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# The Relationship between External Debt and Agricultural Growth in Three Developing Economies using Panel ARDL

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**ABSTRACT**

This study explores the complex interplay between external debt, government expenditures in Agriculture, agricultural investment, and economic growth in three developing countries (Egypt, Pakistan, and Argentina). The study uses data from the Agriculture Orientation Index, External Debt, Agricultural Capital formation coefficient, Agricultural Credit, and Agricultural Gross Domestic Product covering the period from 2002 to 2022 from the three developing countries to examine the long-run relationships between these variables. The results suggest that external debt might have a negative impact on real AGDP in the long term. On the other hand, the research finds a positive relationship between agricultural credit access with real AGDP. The study also reveals that short-term imbalances are decreasing by about 4% which means that it would take 25 years to reach a state of equilibrium in the long term.

## INTRODUCTION

The agricultural sector plays a pivotal role in the economies of many countries, serving as a backbone for rural livelihoods, food security, and socio-economic development (FAO, 2020). Within this context, external debt emerges as a significant but complex financial instrument that governments leverage to catalyze growth within this crucial sector (World Bank, 2023). The impact of external debt on agriculture varies across regions and merits a nuanced exploration to understand its varied effects (Von Braun *et al.*, 2009). Egypt, Argentina, and Pakistan, each with their unique economic landscapes, present an ideal study to gauge how external debt influences agricultural growth. Those three countries were selected as the highest developing borrowers countries of the International Monetary Fund (IMF, 2024)

The impact of external debt on the agricultural gross domestic product (AGDP) in developing countries has been a subject of extensive research and debate (Phiri *et al.*, 2020). Literature on the subject highlights a dual role of external debt: acting as an economic stimulant imperative for the growth of key sectors like agriculture (World Bank, 2023). The relationship between external debt and economic growth is multifaceted, encompassing both positive and negative dimensions. Studies have shown that external debt can provide essential financial resources for investment and development (Mody, 2003). When used effectively, external debt can finance investments in irrigation infrastructure, improved seeds and fertilizers, and extension services, leading to increased agricultural productivity and output (Ahmed *et al.*, 2018, Easterly *et al.*, 2001, World Bank, 2010). External debt can also become a burden as its indiscriminate accumulation and mismanagement would impede economic growth (Hausmann & Panizza, 2010). Beyond a reasonable threshold, it can lead to resource allocation towards debt servicing at the expense of crucial sectoral investment (Von Braun *et al.*, 2009). This can occur when a significant portion of government revenue is directed towards debt repayment, leaving less available for investments in agricultural research, education, and infrastructure (Egwunatum & Onwuche, 2021). Also, studies have shown that high levels of external debt can crowd out private investment, lead to currency depreciation, and ultimately stifle economic growth (Beck *et al.*, 2003).

For some developing countries, a study conducted in Nigeria by Peter *et al.* (2012) found a complex interplay between external debt and economic growth. Their results showed that external debt can have a negative impact (Sulaiman *et al.*, 2018). Contrary to the potential benefits, reliance on external debt can also pose significant challenges to economic growth. Similar findings emerged in Pakistan, where external borrowing and debt servicing obligations have been linked to hampered economic growth (Mody, 2003). Research by Rahman *et al.* (2012) further highlights this negative impact, demonstrating that both external debt and total debt service exert statistically significant deleterious effects on Pakistan's GDP growth rate. Additionally, a study by Ahmed *et al.* (2016) suggests adverse effects on economic growth in Pakistan when relying on public debt, including

external borrowing.

Empirical studies from other countries reveal a similarly complex relationship between external debt and economic growth. While some studies suggest a positive effect of external debt on economic growth in Egypt (World Bank, 2010), others, like Bayoumi and Eichengreen (1999) examining Egypt, underscore the potential for negative impacts on economic performance. This duality underscores the need for context-specific analysis and policy interventions tailored to address the unique challenges faced by each country.

