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Exploring the Role of Country Governance in Shaping Key Determinants of Agricultural Production: Evidence from Panel Data Analysis

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Agricultural production becomes an integral factor for economic development and food security. Therefore, the study investigated the effect of foreign aid and foreign agricultural aid on Saudi Arabia's agricultural production. Researchers also tested the moderating effect of country governance. Quantitative longitudinal data was collected from the world development indicators for the period of 2013 to 2024. The feasible Generalized Least Squares (FGLS) regression technique was used to address econometric concerns such as heteroskedasticity, autocorrelation, and cross-sectional dependence. For robustness of findings, Panel-Corrected Standard Errors (PCSE) were also applied. From those regression models, FGLS results were more appropriate. FGLS results show the significant impact of total foreign aid and total agricultural aid on the agricultural production of Saudi Arabia. Country governance also significantly moderates among total foreign aid, foreign agricultural aid, and agricultural production of Saudi Arabia. These findings highlighted that an effective governance structure improves the efficiency of aid utilization which is ensuring its alignment with national agricultural objectives. The research results highlighted that policymakers must focus on strengthening governance frameworks, enhancing aid allocation efficiency, and ensuring transparency in financial assistance programs to maximize the impact of foreign aid on agricultural production. Private sector stakeholders can leverage foreign aid for technology adoption, infrastructure development, and market expansion. This study is the first to empirically examine the direct and moderating effects of foreign aid and foreign agricultural aid on agricultural production in Saudi Arabia. This study also contributes to both agricultural economics and governance literature which offers novel insights into how governance improves the foreign aid in the country.

Keywords: Foreign aid, Agricultural production, Country governance, Saudi Arabia.

Introduction

Agricultural production is a crucial factor in food security and a country's sustainable economic development (Guiné et al., 2021). This is the reason, national development initiatives often emphasize the security of food as a priority to increase domestic production to meet the needs of the population (Godfray & Garnett, 2014). Agriculture production decreases due to waste resources and weak irrigation systems which encourage farmers to adopt alternative farming techniques such as hydroponics and vertical farming (Nazir et al., 2024). When the country is facing the issue of water resources then agricultural production decreases which emphasizes focused food imports and limited arable land necessitating continuous innovation and financial support to fill the needs of the population (Giller et al., 2021). To overcome these constraints, foreign aid has played an important role in strengthening agricultural capabilities, supporting infrastructure development, and ensuring food availability (Norton, Alwang, & Masters, 2021). Moreover, external investments and aid have helped develop agribusiness opportunities, allowing nations to reduce dependence on imported food products while promoting local agricultural sustainability (Pretty, Morison, & Hine, 2003). Based on the studies, it is essential to note that food production is influenced by foreign aid which makes it a central idea for the research.

Historically, foreign agricultural aid has become an integral component in increasing the agricultural sector because it increases the fund's facility for the farmers which leads to investments in modern farming techniques, sustainable irrigation methods, and technology transfer (Islam, 2011). Official Development Assistance (ODA) directed towards agricultural projects has enabled the adoption of precision farming, hydroponics, and desalination technologies to support food production in arid conditions (Salinas-Velandia et al., 2022). Such kind of advancement in technology helps to improve the usage of water efficiency which is helping the countries optimize limited freshwater resources for agricultural purposes (Evans & Sadler, 2008). In other words, foreign agricultural aid has also contributed to improving infrastructure in rural areas which is enabling farmers to access better transportation networks and market opportunities (Shiferaw, Hellin, & Muricho, 2011). While agricultural aid has proven beneficial in many developing regions, its effectiveness depends on strategic implementation and alignment with national policies aimed at maximizing productivity and resource efficiency (Alzahrani et al., 2023). If there is no proper planning then the foreign trade assistance benefits might be limited by inefficiencies in resource allocation and institutional bottlenecks. Therefore, the study addressed the influence of foreign agricultural aid on agricultural production.

Along with the agricultural aid, total foreign aid also contributed significantly to agricultural sustainability

(Trentinaglia, Baldi, & Peri, 2023). Foreign aid improves investment opportunities in infrastructure, transportation networks, and water conservation systems which increases agricultural production through reducing the supply chain disruptions and enhancing market accessibility (Tondel, D'Alessandro, & Dekeyser, 2022). Investment in modern storage facilities always helps to reduce harvest losses and ensures that products reach to consumers is an optimal condition (Kaur & Watson, 2024). On the other hand, foreign aid also increases the opportunities for research and development which increases the innovations in sustainable farming practices, which is enabling countries to mitigate the challenges posed by harsh climates (FAO, 2021). Another study also highlighted that international partnerships through providing foreign aid in renewable energy projects, particularly in the development of solar-powered irrigation systems that reduce dependency on fossil fuel-based water extraction (Athuman, 2023) could increase agricultural production. These studies highlighted that total foreign aid and total agricultural aid are important indicators of improving agricultural production and food security. Therefore, the study addressed the influence of total foreign aid and agricultural aid on agricultural production.

