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International Journal of Energy Economics and Policy (IJEEP)

Reference: Hfaiedh, Mohamed Ali/Bardi, Wajdi (2021). Does FDI and corruption affect environmental quality in Tunisia?. In: International Journal of Energy Economics and Policy 11 (4), S. 267 - 275.
https://www.econjournals.com/index.php/ijeep/article/download/11089/5920.
doi:10.32479/ijeep.11089.

This Version is available at:
http://hdl.handle.net/11159/7776

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International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(4), 267-275.

Does FDI and Corruption affect Environmental Quality in Tunisia?

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Received: 17 January 2021 **Accepted:** 27 April 2021 **DOI:** https://doi.org/10.32479/ijeep.11089

ABSTRACT

This paper investigates the impact of foreign direct investment (FDI) and corruption on the environmental pollution in Tunisia over the period 1984-2014 by applying an autoregressive distributed lag model. Our results revealed the existence of Environmental Kuznets Curve in Tunisian case. The pollution haven hypothesis postulates that polluting industrial activity in developed countries is shifting to developing countries with less stringent environmental regulations. This hypothesis has been proved. Hence, this study advises to make more aware to the negative effect of corruption. Overall, to improve environmental quality, the findings suggest that Tunisia should promote energy efficiency with sustainable growth. Therefore, results show that Tunisia should encourage more FDI inflows particularly in technology- intensive and environment-friendly industries.

Keywords: Foreign Direct Investment, Economic Growth, CO_2 Emission, Corruption, EKC Hypothesis, ARDL Model
JEL Classifications: F21, O43, O13, C3

1. INTRODUCTION

From the 2000s, Tunisia changed its investment regime; this regime becomes increasingly open to opening up its multinationals borders. Economic policy's evolution could have technological spin-offs, facilitate integration with international trade, contribute to the formation of human capital, and favor the creation of many competitive business climates. If FDI flows are combined with other factors, they may play a positive role in growth. FDI flows may have explanatory factors of growth such as labor, capital, technical progress, the level of human capital, infrastructure, the level of financial development etc. Recently, a new factor emerges as a determinant of the location of companies abroad: the quality of environment (Erdal et al [2008], Frankel and Rose [2005] Haisheng et al [2005] and Managi [2004]).

This determinant was evoked Al-Mulali and Tang (2013), Pao and Tsai (2011), Dong et al. (2010), stating that developed countries, are concerned about protecting their environment and would abandon polluting activities for the benefit of developing countries. In these countries environmental regulations are lax. This is illustrated by the hypothesis of "pollution haven". However, several authors claim that this situation is inferior to reality. They reclaim that the classical theory of factor endowments remains dominant (Jaffe et al. [1995], Wheeler and Ashoka [1992]). However, the work of List and Co (2000), Keller and Levinson (2002) and Smarzynska and Wei (2001) found a statistically significant effect of environmental regulation on investment choices. Dean et al. (2005) invalidate the hypothesis of pollution haven in the case of China. Indeed, they show that a lax environmental policy determines the attractiveness of a Chinese province.

The relationship between FDI and the environment quality has been discussed for some time. Moreover, it has become clear that this relationship is increasingly dependent on the quality of the institutions and the behavior of the men who make it up. Indeed, corruption can go as far as influencing the choices and direction

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of public spending (Leite and Weidmann, [1999], López and Mitra [2000] and Mendez and Sepulveda [2006]).

The purpose of this article is twofold. First, we examine the existence of the Kuznets curve for the case of Tunisia over the period 1984-2014. We use the ARDL estimation technique. This technique has the particularity of taking into account the temporal dynamics in the explanation of a variable, thus improving the forecasts and the effectiveness of the policies. Second, we will investigate the relationship of corruption, FDI inflow, and environmental quality for the case of Tunisia. The choice of Tunisia, was motivated by the fact that this nation to start making economic and fiscal reforms to attract more foreign capital to support its economic growth.

The main results show that the environmental curve of Kuznets is verified for the case of Tunisia. In addition, the capital/labor ratio variable has a negative sign, which shows that the composite effect does not play in Tunisia. Thus, the capital/labor ratio has a negative effect on the quality of the environment. While the effects of foreign direct investment are of negative and significant sign. The corruption index has a positive and statistically significant coefficient. Thus, corruption has a negative effect on the quality of the environment.

