How Does Informal Economy Affect Ecological Footprint? Empirical Evidence from Saudi Arabia

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Abstract: Given the increase in the informal economy in developing countries economies, a better understanding of the effect of the informal economy on environmental degradation is essential for policy makers. The aim of this study is to examine the impact of the informal economy (IFE) on the ecological footprint (EFP) in Saudi Arabia during the period 1981-2017. An autoregressive distributed lag model (ARDL) was used to test the long-term relationship between the examined variables. It determined which variable was causally related to the other using Granger causality analysis. The long-run coefficients of ARDL showed that the IFE had a positive influence on ecological footprint in Saudi Arabia in the long run. In contrast, EFP can increase the informal economy. The Granger causality based on VECM approach shows bi-directional causality between EFP and IFE in the short run and the long run. Therefore, the findings of this study can help policy makers in Saudi Arabia and a number of countries with a large informal sector to better understand the role of governance in reducing the IFE in order to improve the environmental quality.

Keywords: ARDL; Ecological footprint; Shadow economy; Saudi Arabia.

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1 Introduction and Literature Review

The informal economy employs more than half of the global workforce and more than 90% of micro and small enterprises worldwide, [1]. Informality is a prominent feature of global labor markets, with millions of economic units operating and hundreds of millions of workers earning their living in informal conditions ([2]; [3]). The term "informal economy" covers a wide variety of situations and phenomena. The informal economy manifests itself in various forms from one country to another or within economies. Formalization measures and processes aimed at fostering the transition to formality must be adapted to the particular circumstances encountered in different countries and categories of economic units or workers ([4]). Although the informal economy plays a positive role in alleviating poverty and providing employment and income to some disadvantaged groups, especially in developing economies, the informal sector poses potential long-term risks to sustainable development ([5]; [6]; [7]).

Informality is only directly addressed by one target of the Sustainable Development Goals (SDGs), namely target 8.3. Indirectly, several other SDGs on poverty (SDG 1), gender equality (SDG 5), inequality (SDG 10), institutions (SDG 16), and partnerships (SDG 17) are also important for informality. Sustainable development is considered the ideal paradigm of development and the search for the satisfaction of three objectives: environmental protection, economic efficiency and social equity ([8]; [9]; [10]).

Over the past decades, several articles have investigated the relationship between environmental degradation and a set of macroeconomic variables. The link between the informal economy and environmental quality has received little attention in the academic literature ([11]; [12]; [13]). According to this empirical perspective, developing countries have a large informal economy as a percentage of formal gross domestic product (GDP) ([14]). Studies that ignore the informal economy can lead to biased conclusions when it comes to the link between environmental degradation and economic growth.

Several fields have benefited from the contribution of this current study to environmental economics literature. This paper is the first to tackle the informal economy's (represented by GDP growth) role in environmental degradation in Saudi Arabia ([15]; [16]; [17]; [18]). This study is needed, however, because the informal sector is neglected when it comes to environmental issues. Economic activities have an environmental impact that is not adequately represented by the formal economy. Second, this study uses the Ecological Footprint (henceforth EFP) as a proxy for environmental degradation. Previous studies used CO_2 emissions, methane emissions and PM4 ([19]; [20]; [21]; [17]) as a proxy for environmental pollution. Although these indicators are widely used in the existing literature, they do not reflect the entire natural habitat ([22]); while increasing technological progress and regulatory framework could reduce CO_2 emissions.

Additionally, this study examines the causal directions between informality and EFP. Studies that examined causal relations between economic growth and environmental degradation without acknowledging the influence of the informal economy tend to be inconclusive. In Mexico, [23] demonstrated a one-way causal relationship between economic growth and environmental pollution; in China and Malaysia, [24] confirmed it. Meanwhile, in [25], [26], and [27] the authors found that pollution is causally related to economic growth unidirectionally, while studies by [28] and [29] found that environmental degradation did not have a negative impact on economic growth. Environmental degradation and the informal economy need to be investigated to contribute significantly to existing studies.