To improve foreign aid utilization and its enhancement, country governance played a key role which could lead to improved agricultural production. An effective country governance increases the transparency in the economies and leads to better utilization of foreign aid which ensures that aid is allocated efficiently and aligns with national objectives (Newman et al., 2024). A strong governance structure has established strong measures to increase the effectiveness of aid utilization which consisted of streamlining bureaucratic processes and improving monitoring mechanisms for foreign-funded projects. Many countries have established strong agricultural development funds that provide financial support to farmers and agribusinesses (Dzakaklo, Hlovor, & Tandoh-Offin, 2024). Country governance through providing low-interest loans to their nations could facilitate investments in modern farming equipment, sustainable irrigation methods, and innovative food production techniques (Jiang, 2023). Furthermore, country governance could also help to create a public-private partnership and international collaborations have strengthened the ability to attract foreign investments and leverage technological advancements (Poulton & Macartney, 2012). Some countries have also sought to diversify agricultural investments abroad, securing farmlands in regions with abundant water resources to ensure a stable food supply chain (Woodhouse, 2013). On other the hand, an effective governance structure also creates surety that agricultural projects which are being supported through foreign aid are sustainable, environmentally responsible, and beneficial to long-term food security goals (Luo et al., 2024). These previous studies emphasized that country governance is an integral component that increases the foreign aid in the country to increase agricultural production. Therefore, the study focused on the interaction role of country governance among foreign aid, foreign agricultural aid, and agricultural production.

The study concentrated on moderating the role of country governance among foreign aid, foreign agricultural aid, and agricultural production in the context of Saudi Arabia. Various studies were conducted on foreign aid but those studies were mainly focused on economic growth perspectives (Azam & Feng, 2022; Edwards, 2015; Gebresilassie, Legesse, & Gebre, 2024; Tefera & Odhiambo, 2024). With the significance of foreign aid for agricultural production, still, limited studies have been on foreign aid and agricultural production, particularly in the context of Saudi Arabia (Abbas et al., 2024; Alabi, 2014; Bhandari, 2024; Naima, 2016; Verter, 2017). Therefore, to address these gaps, the study contributed literature in the context of Saudi Arabia. Furthermore, extant literature also concentrated on the direct effect of foreign aid with limited concentration on country governance moderating role. In other words, the study also concentrated on exploring the relationship between foreign aid and governance (Asongu & Nwachukwu, 2016; Bräutigam & Knack, 2004) as well as the impact of governance on agricultural production (Ariabod et al., 2019). With the relationship of these studies, a critical gap remains in understanding how country governance moderates. Therefore, this study contributed to the literature on the moderating effect of country governance. Lastly, extant literature tested the individual effect of foreign aid or foreign agricultural aid on agricultural production (Abbas et al., 2024; Mohamed, Omar, & Abdulle, 2024; Pickson et al., 2025). However, these studies have limited literature on the influence of foreign total aid and foreign agricultural land in one model. Therefore, this study contributed to filling the gaps in the total agricultural aid and foreign aid effect on the agricultural production in one model.

Analyzing the study objective in the context of Saudi Arabia has various valuable insights for policymakers. The findings could help in optimizing aid allocation, strengthening governance mechanisms, and enhancing the overall effectiveness of foreign assistance in fostering sustainable agricultural development. Furthermore, the study could also highlight best practices and challenges in leveraging foreign aid which is providing a framework for future collaborations and policy interventions to achieve global food security and agricultural resilience. The study was further divided into four chapters. The second chapter was a literature review where both theoretical and empirical perspectives of previous studies were discussed. The third chapter explores research methods where the research design and research approach were discussed. The fourth chapter was the data analysis where panel data regression techniques were analyzed. The fifth chapter was related to the discussion of the study where each finding was supported by the relevant studies.

Literature Review

Theoretical Background

Agricultural production is an important pillar for the security of food and economic growth (Guiné et al., 2021). It played an integral role in the creation of employment, and poverty alleviation (Liu et al., 2021). With time, various advancements in the agricultural system through advanced technologies and better irrigation systems have contributed to increased productivity and efficiency. Technological advancements such as genetically modified crops, precision

agriculture, and smart irrigation systems have significantly improved crop yields and resource efficiency (Ahmad & Dar, 2020). For increasing agricultural technologies, there is a need for mechanisms from outside sources to help small-scale farmers enhance their production in agriculture (Williams et al., 2021). Foreign aid improves investment opportunities in infrastructure, and water conservation systems which increase agricultural production by reducing the supply chain (Tondel et al., 2022). The investment in modern cold storage facilities helps to minimize post-harvest losses which ensures that food products reach consumers in optimal condition (Williams et al., 2021). Country governance played a key role in strengthening foreign aid to increase agricultural production (Fuglie, 2023). A strong country governance structure increases the transparency in the utilization of foreign aid which ensures that aid is allocated efficiently and aligns with national objectives (Toivola, 2023). A strong governance structure has been established (Fuglie, 2023).

