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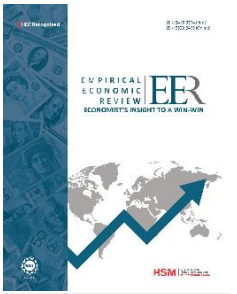

Title:	**Agricultural Exports and Environmental Quality in Developing Countries: A Panel Data Analysis**
Author (s):	Sheeza Ramzan Bhutta, Ayesha Ashraf, and Mehvish Shafiq
Affiliation (s):	The Women University, Multan, Pakistan
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Department of Economics and Statistics, Dr. Hasan Murad School of Management
University of Management and Technology, Lahore, Pakistan

Agricultural Exports and Environmental Quality in Developing Countries: A Panel Data Analysis

Sheeza Ramzan Bhutta, Ayesha Ashraf*, and Mehvish Shafiq

The Women University, Multan, Pakistan

Abstract

The current study aimed to investigate the relationship between agricultural exports and environmental quality in developing countries over the time period of 2002 to 2021. Using panel data regression analysis, the study tested the impact of agricultural exports on ecological footprint (EF) of cropland. Both, EF of cropland production and consumption were used to investigate the Pollution Haven Hypothesis (PHH), Pollution Halo Hypothesis, and the theory of ecological unequal exchange (EUE). The results showed that agricultural exports significantly contribute to EF of cropland in developing countries, providing the evidence in favor of PHH. Furthermore, the study also found some evidence of ecological unequal exchange since agricultural exports were observed to increase the EF of cropland production, however, they did not affect the EF of consumption in developing countries. The study highlighted the need for suitable agricultural practices, eco-friendly policies, and international cooperation to mitigate the environmental impacts of agricultural exports in developing countries.

Keywords: agricultural exports, cropland consumption, cropland production, developing countries, ecological footprint, environmental quality

Introduction

Agricultural exports provide many developing countries with essential foreign exchange which enables them to afford imports, such as capital equipment, modern technologies, and other capital goods. Through globalization, developing countries can access global markets and turn their agricultural output into foreign exchange earnings, helping to support and stabilize their overall economic conditions (Nugroho et al., 2021). Empirical studies have found a positive impact of agricultural exports on income growth in developing countries (Arifah et al., 2022; Dawson, 2005).

* Correspondent Author: ayesha.ashraf@wum.edu.pk

The rapid growth of agricultural exports has also important consequences for the environment. International trade and investment allow countries with strict environmental regulations to shift their polluting production processes to countries with laxer regulations. This occurs because countries with lax environmental regulations offer a cheaper setting for "dirty" production processes. This may guide developing nations to focus on producing more polluting goods, while developed countries successfully export their pollution. This theory is recognized as "*Pollution Haven Hypothesis*" (PHH) or theory of *ecologically unequal exchange (EUE)*. The rapid increase in agricultural exports thus, raises a critical question: Do developing countries import environmental damages while exporting agricultural goods?

An alternate view to PHH, known as "*Pollution Halo Hypothesis*" claims that international trade may have significant positive environmental influences by relocating greener production methods and pollution abatement technologies from developed to developing countries. Globalization through international trade and foreign investment may alter a country's production structure. This potentially encourages a shift towards higher value-added or more environmental-friendly industries instead of relying mainly on pollution-intensive sectors (Doryń & Wawrzyniak, 2024).

While examining the empirical validity of these hypotheses, a number of studies have inspected the effects of trade or Foreign Direct Investment (FDI) on environmental quality (Alvarado et al., 2021; Cutcu et al., 2023; Doytch & Ashraf, 2022; Nathaniel & Khan, 2020). Evidence on the environmental impact of agricultural exports in developing countries is scarce. Substantially, all the existing studies use total ecological footprints (EFs)- EF of consumption (EFc)- as a measure of environmental quality. The EF of cropland, which can be attributed to either production or consumption patterns, plays a crucial role in understanding the environmental impacts of agricultural exports. Understanding the association between agricultural exports and the EF of cropland is more valuable than focusing on the total EFs, as it reveals the underlying determinants of environmental pressure. While total footprint data indicates the scale of impact, it does not display whether it stems from export demand, unsustainable farming methods, or economic factors. Analyzing this relationship indicates the causes of land degradation, reveals which export

crops exert the greatest ecological stress, and supports more efficient policies for sustainable trade, land management, and resource use.

Research Objectives

Against the above-mentioned backdrop, the study aimed to address two main objectives mentioned as follows:

- Firstly, it inspected the impact of agricultural exports on the EF of cropland. To this end, data was collected for 56 developing countries over the period 2002–2021. Furthermore, panel data techniques were used to empirically investigate the relationship among the variables.
- Secondly, the study evaluated whether countries are effectively relocating environmentally-harmful production processes abroad. In other words, it means that whether developing countries are exporting agricultural goods while importing the associated environmental damages. To explore this, the study calculated and compared the effects of agricultural exports on the EF of cropland consumption and the EF of cropland production in developing countries.

