all period from 1971 to 2014. These changes may be due to economic crises and institutional changes. This study indicates that there is the long relationship between growth, energy use, FDI and CO2 emissions and this relationship is in one-way direction. This result is shown by the test of Hacker and Hatemi-J (2012). According to the long-term estimation results by the FMOLS method, EKC hypothesis is valid. The turning point is also calculated for Morocco and it is US$ 1296 (model 0) explaining that economic process reduces CO2 emissions at this point. According to World Bank Data, Morocco reached a GDP per capita US$ 3292,445 in 2017. Therefore, in the future, the growing economic process must have a positive impact on quality environment. Concerning the effect of FDI on CO2 emissions, the result shows a positive impact of FDI and this effect is in one way according to the causality test of Hacker and Hatemi-J (2012). That means, for the case of Morocco, PHH hypothesis is supported and while FDI increase, the emissions of CO2 increase in the same direction. Finally, the energy use affects positively the CO2 emissions and this impact is expected.

Empirical findings provide some economic and policy suggestions. First, Morocco should encourage more foreign direct investment in country into technology-intensive and in environmentally friendly sectors and develop regulations in this direction. Therefore, foreign investments will play a crucial role in reducing long-term CO2 emissions. Undoubtedly, these investments can have positive externalities on the economy and Morocco needs to develop its ability to absorb new technologies. For that reason, Morocco must invest more in human capital to support this new process. Finally, the literature highlights the importance of introducing carbon taxes and investing more in new technologies. By following this taxation policy, multinational companies will be able to calculate their profits by investing in environmentally friendly sectors. As a result, FDI can contribute positively and improve the quality of environment in the case of Morocco.

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