The remainder of the paper is organized as follows. Section 2 presents the data and methodology; section 3 presents the empirical results, and the conclusion and policy recommendations are discussed in the final section.

2 Data and Methodology

2.1 Data

The analysis focuses on the case of Saudi Arabia during the period 1981-2017 to study the effect of the informal economy in addition to the formal economy on the ecological footprint. The main variables of the analysis are the formal GDP per capita (EF), the informal GDP per capita (IFE) and the ecological footprint per capita (EFP). the Ecological Footprint per capita (EFP) is used as a proxy for environmental degradation. The EFP measures human activities in six main areas. Data for FFP is obtained from the Global Footprint Network (2021). The informal economy refers to all illegal activities. Data on the informal economy are from [30]. GDP per capita is expressed in US dollars (constant 2015), the informal economy (in % EF) and the ecological footprint per capita in global hectares (gha) per capita. Urbanization (URB) is Urban population (% of the total population). The other variables are used as control variables, namely trade openness (TOP) is calculated as the ratio of imports and exports to gross domestic product (GDP). Data on EF, TOP and URB were taken from the World Bank database (World Development Indicators ([31])).

2.2 Methodology

In order to test the long-term relationship between the informal economy, the ecological footprint, the formal economy, urbanization and trade openness for the case of Saudi Arabia, our article is based first on the tests of Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root to determine the order of variables. The second step is to study the long-term equilibrium relationship between the variables using the ARDL approach. Finally, the Granger causality test is used to examine the direction of the causal relationship between variables. Indeed, the determination of the order of the variables is a necessary preliminary step before proceeding to the ARDL analysis which only accepts the integrated variables of order I (0) and I (1). Unit root tests are therefore used in order to avoid the inclusion of I(2) variables. In our article, two types of unit root tests are used; namely, the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) test. Then, in order to determine the short- and long-term co-integration between the variables, the autoregressive distributed lag model ARDL, recently developed by [32], is used. Indeed, this approach allows better results when the study concerns a small sample, which is our case. Comparing it to other traditional cointegration methods, this method has three advantages. The first is that it does not require the variables to be integrated in the same order of integration, the variables can be integrated in the same order or in a different order. In other words, they can be I(1) and I(0) but never of an order greater than one. The second advantage is that this method is more efficient than the others in case the sample sizes are small. The third and final advantage is that the ARDL method provides unbiased estimates of the long-term coefficients ([33]). As we can see, we have two key variables (EFP and IFE), and our approach is to work on two models, the idea is that each of the variables occupies the role of the dependent variable in the model.

However, for economic interpretation reasons and in order not to depart from the framework of the problem we posed at the start, we are going to use two models instead of five. This means that only two variables will move to the left side of the model and will occupy the role of the dependent variable in the latter; namely, the ecological footprint and the informal economy. The other three remaining variables- i.e., economic growth, trade openness and urbanization- will occupy the role of control variable in the two models. The ARDL models used in this work are:

$$\Delta EFP_t = \alpha_{01} + \alpha_{11} EFP_{t-1} + \alpha_{12} IFE_{t-1} + \alpha_{13} X_{t-1} + \sum_{i=1}^{m-1} \beta_{1i} \Delta EFP_{t-i} + \sum_{i=0}^{k-1} \beta_{2i} IFE_{t-i} + \sum_{i=0}^{k-1} \beta_{3i} X_{t-i} + \omega_{1t} \quad (1)$$

$$\Delta IFE_t = \alpha_{02} + \alpha_{21} EFP_{t-1} + \alpha_{22} IFE_{t-1} + \alpha_{23} X_{t-1} + \sum_{i=1}^{m-1} \lambda_{1i} \Delta IFE_{t-i} + \sum_{i=0}^{k-1} \lambda_{2i} EFP_{t-i} + \sum_{i=0}^{k-1} \lambda_{3i} X_{t-i} + \omega_{2t} \quad (2)$$

Where EFP is the ecological footprint, IFE is the informal GDP. The variables X_{it} $(i = 1, 2, 3)$ represent the control variables of the model, namely economic growth, trade openness and urbanization; Δ represents the first difference operator. The parameters α_{1i} $(i = 1, 2, 3)$ and α_{2i} $(i = 1, 2, 3)$ characterize the long-term equilibrium between the variables while the coefficients β_{1i}, β_{2i}, β_{3i} and λ_{1i}, λ_{2i}, λ_{3i} represent the short-term dynamics of the series studied; k and m are the optimal delay of the model selected using the Akaike and Schwarz information criteria.

