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Article

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Examining the Relationship between Inflation Instability and Ecological Footprint: Evidence from Turkey

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ABSTRACT

Sustainability is a preeminent global issue. This study delves into sustainability with an examination of the effect of inflation instability on ecological footprint per capita through financial development, economic growth, and energy consumption by using the ARDL model for Turkey for the period 1980 through 2015. The results of this study confirmed that financial development and inflation instability improve the environment insignificantly while economic growth does not significantly damage the environment. In addition, energy consumption is found to cause environmental degradation. Results of this study show that the main issue for Turkey is consumption rather than production. Suggested policy-making implications are provided in the conclusion.

Keywords: Ecological Footprint, Inflation Instability, ARDL, Turkey, Energy Consumption
JEL Classifications: F43; O47; Q43; Q50; O40

1. INTRODUCTION

Ecological footprint (EF) is calculated by taking into account several factors such as built-up land, carbon, cropland, fishing grounds, forest products, and grazing land. EF is also considered by comparing it to biocapacity both on total and per capita means. Turkey is a developing country with a growing population. Turkey started to open its economy to international markets by the beginning of 1980s. During that time, Turkey experience high inflation with double digit inflation from the 1980s to 2003. After 2003, Turkey's inflationary pressures subsided to single-digit inflation levels. This study aims to analyze the effect of inflation instability (INFS) on the ecological footprint per capita (EFPC) for Turkey for the period 1980 to 2015. The studies for the relationship between environment and inflation levels are limited in the literature and as far as we know the effect of INFS on EFPC is not analyzed in the literature prior to this study.

1.1. Relationship between INFS and the Environment

Among studies that analyzed the relationship between inflation and the environment, Hanif and Gago-de-Santos (2017) used carbon dioxide emissions (CO_2), GDP per capita, square of GDP per capita, INFS, and population (PP) variables and analyzed a panel of 86 developing countries for the period 1972-2011. In their study the authors used ordinary least squares (OLS), robust regression (RR), fixed effect (FE), and instrumental variable (IV) techniques. Hanif and Gago-de-Santos confirmed that PP and INFS damage the environment. Ullah et al. (2020) analyzed the relationship between INFS and environmental quality through GDP growth volatility for Pakistan for the period 1975-2018. The authors used the non-linear ARDL model (NARDL) in their analysis. For environmental quality they used carbon dioxide emissions (CO_2), nitrous dioxide emissions (N_2O), and methane emissions (CH_4). They confirmed the effect of negative shocks of INFS on CO_2 and N_2O as positive over the long run. Ahmad et al. (2021) analyzed the effect of INFS on CO_2 for a panel of 40 Asian countries for the period 1990-2018 by using Westerlund (2007) and Fully Modified Ordinary Least Squares (FMOLS). They used CO_2, INFS, financial development (FF), economic growth and energy consumption (EN) variables to confirm INFS improved environmental performance for panel countries. Khan (2019) analyzed the relationship between CO_2, INFS, GDP per capita, square of GDP per capita and FF for Pakistan for the period 1971-2016. Khan confirmed the negative effect of FF and INFS on the environment.

A brief literature review for the relationship between INFS and the environment shows that several models are used such as the NARDL by Shin et al. (2014), ARDL, Westerlund cointegration tests and FMOLS. For the environment, CO_2, N_2O and CH_4 are used. The other variables used alongside the environment are FF, economic growth, EN, population, and GDP growth volatility. This study aims to analyze the relationship between INFS and the environment by using EFPC for Turkey for the period 1980-2015. INFS is used as the studies in the literature by taking the difference from mean values of the inflation levels. The other variables used alongside EFPC are INFS, FF, GDP per capita and energy consumption per capita. This study uses the autoregressive distributed lag (ARDL) model by Pesaran et al. (2001) for the analysis of the variables with Toda and Yamamoto (1995) granger non-causality test to investigate the causal relationships between the variables by including a structural break.