The results indicated that agricultural exports increase the EF of cropland, providing evidence in support of the *PHH*. Furthermore, while agricultural exports lead to a rise in the EF of cropland production, they do not significantly affect the EF of cropland consumption. This suggests that developing countries are effectively outsourcing the environmental harms associated with their exported agricultural goods. This indicates that developing countries are effectively importing the environmental harms associated with goods consumed abroad (evidence of EUE).

Literature Review

Saghaian et al. (2022) examined the impact of agricultural exports on environmental quality in 23 developed and 43 developing countries by using panel data techniques during the time period 2002–2020. The findings suggested that total and raw agricultural exports from developing countries increased greenhouse gas emissions in developing countries, while they reduced the N_2O emissions in developed countries. The study highlighted the need to increase the awareness of farmers about the environmental consequences of their farming activities in developing countries.

Xu et al. (2023) examined the impact of agriculture Global Value Chain (GVC) on ecological footprint in high income and low- and middle-income

groups of countries. Using the dynamic panel data model and moderating effect model, the study showed that upgrading the position of agricultural GVC significantly improves the environmental quality. The effect of agricultural GVC on ecological footprint (EF) is more pronounced in middle- and low-income countries than in high-income countries. Moreover, the analysis of Xu et al. (2023) concluded that there is a positive moderating effect of environmental regulation on the relationship between agricultural GVC and EF. Scoppola (2022) inspected the GVCs in agriculture and food and concluded that participation in GVCs may uplift productivity and income. However, it may also bring risks, such as market concentration and environmental pressures.

Countries often preserve their domestic water supplies by bringing in water-intensive farm products from abroad while exporting goods that entail relatively little water to produce (Chapagain et al., 2006). The study conducted by Chapagain et al. (2006) reported that international trade in agricultural products can significantly reduce global agricultural water use by shifting production to places where water is used more efficiently.

Lopez et al. (2015) developed a multiregional input and output model. This model was developed to evaluate the importance of international trade of agricultural products as well as their food-miles emissions on the proposed extended carbon footprint measure of Spanish agriculture during the time period (2000–2008). The empirical analysis of Lopez et al. (2015) showed that Spain's agricultural carbon footprint in 2008 was 18.5 Mt CO_2, over twice the conventional estimate once imports and exports were properly accounted for and their carbon contributions allocated.

Barbier (2000) investigated how economic liberalization and globalization affect rural resource degradation in developing countries, particularly through land use changes that lead towards forest conversion, degradation, and deforestation. The study focused on trade liberalization and economy-wide reforms that have increased export-oriented Agro-industrialization. While these reforms have promoted rural development and economic growth, they may also have direct effects and indirect effects. These include displacement of landless or poor rural populations who migrate to marginal lands and forest frontiers (Barbier, 2000). Overall, the effect of agricultural exports on environmental quality is uncertain (Balogh & Jambor, 2020).

To the best of our knowledge, no study has examined the effects of agricultural exports on environmental quality in terms of the EF of cropland consumption and production so far. This study aimed to fill that gap.

Empirical Model and Data

To estimate the effect of agriculture export on EF of cropland consumption and EF of cropland production, the following model was used which also accounts for Environmental Kuznets Curve (EKC) effect:

$$\ln(EF_{it}^{k}) = \beta_0 + \beta_1 agriexp_{it} + \beta_2[\log(gdp_{it})] + \beta_3[\log(gdp_{it})]^2 + \beta_4 manf_{it} + \beta_5 urban_{it} + \beta_6 rl_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

$with\ \mu_i \sim i.i.\ (0, \sigma_\mu i)$, $\varepsilon_{it} \sim i.i.d.\ (0\sigma_\varepsilon)$, $E[\mu_i \varepsilon_{it}]=0$ and where i and t are country and time sub- subscript, respectively and μ_i is country fixed effects and ε_{it} is error term.

The variables

- (EF_{it}^{k}) represents two EFs of cropland with the subscript k denoting respectively consumption EF of cropland, and production EF of cropland.
- $gdpit$ is measure of per capita GDP in constant USD and the term $\beta_2[\log(gdp_{it})] + \beta_3[\log(gdp_{it})]^2$ captures the EKC effect. EKC suggests that environmental degradation first increases and then decreases with income growth, forming an inverted U-shape curve. If $\beta_2 > 0$ and $\beta_3 < 0$ then EKC exists.
- $agriexp_{it}$ are the respective agricultural exports. Agricultural exports refer to the quantity and value of agricultural products. These include crops, livestock, and related goods, that are produced domestically and shipped to other countries for consumption, processing, or resale. The PHH holds if $\beta_2 > 0$ and pollution halo exists if $\beta_2 < 0$.
- $manf_{it}$ shows manufactures exports (% of merchandise exports).
- $urban_{it}$ is urban population while,
- rl_{it} is rule of law that measures the governance quality.