The rest of the article is organized as follows: the second section will be devoted to a review of the literature. In the third section, we will present the methodology of our analysis; in the fourth section, we will present our empirical results. Finally, we give our conclusion in the last section.

2. REVIEW OF THE LITERATURE

On the theoretical level, the model of Antweiller et al. (2004) show that, through specialization and exchanges, rich countries, concerned about their environment quality, should relocate their polluting activities in developing countries, generally characterized by quality environmental regulations not enough rigorous. This is the "pollution haven" hypothesis, according to which such havens should be located in developing countries. However, for other authors, such pollution havens do not really exist. Their findings support another theoretical approach based on the classical theory of factor endowments. Therefore, capital-intensive activities will generally be the most polluting and should be located in developed country.

Empirically, the link between FDI and quality environment is not clearly identified. Kolstad and Xing (1998) empirically test the effect of the stringency of environmental regulation on the location of polluting industries. They provide a negative linear relationship between the outflows FDI of US from the chemical industry and the stringency of environmental regulation in the foreign country. Nevertheless, this relationship is not clear for FDI in less polluting industries.

Cole and Elliott (2006) highlight an inverse relationship between FDI and environmental regulation. FDI influences environmental policy. This effect is a function of corruption degree in the host country. The authors show that with a high level of corruption, FDI leads to a less rigorous environmental policy.

In addition, lax environmental regulation is a source of the attractiveness of polluting FDI flows. This result is confirmed by Cole (2004) in their study of outward FDI from the United States to developed and developing countries. They studied two types of manufacturing industries using a panel data model covering the period 1982-1992. Their results show that the rigor of environmental regulation impacts investment decisions, as there is an inverse relationship between environmental standards and FDI flows to developing countries.

Aliyu (2005) examine, during 1990-2000 period, the effect of environmental standards on outward FDI in 11 developed countries and 14 developing countries. The results show a positive correlation between FDI coming out of polluting industries and the rigor of environmental policies in developed countries. According to the author, developing countries should continue to attract FDI because of their contribution to GDP and economic growth. The empirical study shows that FDI is environmentally friendly. Although in OECD countries, economic growth and strict environmental policies approximated by environmental taxes and raising production costs have increased the amount of FDI abroad.

In developing countries, empirical analyzes of relationship between FDI and environment quality remains very modest (Smarzynska and Wei, 2001; Eskeland and Harrison, 2003; He (2006) and Baek and Koo, 2009; Le and Ozturk; 2020; Khan and Ozturk, 2020; Salahuddin et al., 2018; Ozturk et al., 2019; Baloch et al., 2021). Xing and Kolstad (2002) examine the impact of US FDI on the environment quality in developed and developing countries. They prove that developing countries practice lax environmental regulation as a strategy to attract polluting industries, thus compounding their environmental problems. He (2006) apprehends the link between FDI and the environment in China and finds that the increase of FDI flows undermines the environment quality.

Baek and Koo (2009) examine the short and long-term relationship between FDI, economic growth (measured by GDP per capita) and environmental quality (measured by CO_2 emissions) in China and India using the ARDL approach. They find a positive and significant relationship between CO_2 emissions and FDI in China. This indirectly confirms the hypothesis of pollution haven. For India, inward FDI has a negative effect on the environment in the short term but has little impact in the long term. Finally, there is a positive relationship between CO2 emissions and GDP for China and India.

Baek (2015) examine the effect of FDI, growth and energy consumption on CO_2 emissions. He studied five developing countries (Myanmar, Vietnam, Cambodia, Malaysia and the Philippines) during 1981-2010. He notes that FDI, all else being equal, appears to increase CO_2 emissions, confirming the negative effect of the pollution haven hypothesis. It shows that, given that FDI is a driver of economic growth in developing countries if these countries put in place environmental regulations to control CO_2 emissions, there will be a corresponding reduction in FDI inflows and therefore economic growth. In his econometric study, he splits the data into two income groups. The results show that FDI increases CO_2 emissions for countries with low incomes. But for high-income levels, they reduce them. On the other hand, it leads to the fact that income and energy consumption also have a negative effect on the reduction of CO_2 emissions. Finally, he concludes that, since growth impacts energy consumption, any attempt to promote economic growth in developing countries causes a corresponding increase in CO_2 emissions. Moreover, according to the author, if these countries want to maintain the current level of their economic growth, they should try to move from the use of fossil fuels to less polluting technologies so that CO_2 emissions, globally, decrease.