The first step of the ARDL cointegration approach is to carry out the bounds test in order to test the existence of a long-term relationship between the variables. The test statistic is the F-statistic. For equation (1), the null hypothesis is $H_0^1 : \beta_{1i} = \beta_{2i} = \beta_{3i} = 0$ and $H_0^2 : \lambda_{1i} = \lambda_{2i} = \lambda_{3i} = 0$, reflecting the absence of a long-term relationship. The alternative hypothesis is expressed as follows: $H_1^1 : \beta_{1i} \neq \beta_{2i} \neq \beta_{3i} \neq 0$ and $H_1^2 : \lambda_{1i} \neq \lambda_{2i} \neq \lambda_{3i} \neq 0$. The calculated F-statistic is compared to two sets of critical values estimated by [32]. The first represents the lower bound and corresponds to the variables of the model which are stationary and the second represents the upper bound and corresponds to the integrated variables of order 1. Then, the calculated F-statistic is compared to the two bounds: (1) if the value of the F-statistic exceeds the upper bound, we reject H_0; (2) if the value of the F-statistic is less than the lower bound, we do not reject H_0; (3) if the value of the F-statistic is between the two limits, it is not possible to conclude.

If there is a long-term relationship between the variables, the ECM model presented below will be estimated:

$$\Delta EFP_t = \alpha_{01} + \eta ECT_{t-1} + \sum_{i=1}^{m-1} \beta_{1i} \Delta EFP_{t-i} + \sum_{i=0}^{k-1} \beta_{2i} IFE_{t-i} + \sum_{i=0}^{k-1} \beta_{3i} X_{t-i} + \omega_{1t} \quad (3)$$

$$\Delta IFE_t = \alpha_{02} + \delta ECT_{t-1} + \sum_{i=1}^{m-1} \lambda_{1i} \Delta IFE_{t-i} + \sum_{i=0}^{k-1} \lambda_{2i} EFP_{t-i} + \sum_{i=0}^{k-1} \lambda_{3i} X_{t-i} + \omega_{2t} \quad (4)$$

The error correction coefficient (ECT_{t-1}) indicates the speed of return to long-term equilibrium following a short-term shock. This coefficient must be negative and significant to ensure the validity of the models.

In the case of time series, an appropriate technique should be used with a view to estimating the long-term relationship between the model variables. We can use, on the one hand, the FMOLS (Fully Modified Ordinary Least Square) estimator developed by [34], and on the other hand, the DOLS (Dynamic Ordinary Least Square) estimator of [35] and [36]. In this context, for [37], these two techniques lead to asymptotically distributed estimators towards a normal distribution, with zero mean and constant variance. Similarly, in [38] and [39] the authors reach the same result using FMOLS. However, Pderoni recognizes the superiority of the DOLS method for estimating the long-term relationship in the case of time series.

In the case where the variables of the model are cointegrated, the meaning of the causality between variables is measured through the Granger causality test. In econometrics, causality between variables is generally studied in terms of improving a variable's predictability. Indeed, according to the classic causality study approach proposed by [40], the causal link between an endogenous the two variables are X and Y evaluate whether the past values of X are useful to predict Y, and Y is said to be Granger caused by X if helps to predict Y and vice versa.