1.2. Contribution of this Study

The contribution of this study to the literature is that it is the first study to analyze the effect of INFS on EFPC. EFPC is chosen as a proxy for the environment for several reasons. First, EFPC is the impact of humanity's activities on nature in terms of the area of water and biologically productive land to sustain the products consumed and to get rid of the waste created. EFPC is also terms of nature needed to support humanity or its economy and calculated through an ecological accounting system. EFPC is one of the leading terms for sustainability in the current literature. EF calculates the use of productive surface areas while biocapacity calculates nature's ability to regenerate the resources that humanity needs. Biocapacity also considers current technologies and management types for the calculation of nature's capacity to meet people's demands. When EF exceeds in total and per capita meaning then there is an ecological deficit for a certain population or country. This study takes EFPC into consideration. Turkey's ecological deficit started to occur after its opening to international markets started (Figures 1 and 2). Turkey's carbon footprint exceeded the other calculated footprints after Turkey started to open to international markets (Figure 3 and 4). Although Turkey's total biocapacity stayed stable over the years, biocapacity per capita has been on the decline since the 1960s. In that period, Turkey's total EF and EFPC were on the rise and by the 1980s Turkey's EF exceeded its biocapacity. That is Turkey started to experience unsustainability which means Turkey started to consume more than it can produce.

Figure 1: Total EF and total biocapacity

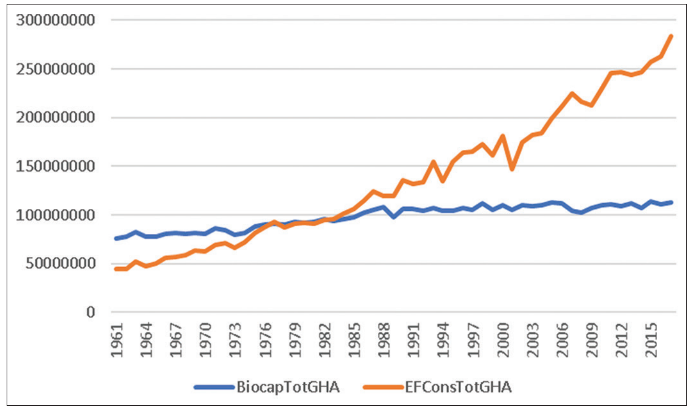


Figure 2: EFPC vs. biocapacity per capita

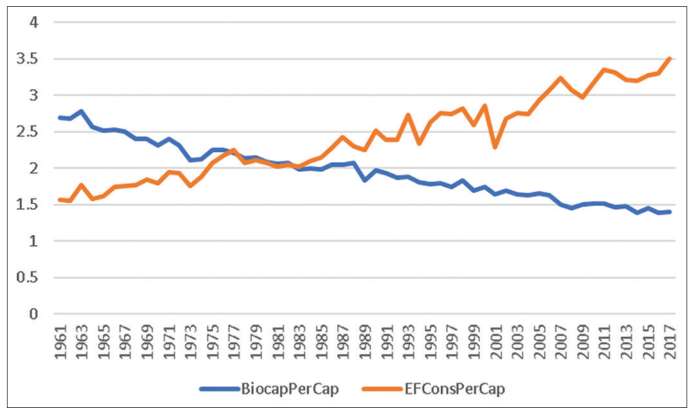
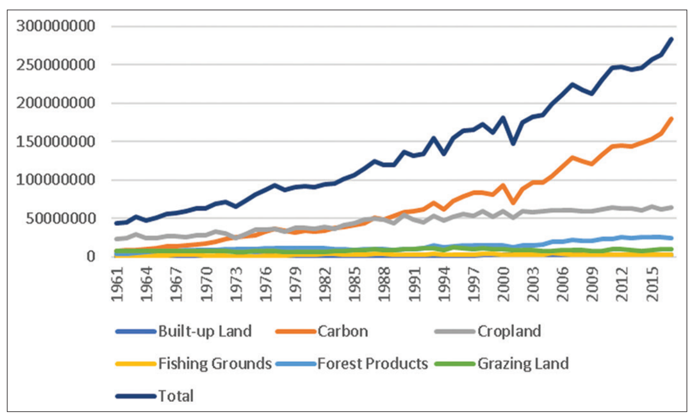