Sarmidi et al. (2015) consider 110 countries over the period from 2005 to 2012 they examined the dynamic relationship between inward FDI, pollution regulation and corruption. The authors use the generalized moments method (GMM) in the dynamic panel. The results suggest that the rigor of environmental regulation has a negative effect on FDI and that high levels of corruption attract FDI. In fact, contrary to previous findings, their results show that strict environmental regulations associated with low levels of corruption attract more FDI. In other words, a good quality of the institutions could cancel out the negative effect of the rigor regulation of pollution.

Umer et al. (2014) examine the relationship between trade openness, public sector corruption, and environmental degradation, using data from 12 Asian countries over the period 1995 to 2012. The results of their different estimations have shown that the trade openness generated by government efficiency implies that corruption in the public sector positively influences trade policies. The government can import devices to reduce pollution. In addition, the economic growth generated by trade openness also has a negative impact on pollution, so trade openness is good for the environment. Finally, the implementation of environmental regulations depends on the level of corruption. Indeed, if government policies are effective, then consumers are willing to pay for a healthy environment.

3. EMPIRICAL ANALYSIS

3.1. Methodology and Data

By taking the Tunisian context, our proposed model aims to examine the nature of relationship among FDI, corruption, and environment quality. It is largely inspired by the empirical work of Kim and Baek (2011) and Pao and Tsai (2011). The equation to estimate has the following structure:

$$\boldsymbol{lnY_t = \alpha_0 + \alpha_1\, lnPIB_t + \alpha_2\, ln(PIB_t)^2 + \alpha_3\, lnKL_t + \alpha_4\, lnFDI}\mathrm{t} + \boldsymbol{\alpha_5\, lnINS}\mathrm{t} + \boldsymbol{\alpha_6\, lnCor + \varepsilon t}$$

We use a time series in which index *t* refers to observation years 1980-2014. αt indicates the constant specific effects. The variable (Y_t) is a measure of the environmental quality estimated by CO_2 emissions and methane emissions respectively. The variable (*GDP*) measures income per capita; in addition to its role of capturing the effect of scale, it is a pollution reduction factor, that is, a measure of the technical effect. The ratio (*KL*) describes the composition effect (we expect a positive coefficient of this ratio). The variable (*INS*) quantifies the effects of the quality of institutions on pollution emissions. The variable (Cor) is the corruption index. In addition to it is important to note that all our variables are logarithms. The variables used in our econometric study are presented in Table 1.

3.2. Econometric Methodology

We use the ARDL approach in time series. This approach is proposed by Pesaran et al. (1996), and modified by Pesaran et al. (2001) who introduced boundary testing approaches. The choice of this technique has been made for two main reasons. First, it is effective for the study of short and long-term relationships between different variables that do not have the same order of integration when studying the stationarity of the variables. Thus, the essential condition is that these variables are stationary in levels, I(0), and/or that they are in first differences, I(1). Then, the ARDL approach can remove problems related to omitted variables and autocorrelation problems between variables.

3.2.1. The wald test

Before performing the unit root tests, it is necessary to use the Wald test to check if there is a long-term relationship between the different variables. The Wald test places some restrictions on long-term estimates. From the results given in Table 2, the value of the F statistic shows that it is significant at 1%, so the long-term (non-cointegrated) null hypothesis is rejected. Hypothesis H_1 is accepted, which means that there is a long-term relationship.

Both models are verified under the H1 hypothesis, which means that there is a long-term relationship between the different model variables.

Table 1: Definition of variables

Variables	Definition	Sources
CO2	CO_2 emissions (metric tons per capita)	World Development Indicators (WDI), 2017
NO2	Methane emissions (kt of CO_2 equivalent)	World Development Indicators (WDI), 2017.
FDI	Net inflows of foreign direct investment per capita	World Development Indicators (WDI), 2017.
Cor	Corruption index	International Country Risk Guide (ICRG)
edu	Scolarisation rate	World Development Indicators (WDI), 2017
GDP	GDP per capita, (2011 constant international PPP $)	World Development Indicators (WDI), 2017
KL	The composition effect is measured by the capital-labor ratio	Penn World Table (Feenstra et al, 2015)
im	Imports as a percentage of GDP	World Development Indicators (WDI), 2017
dev	Loans granted to private sectors by banks	World Development Indicators (WDI), 2017

