Journal of Economic Analysis

Homepage: https://www.anserpress.org/journal/jea

Impact of Institutional Quality and Research and Development (R&D) on Agricultural Productivity in Low-and Middle-Income Countries

Agossou Justin Tovilode [a, *], Wanki Moon [a]

[a] *Agribusiness Economics, Southern Illinois University of Carbondale, Carbondale, IL, USA*

ABSTRACT

This study investigates the impact of institutions and public agricultural Research and Development (R&D) on agricultural productivity in low- and middle-income countries. The paper employs panel data with fixed-effects models, spanning 12 years and including 49 low-and middle-income countries. Agricultural productivity is measured by cereal yield, while institutional factors are assessed through four key indicators: judicial independence, property rights protection, contract enforcement, and impartial public administration. Public agricultural R&D investments serve as the measure for agricultural R&D. The findings show that property rights protection positively influences agricultural productivity, whereas legal contract enforcement has a negative impact across these countries. Additionally, public agricultural R&D significantly and positively affect productivity in Asia and the LAC regions, but not in sub-Saharan Africa.

KEYWORDS

Institution; Agricultural Productivity; Agricultural R&D; Stages of Economic Development

* Corresponding author: Agossou Justin Tovilode
E-mail address: justin.tovilode@siu.edu

ISSN 2811-0943
doi: 10.58567/jea04020003

Received 18 July 2024; Accepted 28 December 2024; Available online 23 January 2025; Version of Record 15 June 2025

1. Introduction

Narrowing the gap between developing and developed countries has been a central question in economic development. This gap has reached a level that would have been incomprehensible to most economists of the 18th and 19th centuries (Acemoglu, 200*8*). Low-income countries are moving back rather than catching up contrary to early neoclassical predictions which indicated that developing countries would grow faster than wealthy countries and catch up with developed countries (Knack and Keefer, 1997). A large body of literature has pointed out that the difference between low-income and high-income countries lies in the difference in economic growth and the main source of economic growth is the accumulation of capital, labour, and technology. However, North (1990) has revealed that institutions are the key determinant that paves the way for economic growth. This insight has been corroborated by a growing body of studies that qualified inclusive institutions (e.g., democratic politic system) as a fundamental determinant of economic growth while accumulation of capital, labor, and technology are deemed as proximate determinants (Knack and Keefer, 1997; Subramanian et al., 2002; Acemoglu et al., 2005). Inclusive institutions appear therefore as a precondition for economic growth.

In the process of development, agriculture is recognized as an engine of economic growth and poverty reduction (Mellor and Johnston 1961, Schultz 1964, Adelman 1984, Mellor 2001, Haggblade et al., 2007, Christiaensen et al, 2011). The success of the Green Revolution in Asia has confirmed the important role of agriculture in the development process. According to Diao et al. (2007), agriculture is even more powerful during the early levels of economic development, when it represents large shares of national income, employment, and exports. In many developing countries, agriculture accounts for the largest sector in terms of GDP and employment (Fan and Saurkarl, 2003). Empirical studies clearly showed that agriculture is the pillar of economic growth, especially in low-income countries and to some extent in middle-income countries. This function devoted to agriculture could not be effective without sustained productivity.

The sustainability of agricultural productivity requires investment. For Fan et al. (2008), investment in agricultural R&D is the most important factor among all types of agricultural expenditures. Investment in agricultural R&D is necessary for agricultural productivity growth (Heisey, 2001). Although it was recognized that investment in agricultural R&D is fundamental for achieving sustainable improvement in productivity, there is no clear-cut view about who should make this investment. According to Moon (2022), given the small size of farms and the lack of dynamic competition, agricultural firms have neither the incentive nor the capacity to invest in R&D, therefore, States must be the primary entity responsible to make the first step of investment in R&D and generate new knowledge, particularly in low- and middle-income countries.

Given the fundamental role of institutions in economic growth and the central position of agriculture as a driver of economic development in low- and middle-income countries, it is crucial to examine the interplay between these two determinants. Specifically, investigate the impact of institutional quality on agricultural productivity. Furthermore, considering the critical nature of public investment in agricultural research and development (R&D) for sustainable agricultural productivity growth, it is imperative to explore the extent to which such investments influence agricultural productivity in low- and middle-income countries.