Figure 3: Total EF and its components



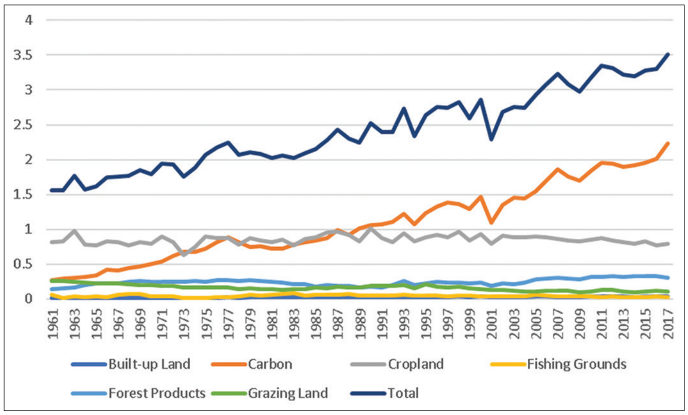
2. LITERATURE REVIEW

There are many studies on the factors affecting carbon emission and ecological footprint in the academic literature. In this context, some of these works examine the nexus between economic growth and environmental degradation by considering the environmental economics theories. Several authors including Bahadir (2022), Dursun (2022), Kayabas (2022), Kirikkaleli et al. (2021), Koksal (2021), Koksal and Cetin (2021), Ozturk et al. (2016), Ozturk et al. (2021), Sarigul and Apak (2022), Siddique (2022), Tarazkar et al. (2021), and Yazici (2022) have tested the environmental economics theories within the sense of carbon emissions and ecological footrprint.

Studies for the relationship between INFS and the environment are limited as briefly explained in the introduction part (Hanif and Gago-de-Santos, 2017, Ullah et al., 2020, Ahmad et al., 2021, Khan, 2019). For relevant studies in the literature Pata (2021), Ahmed and Wang (2019), and Udemba (2020) analyzed EF, Alola et al. (2019) analyzed CO_2 and INF nexus and Lyu (2019) analyzed green economy and INF for China (Table 1).

Shitile and Usman (2020) analyzed the pass-through of oil price (OP) to INF with output gap, exchange rate, inflation, and consumer price index (CPI) sub-indexes for Nigeria for the period 1996-2019 by the ARDL model. They confirmed incomplete pass-through of OP to INF since positive shocks of OP affect CPI sub-indexes while negative shocks of OP affect INF insignificantly.

Figure 4: Total EFPC and its components



Pata and Isik (2021) examined the effect of human capital (HUC) on the environment by using the load capacity factor (LOCF) which is the ratio of biocapacity to EF for China for the period 1981-2017 through economic growth, energy intensity (EI) and total natural resources rent (TNRR). Pata and Isik confirmed HUC improves the environment. Pata and Isik used the ARDL model and the dynamic ARDL model by Jordan and Philips (2018) to compare results from two models.

Pata (2021) analyzed the effect of AG, globalization (GL), and renewable energy generation (REG) on CO_2 and EF for India, Brazil, China, and Russia for the period 1971-2016. For China and Brazil, GL damages the environment and REG improves the environment. REG has an insignificant effect on EF and emissions for Russia and India. Pata used the Fourier Autoregressive Distributed Lag model (FADL) by Banerjee et al. (2017).

Ahmed and Wang (2019) investigated the effect of HUC on EF for the period 1971-2014. EFPC, GDP per capita, EN, HUC, trade openness (TOP), and urbanization (URB).