3.2.2. Nonlinearity test and unit root tests

Before estimating our model, it is useful to carry out stationarity tests and non-linearity tests of the variables used as necessary conditions. Thus, all the variables have ascending or descending tendencies and have broken. To answer these questions, we use the BDS non-linearity test (Brock et al., 1987) to test the nonlinearity of the series. Indeed, the BDS test detects the assumption with an independent and identically distributed data used in the analysis. The BDS test detects nonlinear dependence in time series. In fact, this test can avoid false detections of critical transitions due to poor model specification. The H_0 rejection implies that there is a residual structure in the time series, which could include a hidden non-linearity or a bad structure generated by the fit of the model. In addition, the BDS test is a two-sided test; we should reject the H_0 hypothesis if the BDS test statistic above or below critical values. Table 3 provides the BDS statistics for all the logarithmic variables included in this study. The results suggest strongly that all series (for a standard error $p = 1$ and for several inclusion dimensions $m = 2, \ldots, 6$) reject the null hypothesis at a significance level of 1% implying non-normality and the non-linearity of the series by inference.

Since the ARDL model couldn't be applied to series exceeding an integration in order 2 (I (2)), we emply unit root tests to ensure that the series is I (0) or I (1) or both are I (1) and I (0) (Pesaran et al. (1996) and Pesaran et al (2001)). We use at the three different types of time-series unit root tests: the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test. The table below lists the unit root tests ADF, PP, and KPSS.

Table 4 shows that the null hypothesis of a unit root cannot be rejected for CO_2 emissions, methane emissions, economic growth (GDP per capita growth), measurement of the quality of institutions, capital ratio, the ratio of imports to the percent of GDP, enrollment ratio, and credit to the private sector by banks. On the other hand, the foreign direct investment variable is stationary in levels. In summary, we note that our data are I (0) and I (1), which gives us the possibility to estimate both the short-term relationship and the long-term relationship between the environment quality, corruption index and foreign direct investment flows using an ARDL approach.

3.3. Application of the ARDL Approach and Cointegration Tests

According to the diagnostic tests, the conditions leading to efficient and unbiased estimators by OLS application are satisfied. Indeed, the residue tests prove that diagnostic tests follow a normal distribution (Jarque-Bera test) and that they are not autocorrelated (Appendix, Table A1). The Ramsey RESET test rejects the hypothesis of specification errors. Finally, the CUSUM and CUSUM square tests show that estimated parameters are stable over the estimation period (Appendix, Figures A1 and A2). They illustrate respectively the results for the CUSUM test and the CUSUMSQ test indicating the absence of coefficient instability because the curve of the CUSUM and CUSUMSQ statistics falls within the critical bands of the confidence interval when the stability parameters are equal at 5% (Pesaran and Pesaran [1997]).

Cointegration tests based on the ARDL approach (Bounds test) reject the hypothesis of absence of a long relationship. The values

Table 2: Wald test results

Test statistic	Value	df	Probability	Test statistic	Value	df	Probability
F-statistic	2.82367	(8, 11)	0.0017*	F-statistic	2.2379	(9, 14)	0.0085*
Chi-square	12.3022	7	0.0175	Chi-square	14.3646	7	0.0045

*, ** et *** significant at 1%, 5% et 10%

Table 3: BDS test results

m	Lnco2	Lnno2	Lngdp	Lnfdi	Lnkl	Lncor	Lnm	lnedu	lndev
2	0.1496	0.0610	0.1895	0.1041	0.1529	0.1540	0.1024	0.1949	0.0701
3	0.2538	0.0594	0.3132	0.1831	0.2229	0.2533	0.1749	0.3231	0.0814
4	0.3260	0.0455	0.3958	0.2259	0.2348	0.2977	0.2237	0.4084	0.0608
5	0.3794	0.0432	0.4493	0.2454	0.1934	0.2927	0.2464	0.4703	0.0207
6	0.3992	0.0396	0.4839	0.2489	0.0919	0.2612	0.2554	0.5220	0.0422
Significativity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4: Results of unit root tests