While a substantial body of research examines the impact of institutions on economic activities, limited attention has been given to their implications for agriculture. This article aims to address this gap and contribute to the existing literature by investigating the role of inclusive institutions and public R&D investment in agricultural productivity growth. To the best of our knowledge, this article is the first to analyze the potential impact of institutional factors on the agricultural sector.

Using panel data from 2000 to 2011 across 49 low- and middle-income countries, the paper employs a linear regression model to address this research question. our findings suggest that the protection of property rights is positively associated with agricultural productivity, while legal enforcement exhibits a negative relationship.

Furthermore, the study reveals that public agricultural R&D investment have a significant and positive impact on agricultural productivity in Asia and Latin America and the Caribbean (LAC), though this effect is absent in sub-Saharan Africa. The remainder of the paper is organized as follows: the next section provides an overview of the role of institutions in economic development, agriculture role in the process of development, agricultural productivity and R&D investment, and the state of agriculture in low- and middle-income countries. Section three describes the methodological approach, followed by the empirical results in section four. Finally, the concluding section presents key findings, policy recommendations and study limitations.

2. Role of Institutions and Agriculture in the Economic Development Process

This section reviews the existing literature on the role of institutions in economic growth, the contribution of agriculture to economic development, the significance of agricultural productivity and research and development (R&D) investments, and the role of agriculture in low- and middle-income countries.

2.1. Role of Institutions in economic growth

The foundational work of Douglass North (1990) established the central importance of institutions in driving economic growth. North conceptualized institutions as the "rules of the game" that govern societal interactions. He defines institutions as humanly devised constraints that shape behavior and structure human relationships. These institutions include both formal rules, such as statutory laws and regulations, and informal norms, including conventions, behaviors, and self-imposed codes of conduct. The enforcement of these rules through diverse mechanisms ensures stability and predictability in societal interactions.

Building upon North's framework, Acemoglu et al. (2005) highlighted the critical role of economic and political institutions in shaping economic incentives. They highlight that institutions serve as constraints that shape individual behaviours and influence human interactions. Acemoglu (2008) further emphasized the importance of property rights and contracting institutions. Property rights institutions safeguard individuals against exploitation by elites and privileged groups, while contracting institutions regulate interpersonal relationships, ensure market efficiency, and facilitate resource allocation. Without well-functioning economic institutions, particularly the protection of property right, individuals have little incentive to invest in capital, labor, or the adoption of advanced technologies (Acemoglu et al., 2005).

Knack and Keefer (1997) assert that a robust institutional framework is indispensable for supporting complex impersonal exchanges, which are essential for both political stability and economic development. Such institutions enable societies to leverage modern technologies effectively. Similarly, Subramanian et al. (2002), contend that achieving economic growth is unlikely to occur in the absence of sound institutions as these institutions play a fundamental role in fostering technological advancement, capital accumulation, and labour productivity. Easterly (2002) reinforces this argument, asserting that traditional economic growth factors such as capital, labor, and technology cannot yield significant economic output without a stable and trustworthy institutional environment. Knack and Keefer (1995), alongside Acemoglu et al. (2001, 2005) and Subramanian et al. (2002), categorize institutions as the fundamental causes of economic growth, while physical capital, technology, and human capital accumulation remain proximate determinants. They argue that institutional quality critically shapes the long-term economic trajectory of nations, with institutional disparities often explaining global differences in development outcomes. For instance, Acemoglu et al. (2001) cite the contrasting economic experiences of North and South Korea, attributing their divergence primarily to differences in institutional frameworks. Knack and Keefer (1997) further highlight that the persistence of poverty in some regions is a direct consequence of weak institutional environments. Although reforming institutions can be difficult due to entrenched political interests and power dynamics, it

remains both feasible and essential for economic growth. Even though Hussey et al. (2021) suggest that institutional quality may be less central to reducing international inequality today compared to the past, institutions continue to play a pivotal role in fostering economic growth and societal well-being.

In summary, the seminal contributions of Douglass North and subsequent research by scholars such as Acemoglu and Robinson underscore the fundamental role of institutions as the "rules of the game" that shape economic incentives, societal outcomes, and long-term development trajectories.