However, there is limited research on the specific impact of external debt on the agricultural sector and its contribution to GDP in developing countries (Sogah *et al.,* 2024). While studies on Ghana (Sogah et al., 2024) suggest a positive relationship between external debt and AGDP growth, highlighting the potential benefits of effective allocation, the broader understanding of this relationship across various contexts remains underdeveloped. Several studies acknowledge this research gap. For instance, Phiri *et al*. (2020) emphasize the need for further investigation into the nuanced dynamics between external debt, agriculture, and economic growth in Sub-Saharan Africa. Similarly, Egwunatum and Onwuche (2021) call for more research on the potential crowding-out effect of external debt on crucial agricultural investments in developing countries. Addressing these knowledge gaps is crucial for developing informed policies regarding external debt and agricultural development strategies in diverse economies (Fadeyi, 2018). Studies in Pakistan, for example, echo similar concerns about the limited research on the specific impact of external debt on agriculture (Zaman, 2014; Ali, 2011, Ud-Din, 2020; Sajjad, 2019).

## MATERIAL AND METHODS

The research utilized the Panel ARDL methodology to examine the relationship between external debt and agricultural GDP (AGDP), incorporating both cross-sectional and time series data. This approach is less frequently employed in agricultural research, where the ARDL methodology is more commonly used (Uslu, H. 2021; Asteriou, D. et al., 2021; Hassanien, K. 2023).

By examining the cases of Egypt, Argentina, and Pakistan, this research will contribute to bridging these literature gaps. The primary objective of this study is to analyze the impact of external debt on the agricultural sectors of Egypt, Argentina, and Pakistan, by examining key indicators such as agricultural GDP, agricultural investment, government expenditure on agriculture, and the prevalence of agricultural loans, using Panel ARDL aiming to uncover the intricate relationship between external debt burdens and agricultural growth in these countries.

**1. Panel unit root test:**

Panel unit root tests are similar, but not identical, to unit root tests carried out on a single series. We begin by classifying our unit root tests based on whether there are restrictions on the autoregressive process across cross-sections or series. Consider a following AR(1) process for panel data:

$$y_{it} = \rho_i y_{it-1} + X_{it}\delta_i + \varepsilon_{it}$$

where:

i= 1, 2,…….N cross-section units or series, that are observed over periods t= 1,2,……N.

$X_{it}$ = the exogenous variables in the model, including any fixed effects or individual trends.

$\rho_i$ = the autoregressive coefficients.

$\varepsilon_{it}$ =mutually independent idiosyncratic disturbance.

For testing purposes, there are two assumptions about $\rho_i$.. First, it can be assumed that the persistence parameters are common across cross-sections, so $\rho_i = \rho$ for all i. The Levin, Lin, and Chu (LLC) and Breitung tests apply this assumption. Alternatively, $\rho_i$ can be allowed to vary freely across cross-sections. The Im, Pesaran, and Shin (IPS), Fisher-ADF, and Fisher-PP tests follow this approach.

LLC and Breitung tests assume a common unit root process meaning $\rho_i$ is identical across cross-sections. Both tests use a null hypothesis of a unit root.

LLC and Breitung both consider the following basic ADF specifications:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{\rho_i} \beta_{ij}\Delta y_{it-j} + x'_{it}\delta + \varepsilon_{it}$$

where

a common $\alpha = \rho - 1$ is assumed, but the lag order for the difference terms, $\rho_i$, can vary across cross-sections. The null and alternative hypotheses for the tests are:

$H_0: \alpha = 0$

$H_0: \alpha < 0$

Under the null hypothesis, there is a unit root, under the alternative, there is no unit root.

The IPS, Fisher-ADF, and PP tests allow for individual unit root processes, so $\rho_i$ may vary across cross-sections. These tests combine individual unit root tests to derive a panel-specific result.

**2. The Autoregressive Distributed Lag (ARDL)**

Cointegration analysis is a fundamental tool in econometrics, allowing researchers to investigate the existence of long-run equilibrium relationships between variables. Panel data, encompassing time series observations for multiple cross-sectional units (e.g., countries, firms), provides a rich source of information for such analysis. However, traditional cointegration techniques, such as the Engle-Granger and Johansen tests, can be restrictive. These

methods often require pre-testing for stationarity (unit roots) in the variables, which can be problematic in small samples and potentially lead to spurious (false) cointegration results.