Various theories support the connection in foreign aid and agriculture production with the moderating effect of country governance. Among the theories, structural growth theory highlights the significance of foreign aid, and structural growth theory is linked to economists (Lewis, 1954; Nurkse, 1953). This theory explains foreign aid helps agriculture grow by supporting modern techniques and investments, leading to economic transformation. The Harrod-Domar model originated by Domar (1946) and Harrod (1939) adds that higher investment rates drive growth, while the linear-stages-growth approach (Rostow, 2013) highlights step-by-step progress in an economy. Both models support the idea that foreign aid is important for shifting from traditional to modern agriculture. This transformation increases productivity and helps the overall economy grow. North (1990) originates institutional theory which highlights the relationship between governance and foreign aid. This theory emphasizes the role of governance structures, regulatory frameworks, and institutional quality in determining foreign aid effectiveness. This theory suggests that well-functioning institutions enhance foreign aid utilization in agriculture through ensuring transparency, reducing corruption, and aligning aid initiatives with national priorities (Newman et al., 2024). Based on the theories, researchers formulated the research framework below in Figure 1.

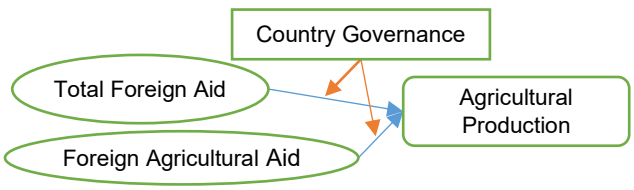

Figure 1: Theoretical Framework.

Foreign Aid and Agricultural Production: Hypothesis Development

Agricultural production is boosted by foreign aid, especially in those countries where people have low incomes (Adan, 2023). It has been noticed in the extant literature that foreign aid provided to farmers increases their capacity to produce more agricultural crosses by improving their water system and irrigation systems (Gollin, 2019). Other authors also highlighted the key role of foreign aid in improving agricultural production through overcoming financial and technological barriers, which improves food security (Alotaibi, 2023). In the same vein, Sultana (2023) also found the significant role of foreign aid in increasing agricultural production. Equally, Kamguia et al. (2022) emphasized that corruption and misallocation of foreign aid in recipient nations frequently reduce the intended benefits of international agricultural assistance. Similarly, Adan (2023) also suggested that excessive dependence on foreign aid may reduce incentives for self-sufficiency which is leading to inefficiencies and stagnation in agricultural growth. They also emphasized the necessity of including more variables, such as institutional framework procedures or country governance, to guarantee that aid is used efficiently and benefits the agricultural sector in the long run. Adan (2023) also investigated the increasing effect of foreign aid on agriculture production in developing nations.

Further, Garbero & Jäckering (2021) showed that specific foreign agricultural assistance raises food security and rural income levels. Similarly, Wehmeyer (2024) has shown that when supported by efficient governance practices, foreign agricultural aid results in long-term sustainable agricultural production. Moreover, Kirikkaleli et al. (2021) found the influence of foreign aid on agricultural growth is reliant upon policy coherence and institutional quality. According to other studies, nations with established infrastructure and policy frameworks are more likely to make better use of foreign aid, which results in long-term agricultural growth (Niyonkuru, 2016). Conversely, other studies contend that because of problems including misallocation of funds, corruption, and inconsistent policies, foreign aid may not necessarily result in better agricultural outcomes (Dangi et al., 2021; Osman, 2024; Pickson et al., 2025). Additionally, Hussain (2016) discovered that foreign aid increase the agricultural prodcuauction. However, Cherkaoui (2022) also highlighted the significant relationship between foreign agricultural aid on agricultural production.

Ibrahim Ali Hussien (2022) found the significant impact of agricultural production in more than one country. They also highlighted that foreign aid is an important factor for developing those nations that have scarce water resources, limited access to modern agriculture technologies, and struggling with resource constraints and inadequate infrastructure. This argument is further supported by the view of Marei (2023) who highlighted that investments in rural roads and irrigation infrastructure, funded by foreign aid, substantially improve agricultural production by increasing market access and efficiency. Similarly, Ssozi, Asongu, & Amavilah (2019) discovered that foreign aid in agriculture contributes more to the adoption of the newest farming practices and seed varieties, which raises crop yields. Moreover, Abbas et al. (2024) aid can stimulate long-term agricultural growth that benefits both smallholder farmers and commercial agricultural firms provided it is distributed efficiently within a robust policy framework. However, Effective governance and well-

designed rules are essential for ensuring that foreign agricultural aid is allocated to well-known agricultural initiatives rather than inefficient administrative processes (Alotaibi, 2023). Thus, its empirical results suggested that the moderating effect of governance structure on the relationship between agricultural production and foreign agricultural aid could be the subject of future research.