2.2. Agriculture in the process of economic development

The role of agriculture in economic development has been a subject of controversial debate within development economics. Traditionally, neoclassical economists viewed agriculture as a passive contributor to economic growth. Drawing on Lewis' (1954) surplus labor model, agriculture was primarily seen as the source of surplus labor essential for the expanding industrial sector. This view was further supported by Ranis and Fei (1961), and Jorgenson (1961). Schultz (1964) underscored the role of agriculture as a vital food supplier, arguing that economic growth would be unattainable without it. Similarly, Kuznets (1966) align to this viewpoint but noted that agriculture's contribution to production and employment declines as economies advance, reinforcing the perception of agriculture as a low-productivity sector supplying cheap food and labor to industries. This passive characterization was challenged by Johnston and Mellor (1961), who asserts that agriculture is an active and dynamic driver of economic development. Beyond providing food and labor, agriculture fosters development through complex production and consumption linkages. It supplies inputs for agro-industries, generates export earnings to finance capital goods, expands domestic markets for industrial output, and contributes savings for industrial investment. Singer (1979) empirically demonstrated the significance of these linkages, while Adelman (1984) introduced the concept of Agricultural Demand-Led Industrialization (ADLI), arguing that agriculture-led economies outperform export-oriented ones. By testing the ADLI strategy, Vogel (1994) and Bautista et al. (1999) studies confirmed the vital role of agriculture in economic development. This viewpoint further supported by Haggblade et al. (2007).

In recent decades, a more pessimistic view of agriculture's role in economic development has gained traction. Drawing from trade theory, Collier (2003) suggested that resource-rich African countries should prioritize non-agricultural exports, while resource-scarce nations should focus on labor-intensive goods for global markets. Dercon (2009) and Gollin (2010) extended this argument, linking agriculture's role to a country's openness to trade. They proposed that agriculture is crucial for growth in closed economies, particularly landlocked and resource-limited nations, but becomes less significant in open economies integrated into international markets.

However, the Green Revolution in Asia and Latin America challenges this pessimistic outlook, demonstrating agriculture's potential as a catalyst for growth (Christiaensen et al., 2011). The World Bank's 2008 *World Development Report* reaffirmed agriculture's substantial role in driving economic growth in developing countries. This perspective is widely supported by a robust body of research, emphasizing that agriculture's transformative role can only be realized through sustained productivity growth, underpinned by strategic investments in agricultural research and development (R&D).

2.3. Agricultural productivity and R&D investment

Development literature highlights the critical role of agriculture in driving economic growth during the initial stages of development, with its effectiveness largely dependent on sustained increases in agricultural productivity. In agriculture-based economies with low productivity, agriculture's role as a driver of economic growth is unlikely effective. Gollin (2010) emphasizes that many developing countries face persistently low agricultural productivity,

which limits agriculture's capacity to contribute meaningfully to overall economic growth. Consequently, poor economic conditions in these nations are often rooted in stagnating agricultural productivity. According to Diao et al. (2010), sustained improvements in agricultural productivity significantly influence both economic growth and poverty alleviation. Pal (2017) identifies agricultural productivity as a prerequisite for achieving sustainable economic development and poverty reduction, particularly in transitioning economies. Fan (2002) similarly asserts that continuous advancements in agricultural productivity are indispensable to the development process. Timmer (2005) reinforces this perspective, describing agricultural productivity growth as the cornerstone of sustainable economic development. Piesse and Thirtle (2010) further note that in Asia and other developing regions, productivity gains rather than the expansion of cultivated land constitute the primary driver of agricultural growth. Empirical evidence from Diao et al. (2007) highlights agriculture's leverage on the broader economy, particularly in the early stages of structural transformation. For instance, Rangarajan (1982) found that in China, a 1% increase in agricultural production results in a 0.5% rise in industrial production and a more than 0.7% increase in national income.

Beyond economic growth, improvements in agricultural productivity play a crucial role in poverty reduction. Thirtle et al. (2003) provide empirical evidence showing that agricultural productivity growth has a more pronounced impact on poverty alleviation than productivity growth in industrial and service sectors. Their findings indicate that a 1% increase in crop productivity lifts over six million people out of extreme poverty threshold of $1 per day, with 95% of these individuals residing in Africa and Asia. Similarly, Ravallion and Datt (1996) demonstrated that in India, a 1% increase in agricultural value added per hectare reduces poverty by 0.4% in the short term and by 1.9% in the long term. In China, De Janvry and Sadoulet (2010) observed that a 1% increase in agricultural growth generates a 0.45% increase in aggregate income, with the non-agricultural sector yielding half the impact. Christiaensen et al. (2006) revealed that in low-income countries, agriculture exhibits a poverty elasticity 2.3 times greater than non-agricultural sectors. Supporting this, Christiaensen and Demery (2007) argue that a 1% per capita growth in agriculture reduces poverty 1.6 times more effectively than industrial growth and three times more effectively than service sector growth. Gollin et al. (2019) demonstrated that in developing countries from 1960 to 2010, a 1% increase in agricultural productivity corresponded to an average 1% increase in GDP per capita. Ivanic and Martin (2018) further corroborate this view, concluding that agricultural productivity growth has a greater poverty-reduction impact than productivity growth in industry or services, particularly in poorer nations.