The ARDL approach offers a robust and flexible alternative for cointegration analysis in panel data. Unlike traditional techniques, ARDL does not require pre-testing for unit roots. It can handle a mix of integrated variables of order zero (I(0)) and one (I(1)), providing more reliable results in situations with uncertain integration orders. This characteristic makes ARDL particularly advantageous for empirical research where data limitations or theoretical ambiguities make pre-testing for stationarity undesirable.

**3. The Panel ARDL Model:**

It allows for estimating a model that incorporates both short-run dynamics and long-run relationships simultaneously. The general form of the Panel ARDL model can be expressed as:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum \delta_j \Delta X_{t-j} + \sum y_j Y_{t-j} + \varepsilon_t$$

- $\boldsymbol{y_t}$: Dependent variable for unit i at time t
- $\boldsymbol{X_t}$: Vector of independent variables for unit i at time t
- Δ: First difference operator (Yt - Yt-1)
- $\boldsymbol{\alpha_0}$, $\boldsymbol{\alpha_1}$, $\boldsymbol{\delta_j}$, $\boldsymbol{y_j}$: Coefficients to be estimated
- $\boldsymbol{\varepsilon_t}$: Error term

**4. Data collection**

Data was collected from secondary published data available on FAO and World Bank databases covering the period from 2002 to 2022 for the countries in the study (n = 63). Data was firstly transformed into Real (R) and logarithmic forms (Ln) to prevent inflation effect and price fluctuations and also to harmonize measurement units.

**5. Data analysis**

**5.1. Panel stationary analysis**

The research starts the empirical analysis by conducting panel unit root tests for all variables. This study uses the LLC's test (Levin et al., 2002), the Breitung (2000) t-statistic, the IPS-W-statistic (Im et al., 2003), the ADF-Fisher Chi-square (Augmented Dickey-Fuller, 1979), and the PP-Fisher Chi-square tests (Phillips and Perron, 1988) as five distinct unit root tests to evaluate the stationary nature of the variables. Table 1 summarizes the results of the unit root tests, which revealed that the variables of interest are stationary at the first differences but non-stationary at level I(0). Agriculture Orientation Index (AOI), External Debt (LnREXDEB), Agricultural Capital formation coefficient (LnRAGFCF), Agricultural Credit (LnRAGCR), and Agricultural Gross Domestic Product (LnRAGDP) are I(1) according to all unit root tests. Consequently, it is necessary to perform cointegration tests between real AGDP and external debt to AGDP to check for the possible existence of a long-run relationship.

**5.2. Panel cointegration analysis**

The panel cointegration test findings must be analyzed to ascertain whether the regressions are erroneous. Testing the cointegrating link between the five variables is relevant in light of the findings. Three cointegration tests-the Pedroni (2004), Kao (1999), and Johansen (1988) Fisher panel cointegration tests-were used in this study to examine the long-term connection between the independent variable LnRAGDP and the dependent variables AOI, LnREXDEB, LnRAGFCF, and LnRAGCR.

## RESULTS AND DISCUSSION

**1. Pedroni Cointegration Test:**

The results of Pedroni's (2004) heterogeneous panel tests (see Table 2) indicate that the null of no cointegration in a heterogeneous panel can be accepted at the 1% and 5% significance level except for Panel rho-, Panel ADF- Statistic, Group rho-Statistic, and the Group ADF- Statistic. The Pedroni cointegration test reveals the existence of a panel long-run equilibrium relationship between AOI, LnREXDEB, LnRAGFCF, LnRAGCR as dependent variables and LnRAGDP as an independent variable.

**2. Kao Cointegration Test:**

Table 3 reports the results of Kao's (1999) residual panel cointegration tests, which reject the null of no cointegration at the 1% significance level. The same result is obtained from Kao's test of existing a cointegration between variables, showing low probabilities of accepting the null hypothesis in the p values.