The data on agricultural exports, manufacturing exports, urbanization, and GDP per capita was taken from World Development Indicators (WDI), while the data on rule of law was taken from World Bank Governance

Indicators (WGI). The data on EF of cropland was taken from Global Footprint Network. Merging the data from all these sources, the study ended up with the data for 56 countries over the period (2002-2021). Using 2021 data provided with an up-to-date picture of the effects of agricultural exports on the environment.

Equation [1] was estimated using both fixed effects and random effects models. The Hausman test was applied to determine whether the fixed effects specification was more suitable than the random effects. Additionally, the study used system Generalized Method of Moments (GMM) estimation to make the results robust to potential endogeneity issues.

Empirical Analysis

Effects of Agriculture Exports on EF of Cropland Consumption

Table 1 shows the results obtained from fixed effects estimation (col. 1) and random effects estimation (col. 2) on the effects of agriculture exports on EF of cropland consumption. The results of the Hausman test indicated that fixed effects estimation is preferred to random effects estimation (chisq: 37.04; p.val.000). Therefore, the results reported in column (1) of Table (1) are discussed here.

As can be seen, the coefficient on GDP per capita is positive and significant and the coefficient on its square term is negative and significant. This indicates the existence of an inverted U-shaped relationship (EKC) in developing countries. The coefficient on urbanization is significantly negative, suggesting that an increase in urbanization reduces the EF of cropland consumption and therefore, improves the environmental quality. However, the coefficient on manufacturing exports is insignificant.

The improved quality of governance has positive effect on environmental quality as indicated by the negative and significant coefficient on rule of law. Concerning the study's main variable of interest, the coefficient on agricultural exports is positive, suggesting that transfer of agricultural goods to abroad does not affect the environmental quality. There is no evidence on the existence of pollution halo or pollution haven effect.

Table 1
Effects of Agricultural Exports on EF of Cropland Consumption

Variables	[1] Fixed Effects	[2] Random Effects
lg (agriculture export)	0.0041	0.0091
	[0.0072]	[0.007]
lg (GDP_{pc})	0.7895***	0.5040***
	[0.1936]	[0.158]
lg $(GDP_{pc})^2$	-0.0240**	-0.0131
	[-0.0115]	[-0.0095]
lg (Manufacturing Export)	0.0121	-0.001
	[0.0115]	[-0.0108]
lg (Urbanization)	-0.0990***	-0.0068
	[-0.0301]	[-0.0153]
Rule of Law	-0.0460*	-0.0604**
	[-0.0264]	[-0.0248]
Observations	1,086	1,086
Number of Countries	57	57

Note. Standard errors are in parentheses. ***, ** and * indicate 1%, 5% and 10% level of significance.

Effects of Agricultural Exports on EF of Cropland Production

The results on the effects of agricultural exports on EF of cropland production are reported in Table 2. Column [1] shows the results obtained from fixed effects estimation and column [2] reports the results from random effects estimation. Again, Hausman test was conducted which preferred fixed effects results than random effects estimation (chi sq: 390.95; *p*-val (0.0000)).

The coefficient on agricultural exports is positive and significant as seen in column [1]. A 1% increase in agricultural goods exports increase the EF of cropland production by 0.0157%, indicating the existence of PHH. Again, the coefficient on GDP per capita is significantly positive, and coefficient on its square term is significantly negative. This points out the existence of EKC in developing countries. The signs of other control variables are also in line with the existing studies. Manufacturing exports, urbanization, and rule of law improve the quality of environment by reducing the EF of cropland production.

Table 2
Effects of Agricultural Exports on EF of Cropland Production

Variables	[1] Fixed Effects	[2] Random Effects
lg (Agriculture Export)	0.0157**	0.0218***
	[0.0068]	[0.0074]
lg (GDP_{pc})	1.4245***	1.3183***
	[0.1831]	[0.1937]
lg $(GDP_{pc})^2$	-0.0588***	-0.0607***
	[-0.0109]	[-0.0116]
lg (Manufacturing Export)	-0.0187*	-0.0295**
	[-0.0108]	[-0.0117]
lg (Urbanization)	-0.3591***	-0.2199***
	[-0.0284]	[-0.0276]
Rule of Law	-0.0469*	-0.0530**
	[-0.0249]	[-0.0269]
Observations	1,086	1,086
Number of Countries	57	57

Note. Standard errors are in parentheses. ***, ** and * indicate 1%, 5% and 10% level of significance.