Variables	ADF		PP		KPSS		Level of integration
	In level	In first difference	In level	In first difference	In level	In first difference	
Lnco2	0.0823	−8.9916*	−0.0314	−9.0258*	0.7090	0.0982*	***I (1)***
Lnno2	−1.5534	−4.9882*	−1.6062	−5.0261*	0.3767	0.2739*	***I (1)***
Lngdp	−0.1834	−5.3790*	−0.2209	−5.4486*	0.6422	0.1711*	***I (1)***
Lnfdi	−2.9696**		−2.9730**		0.4630***		***I (0)***
Lnim	−1.3826	−6.6439*	−1.3560	−6.7142*	0.1184	0.5763*	***I (1)***
Lncor	−1.6682	−6.0335*	−1.6682	−6.0315	0.4201	0.0863*	***I (1)***
Lnkl	1.3435	−4.2660	1.2377	−4.2950	0.4717	0.3389	***I (1)***
Lnedu	0.4437	−2.4229*	0.3230	−2.6072*	0.7374	0.1681*	***I (1)***
Lndev	−0.3162	−3.3488*	−1.8468	−5.3399*	0.2819	0.1083*	***I (1)***

** and * indicate, respectively, a significance at 5% and 1%

of the "F statistic" given in Table 5 confirm that there are long-term cointegration relationships in both models. The results of the Bounds test show that the F-statistics values (5.2219 for model 1 and 5.1598 for model 2) which above the critical level thresholds of 1%, 2.5%, 5%, and 10%, respectively. Consequently, H0 hypothesis is rejected, so hypothesis H1 is accepted. H1 confirms the existence of long-term cointegrating relationships.

The 20 best models are given on the basis of the Akaike Information Criteria (AIC) (see appendix, Figures A3). The criterion for choosing the best delay for the ARDL is the smallest value of AIC. For both models this criterion shows that ARDL model (1,1,1,0,1,1,1,1,1,1,1) is the best for the estimation of the model 1 and the best ARDL model is (1,0,0,0,1,1,0,1,0) for the estimation of model 2.

4. RESULTS AND INTERPRETATION

In the results presented in the table below, the first difference of the variables examined is designated by Δ. The term CointEq (−1) defines the delayed residue from our long-term equilibrium equation. Thus negative sign of its estimated coefficient for the two models confirms the presence of an error correction tool. The coefficient of cointegration of the equation explains the order when the variable Yt (CO_2 emissions and methane emissions) will be mobilized towards the long-term goal. For our model ARDL, this coefficient is estimated at −1.1816 for model 1 and at −1.0419 for model 2. In addition, the short-term results indicate that the Kuznets environmental curve is verified for both models in the case of Tunisia. The corruption index is positive and significant. The coefficient of the FDI is of the negative and significant sign.

In the long run, and based on the results given in Table 6, we note that the Kuznets environmental curve is checked in the case of Tunisia in both models with significant coefficients. Indeed, the coefficient of the growth variable of GDP per capita is of positive sign and that of the growth of GDP per capita squared is of negative sign. This sign shows the existence of a relation of second order and a relation concave between these two variables.

The coefficient of the capital/labor ratio variable has a negative sign, which indicates that the composite effect does not play in Tunisia. Thus, the capital/labor ratio has a negative effect on the quality of the environment. The sign of foreign direct investment is negative and significant. Due to the FDI entering to Tunisia is not very capital intensive; result can be explained, generally related to the textile sector (Ayouni and Bardi [2018] and Bardi et al [2019]). In addition, the corruption index has a positive and statistically significant coefficient. Thus, corruption has a negative effect on the environment quality. We conclude that the quality of institutions prevents Tunisia from effectively implementing its environmental policy following an increase in income. Finally, the financial development variable acts positively on the quality of the environment.

Table 5: Bound test result

Test statistic	Model 1		Model 2	
Statistic test	Value	K	Value	K
F-statistic	4.9750***	7	4.6577****	7
Critical value bounds				
Significance	I0 Bound	II Bound	I0 Bound	II Bound
10%	2.03	3.13	2.03	3.13
5%	2.32	3.5	2.32	3.5
2.5%	2.6	3.84	2.6	3.84
1%	2.96	4.26	2.96	4.26