3 Empirical Results and Discussions

3.1 Unit Root Tests

To avoid making false estimates, it is essential to determine the order of integration of each variable before estimating the relationship between them. For this, we apply unit root tests on formal economy, ecological footprint, informal economy, trade openness and urbanization in level and first difference. Here, we perform the ADF unit root test from Dickey & Fuller and the PP test from Phillips & Perron. These tests are conducted to determine whether a unit root is present (non-stationarity) or absent (stationarity). As shown in Table 1, these tests yield the following results:

Table. 1. Results of unit root tests

Variables	ADF		PP	
	Level	First	Level	First difference
EFP	-2.121	-4.544***	-2.583	-3.587***
FE	-1.456	-3.366***	-1.569	-4.298***
IFE	-1.380	-3.088***	-1.525	-3.168***
TOP	-2.267**	_	-2.311**	_
URB	-1.118**	_	-1.311***	_

Notes: *, **, and *** indicate 10%, 5%, and 1% of significance threshold, respectively.

Table 1 illustrates the results of these tests which consistently record that all the series are non-stationary in level, and stationary in first difference. They are therefore integrated of order one I(1), with the exception of the opening commercial (TOP) and urbanization (URB) which are stationary in level (I(0)). Considering these mixed order integration results of the variables, I(0) and I(1), our study fulfills the prerequisites for the application of the ARDL model which is more appropriate than the Johansen cointegration model, to study the impact of each explanatory variable on each endogenous variable in Saudi Arabia.

3.2 The Bounds Cointegration Test

After determining the order of integration of the different variables as well as the optimal lag of the model, we use the ARDL approach for co-integration in order to determine the long-term relationship between the variables. For this, we use the "Bound Test", the objective of which is to calculate an F-statistic (Table 2).

Table 2. Results of Bounds test for cointegration

Dependent variable	*F*-statistics (Bound Test)	Lower Bounds I(0)	Upper Bounds I(1)	R^2	DW	*F*-statistics	χ^2_{Normal}	χ^2_{ARCH}	χ^2_{RESET}	χ^2_{SERIAL}
F(EFP/ FE, IFE, TOP, URB)	11.253	3.112**	5.680**	0.857	2.587	141.542	2.35	0.19	0.66	1.75
F(IFE/ FE, EFP, TOP, URB)	10.789	4.046**	5.088**	0.798	2.147	139.887	3.06	0.87	0.32	0.94

**denote significance at the 1% threshold.

The notation F(EFP/FE, IFE, TOP, URB) shows that the dependent variable is EFP. We notice in Table 2 that when EFP and IFE occupy the role of dependent variables, the value of the Fisher statistic exceeds that of the critical value of the upper limit at 1%; thus, with a risk of 1% we accept the alternative hypothesis of cointegration in both models. Hence, we can conclude that there is cointegration between the variables.

Following the results of table 3, confirming the existence of short- and long-term relationships between the ecological footprint and its determinants in Saudi Arabia, we estimate the ARDL models corresponding to equations (1)-(2) to verify the impact of these variables in the long term as well as in the short term. Table 4 presents the results of the ARDL estimation using the two models above. In the first model, we consider the different variables as potential determinants of the ecological footprint. Then, in the second model, we replace the ecological footprint with informal GDP as the dependent variable.

In the long run, the empirical results present the coefficients with their critical probabilities for all the models. We find from the model (1), where the dependent variable is the ecological footprint, that the variables IFE, URB, TOP and FE have positive and statically significant coefficients at the 1% threshold. To be more explicit, a 1% increase in informal economy, formal economy and urbanization will lead to an increase of 0.064; 0.002 and 0.008% ecological footprint, respectively. On the other hand, a 1% increase in trade openness will lead to a 0.004% decrease in the ecological footprint. In model 2, all the coefficients are significant. We retain for this model, where the dependent variable is the informal economy (IFE), that the ecological footprint (EFP) accounts for the IFE with a coefficient of (0.012) and which is significant at 1%. To be more explicit, a 1% increase in the ecological footprint and urbanization will lead to an increase of 0.012 and 0.004% in the informal economy. In contrast, a 1% increase in formal economic growth and trade openness will lead to a decrease of 0.002 and 0.005% in the informal economy.