In addition, Vernooy (2022) found that while ensuring sustainable agricultural development, foreign agricultural aid increases crop diversification and the efficacy of climate adaptation techniques. Furthermore, Daly et al. (2020) believed that financial interventions like microfinance schemes that help smallholder farmers boost their output and lower production risks are also supported by foreign agricultural aid. Contrariwise, other study claim that because of problems including misallocation of funds, corruption, and inconsistent policies, foreign aid does not necessarily result in increased agricultural production (Osman, 2024). This aligns with the study of Kamguia et al. (2022) where they found that foreign aid does not positively increase agricultural production. They highlighted the reason for declining production was due to weak governance structures in recipient countries. In the same vein, Pickson et al. (2025) study also examined the influence of agricultural foreign aid on agricultural production and found that aid dependency, rather than investment in sustainable projects, led to stagnation in agricultural production. Alternatively, Cherkaoui (2022) argues that excessive foreign aid can weaken domestic institutions, reducing incentives for self-sufficiency and economic development. Similarly, Anderson (2023) demonstrated that certain kinds of food aids, especially in-kind donations can disincentives local production and disrupt agricultural markets. These studies argued that countries' proper governance can increase foreign aid effectiveness for agricultural production. To address the previous gaps and keep in view the relationship, the following hypothesis formulated below,

H1: Foreign aid for agriculture increases agricultural production.
H2: foreign aid significantly improves the agricultural production.

Country Governance Moderation

Extant studies in the previous section highlighted that foreign aid from both total and agricultural perspectives have inconsistent findings which highlights that there is a need for relationships in other contexts with moderating variables (Arpaci-Ayhan, 2023). For this purpose, effective country governance could be a potentially moderating variable in ensuring that foreign aid could tangible improvements in agricultural production (Arpaci-Ayhan, 2023). Strong institutions transparent policies and better regulatory frameworks increase the effectiveness of the allocation and utilization of foreign aid which prevents misallocation and corruption (Le, Nguyen, & Do, 2021). Strong governance systems enable nations to more effectively direct help toward vital agricultural requirements including market growth, infrastructure, and technology (Bräutigam, 2000). Lawson (2020) also provided more evidence in favor of the idea that the effectiveness of help is strongly influenced by the quality of government, with well-run nations showing faster rates of agricultural growth as a result of effectively managed foreign aid. Akramov (2012) also underlines the importance of effective governance in promoting accountability, ensuring that foreign aid is spent on productive agricultural development rather than administrative overhead or elite capture.

Rajan & Subramanian (2011) further revealed that while poorly governed countries suffer from inefficiency and aid dependency, countries with solid governance institutions could boost foreign aid to promote long-term agricultural development. Arndt (2009) showed that governance indicators including government efficacy, regulatory quality, and corruption control are critical in assessing the performance of agricultural assistance initiatives. Conversely, Gollin & Udry (2021) suggest that governance issues contribute to aid misallocation, restricting its ability to improve agricultural production. These findings reinforce the need for policy reforms that strengthen governance frameworks to ensure that foreign aid effectively contributes to sustainable agricultural growth. On the other hand, in various studies, country governance significant moderating effect identified by Krishnan & Teo (2012) and Luo et al. (2024). They also argued that further country governance moderating effect could explore other variables' relationship. Therefore, a study has the following hypothesis below,

H3: Country governance significantly moderates between foreign aid for agricultural and agricultural production.
H4: country governance significantly moderates between foreign aid and agricultural production.

Research Methods and Study Variables

The study contented the influence of foreign aid and foreign agricultural aid on agricultural production in Saudi Arabia. We have also tested the country governance moderating influence Table 1. To test the study hypothesis, the research employed the longitudinal panel data approach where data was collected from 2013 to 2024 (World Bank, 2024). The longitudinal designs allow the researchers to examine of analysis in various periods which is capturing the trends in long run relationships in the study variables (Stritch, 2017). The main analysis of the study in panel data was analyzed through using the Feasible Generalized Least Squares (FGLS). For the robustness of the findings, Panel-Corrected Standard Errors (PCSE) techniques were applied. The FGLS is considered to be a more appropriate method for handling the issue of heteroscedasticity and autocorrelation in panel data (Beck & Katz, 1995). On the other hand, PCSE addresses panel heteroscedasticity and contemporaneous correlation. When the data faces the issue of cross-sectional dependence and serial correlation, then FGLS is considered to be more effective (Baltagi, 2008). Therefore, stronger statistically significant results are proposed from the FGLS which is more preferred on PCSE where there is an issue of cross-sectional dependence and autocorrelation and heteroscedasticity.

Table 1: Study Variables.

Variable	Measurement	Proxy	Source
Dependent variable			
Gross Agricultural Production (GAP)	Total agricultural output, including food and non-food production	Agricultural output index	World Bank (WDI) / FAO
Independent variables			
Foreign Agricultural Aid (FAA)	Total financial aid directed toward agriculture	Foreign aid to agriculture	World Bank (WDI)
Total Foreign Aid (ODA)	Total foreign aid received by the country	Official Development Assistance (ODA)	World Bank (WDI)
Moderating variable			
Country governance index	Measures the quality of governance in a country	Worldwide Governance Indicators (WGI)	World Bank (WGI)
Control variables			
Agricultural Labor (L)	Total labor force employed in the agriculture sector	Agricultural employment percentage	World Bank (WDI)
Arable Land (AL)	Total land available for agriculture	Percentage of total land area used for farming	World Bank (WDI) / FAO
Gross Domestic Saving (SAV)	National savings as a percentage of GDP	Savings rate	World Bank (WDI)

Source: Author's Own Illustration.