Bayer and Hanck (2013) and ARDL bounds test are used to investigate the cointegration between the variables. HUC improves the environment, inverted U relationship between EF and economic growth is confirmed for India, EN damages the environment, URB improves the environment in the long run, and insignificant effect of TOP on the environment.

Table 1: Summary of relevant literature

Authors	Countries	Period	Methodology	Variables	Findings
Ullah et al., (2020)	Pakistan	1975-2018	NARDL	CO_2, N_2O, CH_4, INFS, GDP growth rate volatility, FF	The effect of negative shocks of INFS affects CO_2 and N_2O positively in the long run.
Shitile and Usman (2020)	Nigeria	1996-2019	NARDL	OP, INF, food Sub CPI, output gap	Incomplete pass-through of OP to INF.
Ahmad et al. (2021)	A panel of 40 Asian Countries including Turkey	1990-2018	Westerlund cointegration test and FMOLS	CO_2, INFS, FF, GDP per capita, EN	INFS improved env performance for panel countries.
Lyu (2019)	A panel of 21 Port Provinces in China	2006-2015	PVAR	Green Economy by GML index and ML index, INF	A green economy in China can diminish inflation in China.
Khan (2019)	Pakistan	1971-2016	ARDL	CO_2 INFS, GDP per capita, square of GDP per capita, FF	The negative effect of FF and INFS on the env
Alola et al. (2019)	16 coastline Mediterranean countries including Turkey	1995-2014	ARDL pooled mean group approach	CO_2, FPI, REC, INF	REC and INF decrease emissions in the long run but food production increases emissions in the long run.
Udemba (2020)	India	1975-2016	ARDL	EF, GDP per capita, EN, AG, FDI, PP	AG, PP and EN negatively affect the env
Pata and Isik (2021)	China	1981-2017	ARDL, Dynamic ARDL	LOCF, GDP per capita, EI, TNRR, HUC	HUC improves the env
Ahmed and Wang (2019)	India	1971-2014	Bayer and Hanck cointegration test, ARDL	EF, GDP per capita, energy consumption, HUC, TOP, URB	EN damages the environment, URB improves the environment in the long run and the insignificant effect of TOP on the env
Pata (2021)	China, Brazil, India, Russia	1971-2016	Fourier ADL	EF, CO_2, AG, GL, REG	For China and Brazil, GL damages the environment and REG improves the env
Hanif and Gago-de-santos (2017)	86 developing countries	1972-2011	OLS, RR, FE, IV technique	CO_2, GDP per capita, square of GDP per capita, INFS, PP	PP and INFS damage the env

Udemba (2020) analyzed the relationships between EF, economic growth, EN, agriculture (AG), foreign direct investment (FDI), and PP for India for the period 1975-2016. Udemba confirmed causality from EN, PP, AG and FDI to EF. AG, PP and EN negatively affect the environment. FDI positively affects the environment. ARDL model is used.

Alola et al. (2019) analyzed the relationships between carbon dioxide emissions per capita in kilotons, food production index (FPI), renewable energy consumption share of renewable energy in the total energy consumed in kilotons (REC), and inflation rate as measured by the consumer price index (INF) which reflects the annual percentage in the cost to the average consumer of acquiring a basket of goods and services, for the period 1995-2014. Alola et al. (2019) found that REC and INF decrease emissions in the long run but food production increases emissions in the long run for panel countries which are 16 coastline Mediterranean countries including Turkey.

Lyu (2019) analyzed the relationship between the green economy and INF in China for 21 port provinces by panel vector autoregressive model (PVAR) for the period 2006-2015. Lyu confirmed that the green economy that is calculated both with the global Malmquist-Luenberger (GML) index and the Malmquist-Luenberger (ML) index has a weak but negative effect on inflation in China in the long term. Lyu concluded that green economy in China can diminish inflation in China. Lyu used consumer price index data for INF.