A bunch of research underscores the pivotal role of agricultural research and development (R&D) in driving productivity growth. Pardey and Beddow (2017) assert that agricultural R&D is critical to enhancing productivity over time. Fan et al. (2008) emphasize that investments in agricultural R&D yield greater benefits for agricultural and food production growth compared to other forms of agricultural expenditure. Fuglie and Wang (2012) identify agricultural R&D as the distinguishing factor between countries that have achieved long-term agricultural productivity growth and those that have not. Fan and Rao (2003) provide further evidence, showing that agricultural research investments have a larger impact on productivity than other types of public spending, based on their analysis of 43 developing countries. Thirtle et al. (2003) reinforce this finding, demonstrating that agricultural R&D investments yield substantial returns in the form of agricultural value-added gains. Fan et al. (1999) demonstrate that in India, agricultural R&D investments have historically provided the highest returns on productivity and lifted more people out of poverty per unit of expenditure than most other public investments. Finally, Ouru and Mose (2021) conclude that in East Africa, increased agricultural R&D expenditure and institutional strengthening are essential drivers of sustainable agricultural development.

2.4. Agriculture in low and middle-income countries

Africa is one of the continents with enormous agricultural potential, sharing with Latin America the largest reserves of unutilized arable land (NEPAD, 2013). Approximately 60% of the world's uncultivated arable land is in Africa, while 68.9% of its cultivable rain-fed land remains unused (Abram, 2018). Agriculture is the primary source of employment, accounting for 60% of the workforce, and serves as the largest contributor to GDP in the region (CAADP, 2003; World Bank, 2013).

Despite this substantial potential, sub-Saharan Africa has remained one of the largest global food importers since the 1980s, a phenomenon primarily attributed to distortions in agricultural policy. Bates (1981) identified the promotion of industrial growth, the political imperative to satisfy urban consumer's needs, and the obsession of the political regime to remain in power as critical drivers of these policy distortions. Public investment in agriculture in sub-Saharan Africa ranks among the lowest globally, with public expenditure on agricultural research declining from 0.93% of agricultural GDP in 1981 to 0.69% in 1991 (CAADP, 2003). More recently, Pernechele et al. (2021) reported that per capita agricultural spending in sub-Saharan Africa remains the lowest in the world. Consequently, only 6% of the region's agricultural land is under irrigation (NEPAD, 2013). Africa is particularly vulnerable to climate change, with Niang et al. (2014) predicting that the continent will experience more severe impacts than other regions. Agricultural growth in Africa has historically relied on the expansion of cultivated land and the mobilization of labor rather than the adoption of advanced production technologies (NEPAD, 2013). In 2001, the average cereal yield in Africa stood at 1,230 kg/ha, significantly lower than 3,090 kg/ha in Asia and 3,040 kg/ha in Latin America (CAADP, 2003). This disparity is compounded by the lowest use of agricultural inputs, such as fertilizers, improved crop varieties, pesticides, and mechanization. Moreover, sub-Saharan Africa faces significant institutional challenges, including heightened exposure to conflict and instability. Beegle and Christiaensen (2019) observed that Africa countries are nine times more likely to reside in conflict-affected countries compared to populations in other regions.