**4. Panel causality analysis:**

As shown in Table 4, To verify the existence of cointegration between LnRAGDP and AOI, LnREXDEB, LnRAGFCF, and LnRAGCR for the three countries in the Panel ARDL model for the period (2002-2022) where all variables stationary levels are I(1), The panel ARDL results were estimated from the best model, ARDL (1, 1, 1, 1, 1), selected based on Akaike info criterion (AIC). The value of the F-statistic has been obtained, which equals 4.59 a value that is higher than the upper critical bound (UCB) in the table that provides the maximum and the minimum statistical values specified for this test at the 5% significant level in the three developing countries. Table 4 shows that there are positive relationships between LnRAGDP and LnRAGCR, while there are negative relationships between LnRAGDP and LnREXDEB.

**Table 1: panel Unit root test results.**

| Variable | Levin, Lin & Chu t* | | Breitung t-stat | | Im, Pesaran and Shin W-stat | | ADF - Fisher Chi-square | | PP - Fisher Chi-square | | I |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Level | 1st Difference | Level | 1st Difference | Level | 1st Difference | Level | 1st Difference | Level | 1st Difference | |
| LnRAGDP | 0.19 (0.57) | 0.88 (0.81) | 0.26 (0.60) | -1.79 (0.04) | -0.59 (0.28) | -2.42 (0.01) | 8.21 (0.22) | 16.19 (0.01) | 17.07 (0.01) | 48.48 (0.00) | I (1) |
| AOI[1] | 2.22 (0.99) | 5.28 (1.00) | 0.98 (0.84) | -0042 (0.34) | -0.44 (0.33) | 0.19 (0.58) | 5.73 (0.45) | 2.60 (0.86) | 5.53 (0.48) | 49.79 (0.00) | I (1) |
| LnREXDEB | 0.77 (0.78) | -0.82 (0.21) | 0.38 (0.65) | -1.52 (0.05) | 0.04 (0.51) | -3.25 (0.00) | 4.38 (0.62) | 20.98 (0.00) | 19.52 (0.00) | 60.99 (0.00) | I (1) |
| LnRAGFCF | -0.27 (0.39) | -0.12 (0.45) | 0.19 (0.58) | -1.82 (0.03) | -0.49 (0.31) | -2.56 (0.00) | 7.25 (0.30) | 16.93 (0.01) | 16.99 (0.00) | 49.52 (0.00) | I (1) |
| LnRAGCR | -0.07 (0.47) | 0.57 (0.72) | 1.27 (0.90) | -2.24 (0.01) | 0.53 (0.70) | -2.39 (0.01) | 3.30 (0.77) | 16.20 (0.01) | 7.58 (0.27) | 42.49 (0.00) | I (1) |

[1]Government Expenditures is defined as the Agriculture Share of Government Expenditures, divided by the Agriculture Share of GDP

**Table 2: Pedroni Cointegration Test Results (LrAGDP as dependent variable)**

| Within-dimension | Statistic | Prob. | Between-Dimension | Statistic | Prob. |
|---|---|---|---|---|---|
| Panel $\nu$ − Statistic | 3.46 | 0.00 | | | |
| Panel rho- Statistic | 0.16 | 0.56 | Group rho- Statistic | 0.94 | 0.83 |
| Panel PP- Statistic | -2.10 | 0.02 | Group PP- Statistic | -2.25 | 0.01 |
| Panel ADF- Statistic | 0.94 | 0.83 | Group ADF- Statistic | 0.67 | 0.75 |

**Table 3: Kao (1999)'s residual cointegration test results (LnRAGDP as dependent variable)**

| ADF | t- Statistic | Prob. |
|---|---|---|
| | -3.29 | 0.00 |

**Table 4: Panel ARDL results**

| Variable | Coeff. | t | Sig. |
|---|---|---|---|
| **Long-run** | | | |
| LnRAGFCF | 0.19 | 0.42 | 0.68 |
| LnRAGCR | 0.95 | 1.94 | 0.05 |
| AOI | -0.11 | -0.03 | 0.97 |
| LnREXDEB | -1.04 | -1.93 | 0.05 |
| C | 9.59 | 3.07 | 0.00 |
| **Short-Run** | | | |
| LnRAGFCF | 0.41 | 1.79 | 0.07 |
| LnRAGTC | 0.41 | 2.35 | 0.02 |
| AOI | -1.40 | -1.27 | 0.21 |
| LnREXDEB | 0.15 | 2.73 | 0.01 |
| COINTEQ | -0.04 | -1.65 | 0.10 |
| F Bonds | | 4.59 | 0.05 |

The result of T-statistics and the causality coefficient of ECM are shown in Table 5 and illustrate that the coefficient of the error correction model (COINTEQ) is negative and statically significant suggesting that short-term imbalances are decreasing by about 4% which means that it would take 25 years to reach a state of equilibrium in the long-term.