Javid and Sharif (2016) examined the relationship between financial development, inflation, economic growth, and environmental pollution in Pakistan during the 1972-2013 periods. The findings demonstrated that the Environmental Kuznets Curve hypothesis is valid for Pakistan that financial development and inflation have a positive effect on carbon emissions.

3. METHODOLOGY AND MODEL

This study analyzes the relationship between the variables which are EFPC, GDP per capita, EN, FF and INFS for Turkey for the period 1980-2015 (Table 2 and Equation 1). V1, V2, V3 and V4 are the analyzed coefficients for the variables and b_t is the error term.

3.1. Data

Data is obtained for the period 1980 through 2015. Values for EFPC (Global hectares per person) is retrieved from the Global Footprint Network (2022) and data for GDP per capita (constant 2010 US$), FF Domestic credit provided by financial sector (% of GDP), EN (kg of oil equivalent per capita) and INFS inflation instability are retrieved from The World Bank database (2022a), (2022b), (2022c), and (2022d) respectively. INFS is calculated as INF differs from its mean values (Khan, 2019, Ahmad et al., 2021).

3.2. Methodology

Zivot and Andrews (2002) unit root test with structural break is used to determine the stability levels of the variables (Table 3). Since variables' stability levels are a combination of I(0) and I(1), the ARDL model is used to look for the cointegration between the variables. Toda and Yamamoto (1995) granger non-causality test is used to look for the causal relationship between the variables since variables' stability levels are a combination of I(0) and I(1).

Stability of the models established are checked with Reset test, Heteroskedasticity test: Breusch-Pagan-Godfrey, Heteroskedasticity test: ARCH, Heteroskedasticity test: White, Breusch-Godfrey Serial Correlation LM test, Normality test, CUSUM test, and CUSUM of squares test for ARDL model.

For Toda and Yamamoto granger non-causality test, first the VAR model is established with variables and the stability of the VAR model is checked with inverse roots of AR characteristic polynomial, VAR Residual Heteroskedasticity tests, and VAR Residual Serial Correlation LM. VAR Granger Causality/Block Exogeneity Wald tests are run to check the causal relationships between the variables.

3.3. Modelling

$$\ln(EFPC)_t = v_0 + v_1 \ln(GDP)_t + v_2 (INFS)_t + v_3 (FF)_t + v_4 \ln(EN)_t + b_t \quad (1)$$

The relationship between the variables is examined with ARDL model (equation 2). N is for long run coefficients and M is for short run coefficients for the related variables. b_t is for white noise residuals. Logarithmic form of the variables is used except FF and INFS.

$$\Delta LnEFPC_t = N_0 + N_1\, LnEFPC_{t-1} + N_2 INF_{t-1} + N_3 FF_{t-1} + N_4 LnEN_{t-1} + \sum_{i=1}^{s} M_{1i} LnEFPC_{i=1} \sum_{i=0}^{h} M_{2i} INF_{i=1} + \sum_{i=0}^{c} M_{3i} FF_{i-1} + \sum_{i=0}^{m} M_{4i} LnEN_{i-1} + b_t \quad (2)$$

Hypothesis of no cointegration is $H_0 = N_1 = N_2 = N_2 = N_4$. 0

Hypothesis of cointegration is $H_1 = N_1 \neq N_2 \neq N_3 \neq N_4 \neq 0$

After cointegration is confirmed, long run coefficients are calculated according to the model of ARDL in equation 3. Short-

Table 2: Descriptive statistics

Variables	Observations	Mean	Standard error	Maximum	Minimum
EFPC	36	0.966230	0.158820	1.207750	0.704549
GDP	36	8.982236	0.290894	9.541379	8.514494
FF	36	0.249174	0.137091	0.625962	0.135884
IN	36	6.997961	0.248921	7.409355	6.557901
INFS	36	0.058714	0.217253	0.688096	-0.282978

run coefficients are calculated as in equation 4. Error correction model (ECM) of ARDL model is calculated as in equation 5.