Econometrics Models

To test the connection among total foreign aid, foreign agricultural aid and agriculture production, we construct the following model.

$$GAPit=\beta0+\beta1TFAit+\beta2FAAit+\beta3Lit+\beta4ALit+\beta5SAVit+\epsilon it \quad (1)$$

where:

- GAPit = Agricultural Production (Dependent Variable)
- TFAit = Total Foreign Aid (Independent Variable)
- FAAit = Foreign Agricultural Aid (Independent Variable)
- Lit= Agricultural Labour (Control Variable)
- ALit = Arable Land (Control Variable)
- SAVit = Gross Domestic Saving (Control Variable)
- ϵit = Error term

To test the moderation of country governance between total foreign aid, foreign agricultural aid and agriculture production, we construct the following model. Interaction terms are introduced:

$$GAPit=\beta0+\beta1TFAit+\beta2FAAit+\beta3Lit+\beta4ALit+\beta5SAVit+\beta6GOVit+\beta7(TFAit\times GOVit)+\beta8(FAAit\times GOVit)+\epsilon it \quad (2)$$

where:

- GOVit = Country Governance (Moderating Variable)
- TFAit×GOVitTFA_ = Interaction term for Total Foreign Aid and Governance
- FAAit×GOVitFAA = Interaction term for Foreign Agricultural Aid and Governance

Descriptive and inferential Results

Descriptive Statistics

This section in Table.2 shows a descriptive analysis of variables that provide valuable insights into the agricultural sector and economic factors influencing agricultural production in Saudi Arabia. Among the variables, the Gross Agricultural Production (GAP) mean value is 0.529 which shows a moderate level of agricultural output with minimum and maximum values of 0.312 and 0.845. Foreign agricultural aid (FAA) and total foreign aid (ODA) show mean values of 0.145 and 0.215 respectively, highlighting the role of external financial support in enhancing agricultural development. The agricultural labor force (L) has a relatively low mean of 0.098 which reflects the country's dependence on mechanized farming rather than labor-intensive agricultural practices. Arable Land (AL), with an average of 0.263 which is suggesting limited land availability for agriculture. The gross domestic saving (SAV) mean of 0.175 which indicates that there is moderate savings that can contribute to domestic agricultural investment and infrastructure development. Lastly, Governance (GOV) has a mean value of 0.512 which suggests a relatively strong governance framework that played a significant moderating role in the relationship between foreign aid and agricultural growth.

Table 2: Descriptive Statistics.

Variable	Mean	SD	Min	Max
GAP	0.529	0.187	0.312	0.845
FAA	0.145	0.067	0.074	0.298
ODA	0.215	0.089	0.102	0.389
L	0.098	0.045	0.054	0.176
AL	0.263	0.103	0.132	0.487
SAV	0.175	0.072	0.084	0.329
GOV	0.512	0.124	0.301	0.718

Correlation Matrix

This section represents the correlation matrix results of the study. Among the correlation factors, a strong correlation was identified between GAP and ODA (0.527***), GAP and GOV (0.496***), and GAP and FAA (0.482***) which suggests that foreign aid and governance play crucial roles in enhancing agricultural production. Furthermore, L, AL, and SAV also contribute significantly, though with relatively lower correlation values. Importantly, the relationships among the independent variables themselves are insignificant which indicates no substantial interdependence among them. These findings highlight the independent contributions of each factor to agricultural production in Saudi Arabia without redundancy or overlap in their effects. The above results are predicted in Table 3.

Table 3: Correlation Analysis.

Variable	GAP	FAA	ODA	L	AL	SAV	GOV
GAP	1						
FAA	0.482***	1					
ODA	0.527***	0.089	1				
L	0.398**	0.056	0.071	1			
AL	0.451***	0.074	0.092	0.082	1		
SAV	0.372*	0.062	0.067	0.064	0.059	1	
GOV	0.496***	0.081	0.058	0.079	0.077	0.069	1

Diagnostics Test

Multicollinearity Test (VIF Analysis)

The multicollinearity consists of statistical phenomena where two exogenous variables are correlated in the regression model which leads to instability in the estimation of coefficients and reduces the reliability of statistical inferences (Reddy & Balasubramanyam, 2021). When the strong multicollinearity has existed in the model-independent variables then impact could not be tested on endogenous variable of exogenous variables. One of the most common methods to detect multicollinearity is the Variance Inflation Factor (VIF). The Table.4 results of the VIF analysis indicate that multicollinearity is not a significant concern in this model where threshold values of less than 10 (Gujarati, 2009). Keeping in view these threshold values, all values were less than 5 which indicates that there is no issue of multicollinearity.

Table 4: Multicollinearity Results.