Table 3. Long- and short-run estimation

Variables	Model 1	*t*-Statistic	Model 2	*t*-Statistic
Long-run				
EFP	–	–	0.012^{***} (0.000)	8.551
IFE	0.064^{***} (0.001)	6.074	–	–
FE	0.008^{***} (0.000)	10.141	-0.002^{***} (0.001)	-5.026
TOP	-0.004^{***} (0.000)	-9.231	-0.005^{***} (0.001)	-7.190
URB	0.002^{***} (0.001)	6.055	0.004^{***} (0.001)	8.024
Short-run				
ΔEFP	–	–	0.054^{**} (0.024)	2.210
ΔFE	0.028^{***} (0.000)	5.99	-0.022^{*} (0.064)	-1.821
ΔIFE	0.012^{**} (0.044)	2.331	–	–
ΔTOP	-0.025 (0.301)	-1.324	-0.023 (0.135)	-1.287
ΔURB	0.038 (0.331)	1.135	0.017^{*} (0.084)	1.912
ECT_{t-1}	-0.823^{***} (0.000)	-11.023	-0.654^{***} (0.000)	-10.327
Constant	1.081^{***} (0.001)	7.085	0.765^{***} (0.000)	8.379
Diagnostic Check				
Tests				
White	(0.512)		(0.233)	
LM	(0.620)		(0.366)	
Ramsey-Reset	(0.133)		(0.168)	
Jarque Bera	(0.355)		(0.298)	
CUSUM	Stable		Stable	
CUSUMSQ	Stable		Stable	

Notes: *, **, and *** indicates 10%, 5%, and 1% level of significant respectively.

In the short run, we see in Table 3, which presents the error-correction models, that in both models (1 and 2) the lagged error-correction terms (ECT_{t-1}) are all significant and with the desired negative sign, which confirms the cointegrating relationships in the two models. That said, in the model (1), for example, there is a very high speed of adjustment toward equilibrium with a coefficient equal to -0.823. There is also a strong speed for models (2), but weaker than the first, with a coefficient equal to -0.654. To be more explicit, there is approximately 82% and 65% of the imbalance coming from the shocks of the previous years which is corrected and converges towards the long-term equilibrium each year for models (1) and (2). The results obtained from the coefficients of the short-term dynamics are displayed in Table 3. These results also show similar trends to those observed for the long-term estimates. The estimated short-term results indicate that ecological footprints have a positive and significant effect on ecological footprints. Moreover, the informal economy increases environmental degradation. We can deduce that the underground economy accelerates polluting emissions, whatever the period. Indeed, the results show that urbanization increases environmental degradation in Saudi Arabia and that the direction of the impact is positive in all specifications of the model, but its magnitude changes strongly according to the regression model. Urbanization has long-term effects on the ecological footprint in Saudi Arabia, but in the short term, its impact is insignificant. Our results confirm the conclusions of [41] and [42].

To assess the robustness of our results, we performed the four usual diagnostic tests on the three estimated ARDL models. These tests are presented in Table 4. The LM test for autocorrelation of the regression residuals confirms the absence of autocorrelation. White's test confirms the absence of heteroscedasticity of the residuals while the Jarque-Bera test shows that they follow a normal distribution. The Ramsey test, on the other hand, shows that there are no missing variables or functional form issues in the model. In addition, the stability tests of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) were applied to the four estimated models. As can be seen in figures 1 and 2, the CUSUM and CUSUMSQ statistics plots are well within the critical limits, which implies that all the coefficients of the four models considered are stable during the estimation period.