$$LnEFPC_t = C_0 + \sum_{i=1}^{s} C_{1i} LnEFPC_{t-1} + \sum_{i=0}^{h} C_{2i} INF_{t-1} + \sum_{i=0}^{c} C_{3i} FF_{t-1} + \sum_{i=0}^{m} C_{4i} LnEN_{t-1} + b_t \quad (3)$$

$$LnEFPC_t = D_0 + \sum_{i=1}^{s} D_{1i} \Delta LnEFPC_{t-i} + \sum_{i=0}^{h} D_{2i} \Delta INF_{t-i} + \sum_{i=0}^{c} D_{3i} \Delta FF_{t-i} + \sum_{i=0}^{m} D_{4i} \Delta LnEN_{t-i} + \gamma ECT_{t-1} + b_t \quad (4)$$

$$ECT_t = LnEFPC_t - \sum_{i=1}^{s} Y_{1i} \Delta LnEFPC_{t-i} - \sum_{i=0}^{h} Y_{2i} \Delta INF_{t-i} - \sum_{i=0}^{c} Y_{3i} \Delta FF_{t-i} - \sum_{i=0}^{m} Y_{4i} \Delta LnEN_{t-i} \quad (5)$$

Where: Δ is the first difference.

4. ANALYSIS OF RESULTS

Turkey experienced continuous growth for EF and EFPC since the 1960s till today (Figures 3 and 4). Although total biocapacity remains stable, biocapacity per capita is on the decline since the 1960s (Figures 1 and 2). Turkey experienced a high level of inflation till 2003 and after 2003 Turkey started to experience single-digit inflation levels (Table 2). Turkey also experienced high level of growth beginning with the 1980s since it started to open to international markets.

4.1. Unit Root Tests

Zivot and Andrews unit root test with a structural break shows that the variables are at stable levels of a combination of I(0) and I(1) (Table 3). 2004 which is the structural break for FF is used in the calculations since models with 2001, 2003, and 1995 did not satisfy the stability requirements. 2004 is added as a dummy variable to ARDL model calculations and Toda and Yamamoto granger non-causality tests.

4.2. Cointegration Test

F-statistic value of cointegration shows that the cointegration between the variables is significant at 1% level and the null hypothesis for no long-run relationships exist is rejected (Table 4).

Table 3: Results of the unit root test

Variables	Zivot-andrews unit root test	
	I (0)	I (1)
EFPC	−6.744588* (2001)	-
GDP	−3.166093	−6.662014* (2003)
FF	−1.363435	−5.997997* (2004)
IN	−4.564793	−6.904224* (2003)
INFS	−5.038205* (1995)	-

4.3. The Effect of GDP, INFS, EN and FF on EFPC

EN has a significant and positive effect on EFPC in the long run. INFS and FF have a negative but insignificant effect on EFPC in the long run. Economic growth has a positive but insignificant effect on EFPC. Dummy variable has also an insignificant effect on EFPC. Short-run relationships are similar to long-run relationships for the variables (Table 5).

4.4. Stability Tests

Stability tests are all not significant at 5% levels which means the established model is stable (Table 6). CUSUM and CUSUM of squares tests are also run to check the stability of the model (Figures 5 and 6).

4.5. Causality Tests

Toda and Yamamoto granger non-causality test results show that EN has a positive and causal effect on EFPC (Table 7). Energy consumption of Turkey damages the environment in the long run, and it can be stated that energy consumption causes environmental degradation in Turkey. No causal relationships are found from GDP, INFS, and FF to EFPC for Turkey. The model is stable according to stability tests executed (Figure 7 and Table 8).