Table 6: Results of ARDL approach

Variables	Depends variable: *lnCO*$_2$			*LnNO2*		
	Coef.	Std. Err	P value	Coef.	Std. Err	P. value
Short-run coefficients						
lnGDP	15.2630	9.1545	0.1236	2.3853	9.6099	0.8073
lnGDP2	−0.9688	0.5820	0.1242	−0.1823	0.6110	0.7695
lnKL	−1.1883	0.3293	0.5789	−0.1152	0.5842	0.8462
lnFDI	−0.0078***	0.0105	0.4702	−0.0044	0.0200	0.8266
lnm	−0.1170	0.3028	0.7064	−0.2625	0.1341	0.0693
lncor	0.2496	0.4036	0.5488	0.4443*	0.1483	0.0091
lnedu	0.3990**	0.1652	0.0343	0.017	0.0971	0.8564
lndev	−0.0037	0.0967	0.9697	0.0958	0.1583	0.5541
(lncor*lnm)	0.0850	0.3362	0.7863	_	_	_
CointEq(−1)	−1.1816*	0.2251	0.0003	−1.0419*	0.2277	0.0004
Long-run coefficients						
LnGDP	3.8272**	4.7564	0.0438	2.2893	9.3757	0.0810
LnGDP2	−0.2759**	0.3030	0.0382	−0.1750***	0.598	0.0538
LnKL	−0.5009	0.2653	0.0857	−0.1106	0.5658	0.8476
LnFDI	−0.0076*	0.0143	0.0066	−0.0412	0.0326	0.2265
Lnm	−0.7290**	0.3680	0.0431	−0.0955	0.1588	0.5566
Lncor	1.2460*	0.4857	0.0263	0.4264**	0.0982	0.0459
Lnedu	0.3376*	0.1536	0.0503	0.1545	0.3639	0.6771
Lndev	−0.1101	0.1042	0.3133	−0.1226	0.1774	0.5000
Lncor*Lnm	0.8752*	0.3459	0.0280	_	_	_
C	18.7661	20.9378	0.3893	16.1260	41.9308	0.7059

– *, ** and *** indicate the meaning respectively 1%, 5%, 10%. Δ: Operator first difference of the variables, CointEq (-1): The delayed residue from the long-term equilibrium equation

5. CONCLUSION AND IMPLICATIONS

Our work addresses the problem of the environmental situation and the question of the sustainability of development, which should be one of the priorities of the Tunisian economy. In the econometric methodology, we first used the Wald tests, the Bounds test, and the unit root tests to test the stationary properties of the series and the long-term cointegration. Thus, from these tests, we concluded that, to test cointegration, the use of the ARDL approach is possible and it's considered more appropriate than the Johansen and Juselius (1990) approach.

Our results show that, on the one hand, the CEK is detected in the Tunisian case, assumes that there is an inverted U relationship between pollutant emissions and per capita income level. This notion breaks with the pessimistic view which economic growth is a source of environmental degradation (Payne [2010], Haisheng et al [2005], Galeotti et al [2006], Dijkgraaf and Vollebergh [2005] and Bardi and Hfaied [2021]). On the other hand, the effects of FDI and corruption are important which elaboration in environmental strategy. Some investments are considered as sources of pollution related to CO_2 emissions. These investments have an impact on climate change, especially global warming. The results finding for the first equation is in line with most of the relevant studies (Halicioglu (2009), Jalil and Mahmud (2009) and Kankesu et al. [2012]).

A significant difference in environmental policy between countries is shifting foreign investment from industrialized countries. The environmental policy of these countries is rigorous to developing countries where environmental policy is lax. This situation could harm the process of technology transfer brought by FDI through their positives externalities. However, for this effect to take place, a level of economic stability and quality of institutions are required. In addition, it is important to develop the knowledge and skills of local businesses so that the country can benefit from the environmental benefits of FDI. Thus developing countries have an interest in attracting better-performing foreign firms to take advantage of technological externalities, thereby promoting their sustainable development.