Variables	VIF Value
FAA	3.91
ODA	4.67
L	4.12
AL	5.23
SAV	2.15

Autocorrelation, Heteroskedasticity, and Cross-Sectional Dependence

Along with VIF test for multicollinearity, various authors tested were also conducted to highlight the econometric issues in the panel data regression models. An autocorrelation test was conducted to test correlation in the error terms over time in the entities. For this purpose, the Breusch-Godfrey test was conducted with a p-value of less than 0.05 for both models which shows the serial correlation in the residuals (Breusch & Godfrey, 1986). This violates the assumption of independently distributed errors, which can lead to inefficient standard errors and biased inference. On the other hand, the Breusch-Pagan test for heteroskedasticity produces a p-value of 0.001 which confirms that the variance of the error terms is not constant across observations (Breusch & Pagan, 1980). The heteroscedasticity presence shows that results on OLS are inefficient estimators which is the reliability of statistical inference (Gujarati, 2009). Additionally, the ADF test for cross-sectional dependence yields a p-value of 0.003, highlighting the correlation among residuals across entities. This issue is common in panel data due to unobserved common shocks or spillover effects (Pesaran, 2015) and can lead to biased coefficient estimates and misleading statistical conclusions. When there is an issue of heteroskedasticity, autocorrelation, and cross-sectional dependence, then to handle these econometric violations, FGLS is an appropriate estimation method to improve the robustness of regression results than OLS or fixed-effects models (Beck & Katz, 1995). Prior studies on panel data analysis have demonstrated the advantages of FGLS in correcting for these econometric issues, ensuring that statistical inference remains valid (Baltagi, 2008). Therefore, applying FGLS in this context is justified. Table.5 have above results.

Table 5: Diagnostics Test Results.

Test	Model 1 Value	Model 2 Value.	Decision
Autocorrelation (Breusch-Godfrey Test)	0.002	0.002	Yes (Problem)
Heteroskedasticity (Breusch-Pagan Test)	0.001	0.001	Yes (Problem)
Cross-sectional Dependence (ADF Test)	0.003	0.003	Yes (Problem)

Regression Results (FGLS)

The selected model of the current study was the FGLS where the results of the study concluded. The FGLS regression results show that foreign aid increases significantly to agricultural production. Similarly, foreign agricultural aid increases significantly to agricultural production. These results highlight the role of support to agriculture from external ways to increase agricultural production. Additionally, agricultural labor increases significantly to agricultural production. Moreover, gross domestic saving also increases significantly to agricultural production which suggests that higher financial reserves facilitate investments in agricultural infrastructure to increase productivity. Further moderating effect results strengthen the results by emphasizing the role of country governance in maximizing agricultural growth. The moderating effect results show that foreign aid has a positive and significant impact on agricultural production with the moderating effect of country governance. Foreign agricultural aid also increases significantly to agricultural production with a moderating effect on country governance. This interaction term indicates that effective governance structures enhance the efficiency of foreign agricultural assistance. The above interpreted results are depicted in Table.6 below,

Table 6: FGLS Results.

Variable	Direct Effect (Agricultural Production)	Moderating Effect (Agricultural Production)
Constant	5.131 (2.13)	4.95 (2.28)
Foreign Aid	0.172** (0.045)	0.241*** (0.067)
Foreign Agricultural Aid	0.113** (0.052)	0.123** (0.053)
Governance		0.271** (0.136)
Agricultural Labour (L)	0.074** (0.033)	0.071** (0.034)
Arable Land (AL)	0.144** (0.057)	0.125** (0.056)
Gross Domestic Saving (SAV)	0.084** (0.041)	0.129** (0.042)
Foreign Agricultural Aid × Governance (Interaction)	-	0.009** (0.0031

Note: p < 0.1 (*), p < 0.05 (**), p < 0.01 (***)

Robustness Test (PCSE)

The robust results obtained using Panel-Corrected Standard Errors (PCSE) highlight some inconsistencies in the significance of key variables, reinforcing the argument that Feasible Generalized Least Squares (FGLS) is a more appropriate estimation method for panel data analysis in this context. In Model 1 (Direct Effect), foreign aid shows an insignificant impact (0.042), suggesting that general financial assistance alone does not strongly contribute to agricultural production in Saudi Arabia. However, foreign agricultural aid has a positive and significant impact which indicates that aid specifically targeted toward the agricultural sector enhances productivity. Agricultural labor has a positive and significant impact on agricultural production which reinforces the importance of human resources, while arable land and gross domestic savings also demonstrate positive and significant impacts on agricultural production which shows that both land availability and domestic financial reserves support agricultural production. In Model 2 (Moderation Effect), the interaction term between foreign agricultural aid and governance is insignificant which indicates that governance does not significantly enhance the effectiveness of foreign agricultural aid under the PCSE estimation. Additionally, foreign aid remains insignificant, and agricultural labor loses significance (0.037) which is also weakening the reliability of the PCSE results. In contrast, the FGLS results presented earlier show more consistent and significant effects for key variables, confirming that FGLS better accounts for autocorrelation, heteroskedasticity, and cross-sectional dependence issues that PCSE does not fully address (Saeed, Twum, & Klugah, 2024). Since FGLS provides more efficient and unbiased estimates in the presence of such econometric violations, it is the preferred method for panel data analysis in this study. Thus, the findings from FGLS should be considered more robust and reliable compared to those from PCSE when analyzing the determinants of agricultural production in Saudi Arabia. The above interpreted results are depicted in Table.7 below,

Table 7: PCSE Results.