Economic growth damages the environment although the probability is insignificant. FF and INFS improve the environment although the probability levels of INFS and FF are insignificant. EN significantly affects the environment and EN causes the environmental degradation. This study takes into consideration beginning from 1980s till 2015 regarding available data. Results show that the main reason that affect EFPC among chosen variables is EN.

Table 4: Results of the cointegration test

F-bounds test		Null hypothesis: No long-run relationships exist		
Test statistic	Value	Significance	I (0) Bound	I (1) Bound
F-Stat of lnEFPC	6.665787	10%	2.45	3.52
k	4	5%	2.86	4.01
Durbin-Watson	2.093279	2.5%	3.25	4.49
R-squared	0.974798	1%	3.74	5.06

Table 5: Heteroskedasticity test results of ARDL model

Variable	Coefficient	Standard Error	t-Stat	Prob
Short-run coefficients				
D (GDP)	0.446300	0.235789	1.892799	0.0696
D (INFS)	−0.019604	0.025034	−0.783093	0.4406
D (EN)	0.969113	0.216864	4.468757	0.0001
D (FF)	−0.084613	0.072869	−1.161156	0.2561
D (D2004)	−0.005604	0.023127	−0.242292	0.8105
CointEq(−1)	−0.812635	0.151168	−5.375715	0.0000
Long-run Coefficients				
GDP	0.083768	0.257576	0.325217	0.7476
INFS	−0.024124	0.031333	−0.769914	0.4483
EN	0.564917	0.251374	2.247316	0.0333
FF	−0.104121	0.093490	−1.113710	0.2756
D2004	−0.006896	0.028826	−0.239210	0.8128
C	−3.736617	0.644566	−5.797108	0.0000

Table 6: Stability test results

Stability test	F-statistic	Jarque-Bera	Probability
Reset test	0.591651	-	0.4490
Heteroskedasticity test: Breusch-Pagan-Godfrey	0.800007	-	0.6080
Heteroskedasticity test: ARCH	0.854076	-	0.3623
Heteroskedasticity test: White	0.782391	-	0.6220
Breusch-godfrey serial correlation LM test	0.432836	-	0.5166
Normality test	-	2.365974	0.3063

Table 7: Results of the causality test

Dependent variable: EFPC			
Null hypothesis: No causality			
Excluded	Chi-square	Degrees of Freedom	Probability
GDP	0.025118	1	0.8741
EN	3.879944	1	0.0489
FF	1.127413	1	0.2883
INF	0.086402	1	0.7688
All	7.131250	4	0.1291

Table 8: VAR stability test results

Stability test	Chi-square	LM-stat	Probability
VAR residual heteroskedasticity tests	171.5616	-	0.3471
VAR residual serial correlation LM tests	-	22.44459	0.6100