The Panel ARDL test results demonstrated a positive relationship between agricultural credits and AGDP, indicating that boosting local investments in the agricultural sector can enhance agricultural growth rates. Conversely, there is a negative relationship between external debt and AGDP, reflecting the insufficient allocation of financial resources from these debts towards agricultural development, or their inefficient or ineffective utilization. Additionally, AOI was found to be non-significant in gross agricultural output, underscoring a deficiency in the effectiveness of economic planning and the distribution of government expenditures across various agricultural sectors

The constant coefficient of 9.59 indicates the baseline level of the dependent variable, which is likely the agricultural GDP (AGDP), when all independent variables are zero. This high value suggests that the AGDP has a substantial baseline level, reflecting inherent productivity or other structural factors in the agricultural sector, and might reflect underlying economic conditions, structural factors, or inherent productivity levels in the agricultural sector that persist regardless of the variations in the included explanatory variables

## CONCLUSIONS

The study investigates the long-run relationship between real AGDP (LnRAGDP) and four other variables: Agriculture orientation index (AOI), External debt (LnREXDEB), Agricultural capital formation coefficient (LnRAGFCF), and agricultural credit (LnRAGCR).

**Here's what the results suggest:**

In the long-run relationship, all three cointegration tests (Pedroni, Kao, and Fisher) indicate a cointegrating relationship between the variables. This means that LnRAGDP and the other four variables move together in the long run, even if they may fluctuate in the short run.

As for the direction of causality, panel ARDL analysis suggests both positive and negative relationships between LnRAGDP and the other variables. There's a positive association between LnRAGDP and LnRAGCR, implying that higher agricultural credit may lead to higher LnRAGDP in the long term. However, a negative relationship is

found between LnRAGDP and LnREXDEB, this could suggest that increasing external debt might put a strain on LnRAGDP growth in the long run.

Regarding the speed of adjustment, the error correction model (ECM) coefficient is negative and statistically significant. This indicates that short-term deviations from equilibrium are corrected at a rate of about 4% per year. In other words, it would take approximately 25 years for the system to reach long-run equilibrium after a shock.

Overall, the study suggests a complex relationship between LnRAGDP and the other variables. While agricultural credit seems to have a positive impact on long-run growth, external debt might have a negative effect. Further analysis is needed to understand the specific channels through which these variables influence LnRAGDP

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**الملخص العربي**

# العلاقة بين الدين الخارجي والنمو الزراعي في ثلاث اقتصادات نامية باستخدام منهجية Panel Data

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يحاول البحث الكشف عن العلاقة بين الدين الخارجي، والنفقات الحكومية في الزراعة، والاستثمار الزراعي، والنمو الاقتصادي في ثلاث دول نامية (مصر وباكستان والأرجنتين). واعتمد البحث على بيانات منشورة لعدد من المتغيرات أهمها: الناتج المحلي الإجمالي الزراعي، الديون الخارجية، معامل تكوين رأس المال الزراعي، والائتمان الزراعي تغطي الفترة ٢٠٠٢–٢٠٢٢، تشير النتائج إلى أن الدين الخارجي قد يكون له تأثير سلبي على الناتج المحلي الإجمالي الحقيقي على المدى الطويل، ومن ناحية أخرى فإن البحث يؤكد وجود علاقة طردية بين الوصول إلى الائتمان الزراعي والناتج المحلي الإجمالي الزراعي، كما أوضحت النتائج أن الاختلالات قصيرة الأجل تتناقص بنحو ٤٪ مما يعني أن الأمر سيستغرق ٢٥ عاماً للوصول إلى حالة التوازن في المدى الطويل.

**الكلمات الدالة: ARDL Panel data، الدين الخارجي، التكامل المشترك، اختبار جذر الوحدة، النمو الزراعي.**