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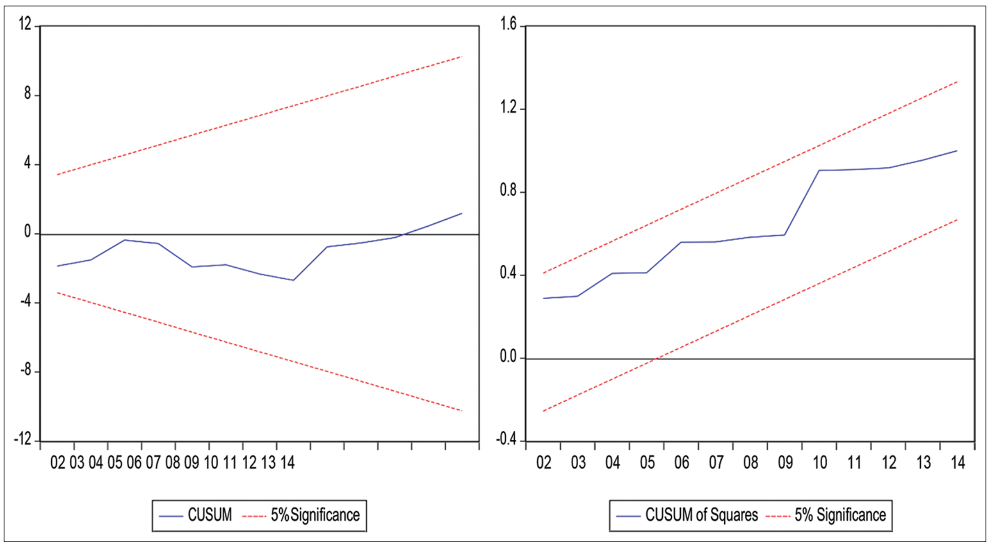
APPENDIX

Table A1: Results of the autocorrelation test

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.150	-0.150	0.6800	0.410
		2	-0.318	-0.348	3.8405	0.147
		3	0.030	-0.101	3.8702	0.276
		4	0.163	0.045	4.7767	0.311
		5	-0.357	-0.389	9.3082	0.097
		6	-0.123	-0.281	9.8699	0.130
		7	0.264	-0.077	12.606	0.082
		8	-0.168	-0.460	13.766	0.088
		9	0.126	0.057	14.456	0.107
		10	0.019	-0.366	14.473	0.153
		11	0.106	-0.187	15.020	0.182
		12	-0.039	-0.036	15.100	0.236

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.243	-0.243	1.8358	0.175
		2	-0.109	-0.179	2.2229	0.329
		3	0.098	0.025	2.5452	0.467
		4	-0.140	-0.137	3.2290	0.520
		5	0.019	-0.039	3.2428	0.663
		6	-0.173	-0.245	4.3890	0.624
		7	-0.192	-0.352	5.8708	0.555
		8	0.086	-0.225	6.1836	0.627
		9	0.269	0.187	9.3768	0.403
		10	-0.229	-0.188	11.822	0.297
		11	0.149	0.004	12.920	0.299
		12	0.058	-0.081	13.096	0.362

Figure A1: CUSUM test and CUSUMSQ test. Model 1



FigureA2: Model2

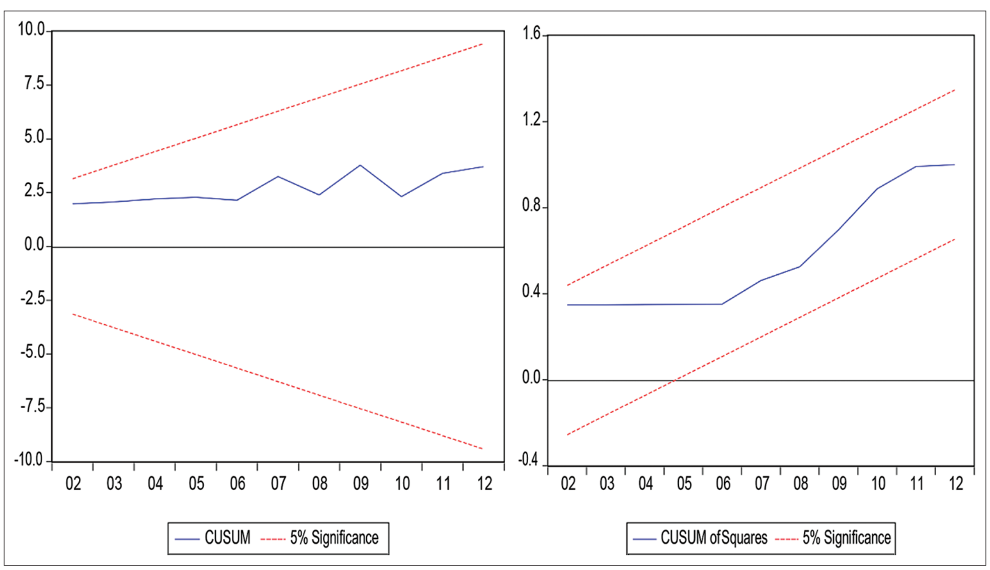


Figure A3: The criteria of Akaike (AIC)