Figure 5: CUSUM test results for ARDL model

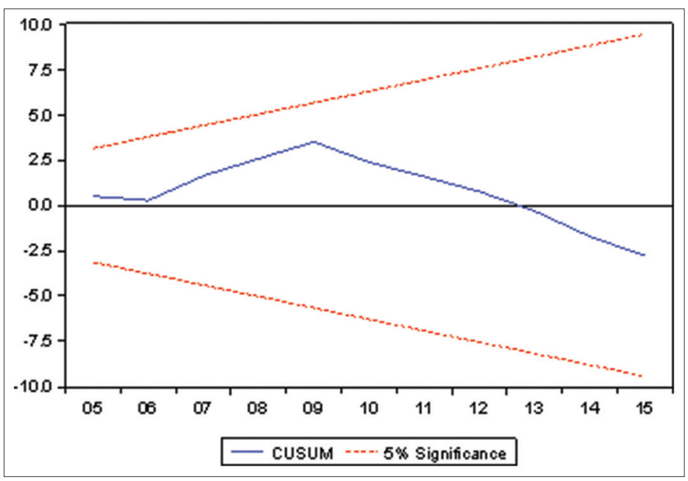


Figure 6: CUSUM test of squares test results for ARDL model

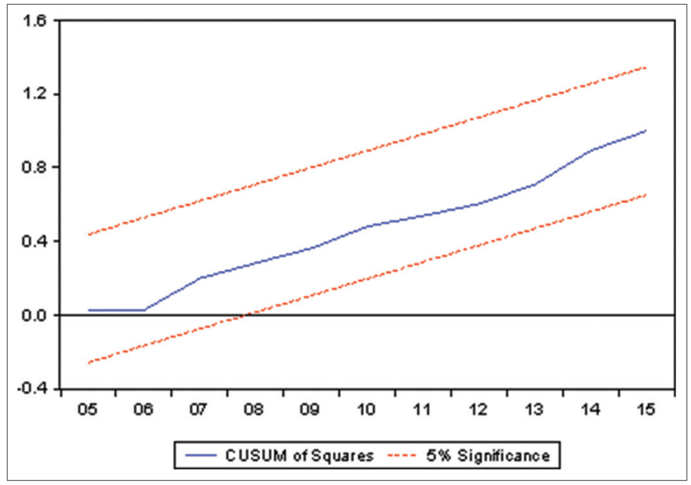
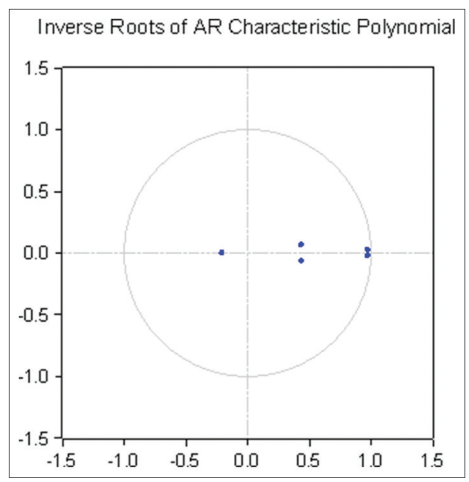


Figure 7: Stability test results for VAR model



INFS damages the environment regarding CO_2 according to Hanif and Gago-de-santos (2017), the effect of negative shocks of INFS affect CO_2 and N_2O positively in the long run according to Ullah et al. (2020) and FF and INFS damage the environment regarding CO_2 according to Khan (2019). For EFPC, this study confirmed FF and INFS improve the environment quality although the coefficients of FF and INFS are insignificant. Carbon footprint is the single footprint among all continuously rising after the 1980s while other footprints are stable both for EF and EFPC. For Turkey, consumption of fossil fuels, food, manufactured goods, materials, roads, and transportation is the main case rather than production. INFS is improving the environment insignificantly since Turkey started to experience single-digit inflation levels starting by 2003.

5. CONCLUSION AND POLICY IMPLICATIONS

This study examines sustainability by studying the effect of inflation instability on ecological footprint per capita through financial development, economic growth, and energy consumption for Turkey. An ARDL model is employed for this analysis for the period 1980 through 2015. The results of this study show that financial development and inflation instability improve the environment insignificantly while economic growth does not significantly damage the environment. In addition, energy consumption is found to cause environmental degradation. Results of this study show that the main issue for Turkey is consumption rather than production.

The results of this study should encourage Turkey to pursue policies that encourage sustainable actions regarding FF and INFS. Turkey should continue to support environmentally friendly products and subsidize its industries for using and producing cleaner energy. Turkey should continue to implement certain economic policies to maintain its macroeconomic stability. Turkey's main issue is its carbon footprint as compared to other countries worldwide.

Where economically feasible, Turkey should support recycling of materials and educate its people to engage in sustainable consumption. Along these lines, Turkey should continue to improve plastic recycling and continue policies regarding reducing plastic usage. Other policy implications may be avoiding throw-away fashion, encouraging sustainable meat consumption, avoiding single-use plastic, increasing energy efficiency for households, and increase use of mass transportation.

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