Variables	Model 1 (Direct Effect)	Model 2 (Moderation Effect)
Constant	5.332 (2.452)	4.932 (2.35)
Foreign Aid	0.042 (0.051)	0.032 (0.048)
Foreign Agricultural Aid	0.122* (0.058)	0.321*** (0.055)
Governance		0.235** (0.135)
Agricultural Labour (L)	0.073** (0.035)	0.037 (0.035)
Arable Land (AL)	0.154** (0.058)	0.135** (0.058)
Gross Domestic Saving (SAV)	0.093** (0.042)	0.092** (0.042)
Foreign Agricultural Aid × Governance (Interaction)	-	-0.000016

Discussion

The research objective was to test the influence of total foreign aid and foreign agricultural aid on the agricultural production of Saudi Arabia. We also tested the moderating effect of corporate governance. The study selected the FGLS model to conduct analysis and reported its results. FGLS results highlighted the positive significant influence of total foreign aid on the agricultural production of Saudi Arabia. These results highlighted that total foreign aid contributed significantly to increasing Saudi Arabia's agricultural production through properly providing the capital for mechanization and research, and infrastructural development that is enhancing productivity. These significant findings also highlighted that foreign aid played an important role in addressing the sectorial inefficiencies and devastating domestic funding shortages in developing agricultural economies. The findings align with the studies of Abbas et al. (2024) and Asmus, Fuchs, & Müller (2020), which emphasize that well-structured foreign aid fund irrigation projects improve farming technologies and provide access to high inputs, thus enhancing agricultural development. Furthermore, the finding is consistent with the study of Ssozi et al. (2019) who claim that foreign aid improves agricultural production by increasing the efficiency of agricultural inputs and technology. Hence, it is emphasized in these studies' empirical evidence that Saudi Arabia should focus on increasing foreign aid to increase agricultural production which can increase Saudi Arabia's economic growth.

In addition to foreign aid, foreign agricultural aid also illustrates a positive significant influence on agricultural production which highlights the importance of sectoral dedicated funding. The findings emphasize that foreign agricultural aid specifically targets farming activities by increasing farmers' accessibility to improved seeds, mechanized equipment, climate-resilient agricultural techniques, and fertilizers. In contrast, general foreign aid targets different economic sectors limiting its impact on agricultural production. However, this targeted funding allows beneficiary countries to modernize their agricultural practices by mitigating post-harvest losses and enhancing productivity. The research results are aligns with the study of Hemathilake & Gunathilake (2022) which confirmed that strong foreign agricultural aid has witnessed significant improvement in countries' food production and rural development. It is recognized that Saudi Arabia is heavily dependent on food imports and it is crucial to boost agricultural production to fulfill its ambitious goals under Vision 2030 to enhance domestic food production, leveraging foreign agricultural aid for smart irrigation systems, controlled environment farming, and biotechnology advancements. Based on the above discussion, agriculture sector of Saudi Arabia should collaborate with global agricultural research institutions to facilitate the adoption of innovative farming techniques suited to Saudi Arabia's unique environmental conditions. Furthermore, the results of the moderating effect support these findings by demonstrating that a country's governance structure plays a pivotal role in determining

the affectivity of foreign aid in increasing agricultural production. The interaction term of foreign aid and governance structure indicates that a well-structured governance structure such as efficient resource allocation, institutional stability, and transparent policies strengthens the benefits of foreign financial assistance for agricultural production. The finding is supported by the previous research of Pradhan et al. (2023) who claimed that countries having strong governance structures tend to benefit more from foreign financial aid due to efficient allocation of funds and corruption. Their study also argued that countries with strong governance can leverage foreign aid to transform the agricultural sector in a modernized way. In the context of Saudi Arabia, where policies and economic reforms are strictly implemented, a strong governance framework further, improves the efficiency of foreign aid utilization. Moreover, the governance structure should develop in such a way that ensures the utilization of aid in high-impact projects, which align with food security goals. Alternatively, if the governance structures are weak then countries might not enjoy the benefits of foreign aid leading to reduced agricultural growth and inefficiencies. Hence, the country's governance structure optimizes agricultural growth in Saudi Arabia by strengthening the relationship between foreign aid and agricultural production.