Model (1)	Model (2)

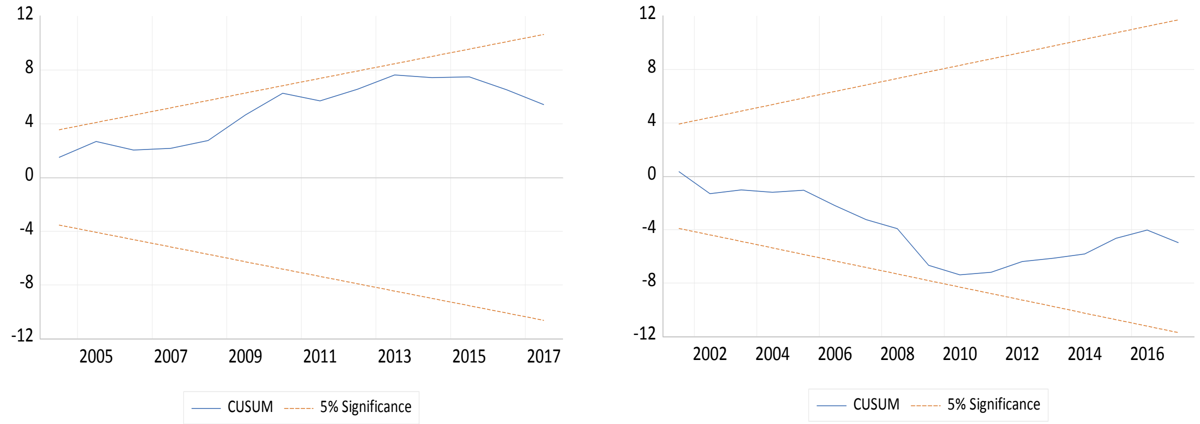

Fig. 1: CUSUM test Results

Model 1	Model (2)

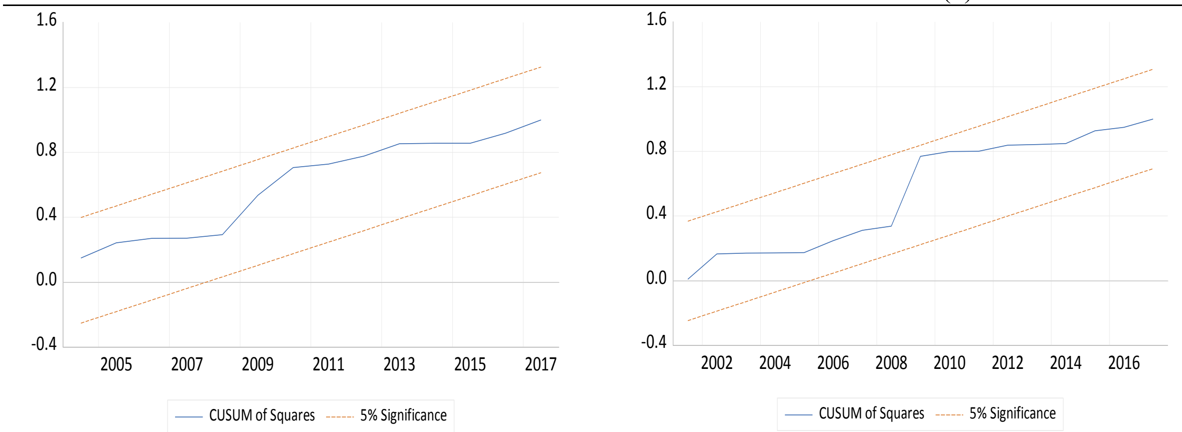

Fig. 2: CUSUM Squares test Results

The presence of a cointegration relationship for the equations having the ecological footprint and the informal economy as endogenous variables does not provide any indication of the direction of causality between the different variables. Since the F-test showed that a relationship exists when EFP and FE are considered as dependent variables in the ARDL, the causality test is performed by estimating a vector error-correction model (VECM) as part of the ARDL.

3.4 The VECM Granger Causality

In the long run as well as in the short run, the results presented in Table 4 show that the equilibrium adjustment coefficients of EFP and IFE have a negative sign and are significant at the 1% threshold. This suggests a dynamic of return to equilibrium, following macroeconomic shocks, which implies the existence of a long-term bidirectional causality between the two variables. For example in the short run, a 1% increase in EFP per capita leads, all other things being equal, to a 0.049% increase in IFE. Similarly, a 1% increase in the IFE will generate an increase in EFP per capita of 0.025%. This result suggests that any change in the informal economy in terms of policy has a resultant effect on EFP, while environmental policy also influences the informal economy. The two-way causality between the informal economy and EFP supports the findings of [43], [11] and [21].