Fundamentally, the insignificant effect of agricultural exports on EF of cropland consumption and significantly positive effect on EF of cropland production suggests the existence of the so-called theory of EUE. This shows that through exports, developing countries are importing the environmental damaging effects.

Robustness

It is a well-known fact that fixed effects estimation does not deal with potential endogeneity problem. To robust the results, the lagged value of the dependent variable was included on right hand side of eq.1. as follows:

$$\ln(EF^{k}_{it}) = \beta_0 + \alpha_1 In(EF^{k}_{i,t-1}) + \beta_1 agriexp_{it} + \beta_2[\log(gdp_{it})] + \beta_3[\log(gdp_{it})]^2 + \beta_4 manf_{it} + \beta_5 urban_{it} + \beta_6 rl_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

To estimate the dynamic specification as shown in eq [2], an estimation methodology was used, specifically designed for dynamic specification, namely Blundel and Bond system GMM. For consistent system GMM results, the study relied on AR2 test which tests whether there is second

order serial correlation and Hansen test which is the test to check whether the instruments are exogeneous. The insignificant value of both tests indicates that the results obtained from system GMM are reliable.

The results from system GMM estimation are reported in Table 3. Column [1] shows the effect of agriculture exports on EF of cropland consumption and column [2] reports the effect of agriculture exports on EF of cropland production. The results were reliable as indicated by the insignificant AR2 test and Hansen test. Moreover, the number of instruments was less than the number of cross-sections.

The results were same as obtained from fixed effects estimation. Apparently, the coefficient on agricultural exports is insignificant in column [1], while it is positively significant in column [2]. This indicates that agricultural exports increase the EF of cropland production only in developing countries. This proves the existence of PHH and to some extent the existence of EUE.

Table 3

Effects of Agricultural Exports on EF of Cropland Production and Consumption: System GMM Estimation

Variables	[1] lg (EF cropland con)	[2] lg (EF cropland pro)
$[\lg(\text{EF cropland con})]_{t-1}$	0.8511***	
	[0.0399]	
$[\lg(\text{EF Cropland Pro})]_{t-1}$		1.0426***
		[0.0178]
lg (Agriculture Export)	-0.0088	0.0062**
	[-0.0062]	[0.003]
lg (GDP_{pc})	0.2596***	0.1735**
	[0.0711]	[0.0671]
lg $(GDP_{pc})^2$	-0.0139***	-0.0101**
	[-0.0047]	[-0.0043]
lg (Manufacturing Export)	-0.0093**	-0.0002
	[-0.0043]	[-0.0095]
lg (Urbanization)	0.0029	-0.0119**
	[0.0066]	[-0.0047]
Rule of Law	-0.0096	0.0352*
	[0.0229]	[0.0208]

Variables	[1]	[2]
	lg (EF cropland con)	lg (EF cropland pro)
Observations	1,031	1,031
Countries	56	56
Instruments	37	39
AR2 Test (*p*-val)	0.214	0.365
Hansen Test (*p*-val)	0.267	0.447

Note. Standard errors are in parentheses. ***, ** and * indicate 1%, 5% and 10% level of significance.

Conclusion

This study investigated the relationship between agricultural exports and environmental quality measured in terms of ecological footprint of consumption and ecological footprint of production in 57 developing countries over the time period of 2002 to 2021. The study investigated and compared the impacts of agricultural exports on ecological footprint of cropland consumption and ecological footprint of cropland production to validate the PHH and/or EUE against the pollution halo hypothesis in developing countries.

The results from the fixed effects and system GMM estimations indicated that agricultural exports are worsening the environmental quality of developing countries. The finding that agricultural exports augment the ecological footprint of production, supports the EUE theory, which posits that environmental production processes are being shifted to less developed countries, thereby raising their ecological footprint.

Policy Recommendations

To reduce the environmental impact of agricultural exports in developing countries, policies should encourage sustainable farming practices, implement strict environmental standards for export crops, and track the ecological footprint of production. Promoting local consumption and value-added processing may help balance economic growth with environmental conservation. Furthermore, regional and international collaboration, combined with improved land-use planning and ecosystem protection, is crucial to prevent the outsourcing of environmental harms and ensure long-term ecological sustainability. Trade policies should integrate environmental safeguards and encourage value-added processing to lessen the pressure for raw export growth.

Author Contribution

Sheeza Ramzan Bhutta: Literature Review, Empirical Analysis, Paper write up. **Ayesha Ashraf:** Theoretical Framework, Empirical Modelling, Paper write up. **Mehvish Shafiq:** Identification of objectives, Theoretical Framework, Paper write up

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

Data supporting the findings of this study will be made available by the corresponding author upon request.

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