Equally, the moderating influence of foreign agricultural aid and country governance is both positive and significant on agricultural production which highlights the role of governance structure in increasing the effectiveness of the agriculture sector. The study findings emphasized that foreign agriculture aid effectively improves agricultural production if a strong governance structure ensures that aid is utilized efficiently, distributed transparently, and fostering sustainable farming practices. Prior studies such as Zhang & Lu (2024) support this finding where they assert that countries with stronger governance frameworks exhibit high returns from foreign agricultural aid due to strict oversight and superior policy execution. In the same vein, they also demonstrate that governance policies strengthen foreign agricultural assistance that in turn enhances agricultural production. Given the above findings, it applies that a strong governance network attracts foreign assistance and investment as the donor institutions believe in investing in countries having exceptional governance standards. Based upon the above discussion, it confirmed that stronger agricultural governance is utilized to accomplish strategic goals like investing in hydroponic farming, enhancing soil fertility supporting rural development initiatives for raising long-term agricultural sustainability.

Implications

Theoretically contributed to understanding of agricultural development in Saudi Arabia with the direct and moderating effect first time in the Saudi Arabia context. The results demonstrate that both forms of aid positively and significantly influence agricultural production, reinforcing the broader economic development literature that highlights the role of external financial support in driving sectorial growth. However, a key theoretical contribution lies of country governance as a moderating factor, which sets it apart from previous research. The findings indicate that strong governance enhances the effectiveness of foreign agricultural aid, suggesting that aid alone is insufficient for achieving optimal results. This has contributed to the theoretical discourse by confirming that governance quality influences the efficiency with which foreign assistance is utilized in the agricultural sector. The study further extends existing theories by emphasizing that governance acts as a crucial contextual factor, shaping the outcomes of foreign investment in agriculture. These insights are particularly important for economies that rely on international aid, as they highlight the necessity of institutional strength in maximizing the benefits of external funding.

From a practical perspective, this study has contributed by providing policy recommendations for Saudi Arabia's agricultural sector, government authorities, and private enterprises. Given the positive and significant impact of foreign aid and foreign agricultural aid, policymakers should focus on strengthening partnerships with international donors and ensuring that aid is directed towards high-impact agricultural projects. The finding also contributed that Saudi Arabian companies and agriculture enterprises prioritize the implementation of foreign aid and foreign agricultural aid as an essential driver to boost agricultural production. The research also helps those companies that are engaged in agribusiness focus on leveraging foreign agricultural aid to adopt innovative farming techniques, improve supply chain efficiency, and invest in sustainable farming practices. However, the findings also indicate that governance plays a critical moderating role, which means that simply increasing aid inflows is not enough; rather, the Saudi government must work towards enhancing institutional transparency, policy consistency, and resource allocation efficiency to fully utilize external financial support. This transparency in data can enhanced mechanisms such as digital tracking systems for aid distribution, financial transparency in agricultural investments, and adherence to regulatory standards will further enhance the benefits of foreign aid. The study could also help to contribute to building agricultural policy development by highlighting the need for regulatory reforms that improve governance mechanisms, ensuring that foreign aid is effectively channeled into sustainable agricultural initiatives.

Conclusion

The research objective was to test the influence of total foreign aid and foreign agricultural aid on the agricultural production of Saudi Arabia. We also tested the moderating effect of corporate governance. Panel longitudinal data was collected from world development indicators for the period for the period of 2013 to 2024. Both regression models were estimated using Feasible Generalized Least Squares (FGLS) and Panel-Corrected Standard Errors (PCSE) techniques to address econometric concerns such as heteroskedasticity, autocorrelation, and cross-sectional dependence. FGLS results highlighted that foreign aid and foreign agricultural aid positively and significantly

improve agricultural production. In addition, country governance also positively strengthens the relationship between total foreign aid, agricultural foreign aid, and agricultural production. The study also confirms that FGLS provides more robust estimates compared to PCS which reinforces its reliability in panel data analysis. Study findings contributed to helping the policymakers they must focus on strengthening governance frameworks, enhancing aid allocation efficiency, and ensuring transparency in financial assistance programs to maximize the impact of foreign aid on agricultural production. In other words, by integrating strong governance structures with foreign aid utilization, Saudi Arabia can achieve long-term agricultural sustainability, increase self-sufficiency, and enhance its competitiveness in the global agricultural market.

Future Research Recommendations

Several limitations are the current study. First, the study focuses solely on Saudi Arabia, limiting the generalizability of the findings to other Gulf or developing nations. Future research could extend the analysis to other GCC countries to assess regional variations in aid effectiveness. Second, the study does not account for sector-specific policies that may have influenced agricultural production alongside foreign aid. Incorporating government policy interventions and agricultural subsidies in future models would enhance the depth of analysis. Third, the study uses annual data from 2013 to 2024, which may not fully capture short-term aid fluctuations and their immediate effects on agricultural production. Future research could explore higher-frequency data (quarterly or bi-annual) to assess the dynamic nature of foreign aid effectiveness. Fourth, the study relies on WDI data, which, while comprehensive, may not include private-sector investments and donor-specific conditions attached to aid. Future research could incorporate qualitative insights from policymakers and aid agencies to provide a more nuanced understanding of aid utilization. Lastly, exploring alternative estimation techniques that could enhance the robustness of future findings.

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