Table 4. Causality Test.

Dep.Var	Source of causality					
	Short run					Long run
	ΔEFP$_t$	ΔFE$_t$	ΔIFE$_t$	ΔTOP$_t$	ΔURB$_t$	*ECT*
ΔEFP$_t$	_	0.167* (0.082)	0.025*** (0.000)	-0.011** (0.020)	0.017 (0.215)	0.018*** [4.206]
ΔIFE$_t$	0.049*** (0.003)	-0.188** (0.039)	_	-0.057** (0.041)	0.038 (0.458)	-0.037*** [-2.891]

Notes: Numbers in square brackets are Student's test statistics, while those in parentheses are *p*-values. ***, ** and * Significant coefficients at 1, 5 and 5% respectively.

Regarding the impact of other macroeconomic variables, we note that economic growth and trade openness negatively and significantly affect IFE and EFP, while urbanization has no effect in the short term. The impact of these control variables on IFE and EFP in Saudi Arabia remains consistent with theoretical predictions. First, increased trade openness improves environmental quality. This result is justified by the fact that trade could play a positive role in this process by facilitating the diffusion of environmentally friendly technologies in Saudi Arabia. Of course, this would require Saudi Arabia to be willing to remove barriers to the import of modern technologies and environmental services. Trade can improve the environment through the composition effect and/or the technology effect. On the other hand, to the extent that there are complementary vertical relationships between the formal and informal economy (interconnected production chains, for example), structural adjustment in the formal sector following trade reforms can have a negative effect – in the short term – on the informal economy.

4 Conclusion and Policy Recommendations

This study examined the relationship between ecological footprint and informal economy of Saudi Arabia between 1981 and 2017 using ARDL bounds testing approach. The results of this study prove the positive effect of informal economic activity on ecological footprint levels, both in the short and long terms. This result will allow us to draw an important conclusion that, in the case of Saudi Arabia, the informal economy is likely to increase pollution levels and induce environmental degradation. Thus, the results show that the ecological footprint has a positive effect on the informal economy. This reveals that the size of the informal economy is very large. Moreover, Granger causality results demonstrated that there was a two-way causal interaction between ecological footprint and informal economy, both in the short and long terms. The results also show that trade openness and urbanization have negative (positive) effects significant on both ecological footprint and informal economy.

In light of these findings, the government should encourage the fight against informal economy activities in general and in the environmental sectors specifically for at least two reasons: (i) with regard to the implementation and monitoring of enforcement of environmental policies; all this with the aim of mitigating the negative economic consequences of the informal economy, which range from the reduction of State revenues through fraudulent environmental controls, to the degradation of the environment and, (ii) the levels of the informal economy are likely to significantly reduce economic growth in the country and that low levels of the informal economy would be beneficial for economic growth. Thus, States must think about putting in place regulatory frameworks adapted to economic reality, such as progressive taxation or simplified registration procedures in order not only to minimize the size of the informal economy but also to improve environmental quality.

However, there are several issues regarding the informal economy and labor regulations. One of the major general problems is that legislation is often not put in place nor does it serve its original purpose, whether formal or informal economy. Legislation may also be out of step with its environment or require amendment. It is not always well designed. Indeed, poorly crafted or poorly enforced laws can clearly have a negative impact. More generally, labor regulations must be adapted to the context to which they apply. This is why it is important to evaluate legal practices within the environment in which they are implemented. National good practices in terms of labor regulations cannot therefore necessarily be reproduced in different national contexts- a good legal practice adopted in a given country does not necessarily bring the same results when applied to another environment. This comment applies to all aspects of the issue of national regulation of workers in the informal economy. Nevertheless, even if there is no common solution to labor regulation, carefully crafted regulation is an essential means for all workers to enjoy their rights.

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