Contrary to Africa, the Asian continent experienced the Green Revolution of the 1960s, which fundamentally reshaped its agricultural sector and played a pivotal role in reducing poverty across the region. Prior to the Green Revolution, Asia was heavily reliant on food imports and aid to meet its growing food demand. In response to this critical situation, Asian governments prioritized agricultural development by significantly increasing investments. On average, agriculture accounted for 15.4% of national budgets in 1972, and agricultural expenditure doubled in real terms by 1985 (Rosegrant and Hazell, 2001). This public sector intervention facilitated widespread improvements in rural infrastructure, including the construction and rehabilitation of roads, irrigation systems, and rural electrification. Additionally, governments promoted mechanization, established state agricultural universities, and developed comprehensive national agricultural research systems. These efforts, combined with the dissemination of improved cereal varieties and the provision of fertilizers, led to substantial yield gains. Between 1961 and 1997, cereal yields more than doubled across the region (Singh, 2002). However, despite the successes of the Green Revolution, the Asian region continues to face significant challenges. According to FAO (2020), the Asia-Pacific region remains burdened by a high prevalence of undernourishment, with an estimated 350.6 million people affected. Furthermore, land degradation remains a critical concern, with approximately 38% of agricultural land affected by human-induced degradation (Lal, 2011; ADB, 2011). In South Asia, Ladha et al. (2003) identified stagnating or declining yield trends, primarily attributed to the overconsumption of agricultural inputs. Addressing these persistent issues requires renewed strategies to enhance sustainable agricultural practices, mitigate land degradation, and improve food security outcomes for vulnerable populations.

Latin America and the Caribbean (LAC) is one of the regions of the world that is well endowed with natural resources. The region covers more than 2 billion hectares, approximately 38% of it is used for agriculture while the remainder is dominated by forest cover (OECD/FAO, 2019). The region accounts for 28% of the world's land identified as suitable for sustainable agricultural expansion (Deininger et al., 2011).

Prior to the 1980s, LAC governments prioritized industrialization as their principal development strategy, often to the detriment of the agricultural sector. This approach resulted in a surge in average inflation rates to unprecedented levels (Remmer, 1991). In response, structural reforms were introduced, marking a paradigm shift in the region's development strategy. These reforms laid the groundwork for the agricultural Green Revolution, which was driven by significant public investment in agricultural research and development (R&D). Public expenditure on agricultural R&D rose from $3.1 billion (2005 PPP prices) in 2006 to $5.1 billion (2011 PPP prices) in 2013 (Stads et al., 2016; Stads and Beintema, 2010). Moreover, agricultural policy reforms facilitated the substantial transfer of technology from developed countries, bolstering productivity growth. Combined efforts by governments and the private sector have enabled the LAC region to emerge as the world's largest net food-exporting region (Morris, 2020). Despite these advancements, persistent challenges remain. Berdegué (2009 and 2011) highlights that 62 million out of the 119 million rural inhabitants continue to live in poverty, despite the GDP per capita increase over 25% during the same period. This discrepancy underscores the need for inclusive agricultural growth strategies to ensure equitable economic benefits across rural populations.

3. Methodology

3.1. Data

The panel data employed in this article span the period 2000–2011 and include 49 low- and middle-income countries: 25 from Sub-Saharan Africa, 11 from Latin America and the Caribbean (LAC), and 13 from Asia. Country selection was informed by existing literature and the World Bank's classification system, which categorizes economies into low-, lower-middle-, upper-middle-, and high-income groups. The chosen time frame reflects data availability. The data used are from multiple sources. Cereal yield, employed as a proxy for agricultural productivity, is extracted from the World Bank database. Agricultural Research and Development (R&D) represented by public spending in R&D is obtained from the Agricultural Science and Technology Indicators (ASTI) managed by the International Food Policy Research Institute (IFPRI). Public R&D spending includes financial contributions from both national governments and development finance partners within the agricultural sector. Institutional quality is assessed using indicators such as impartial public administration, judicial independence, protection of property rights, and enforcement of legal contracts. These indicators, constructed by the Fraser Institute, measure the degree to which the institutions and policies of a country are consistent with economic freedom. The four institutional indicators employed in the study were specifically selected to evaluate the distinct effects of each on agricultural productivity. This approach reflects the critical rationale for their inclusion, as relying on a single indicator would not enable the analysis to capture the unique contributions of the other indicators. Consequently, examining these indicators individually is essential to comprehensively understand their respective impacts on productivity. The indicators are rated on a scale ranging from 0 to 10, where a score of 0 denotes an absence of economic freedom, and a score of 10 reflects maximum economic freedom. The construction of these indicators relies on data obtained from external sources, including the International Monetary Fund (IMF), the World Bank, and the World Economic Forum (WEF).

3.2. Empirical Framework

The paper employs panel data with fixed effects and applies a linear multiple regression model, using Ordinary Least Squares (OLS) estimation to investigate the impact of institutional quality and public agricultural R&D used as proxy of agriculture productivity on agricultural productivity in low- and middle-income countries. The dependent variable is cereal yield, used as proxy of agriculture productivity. The independent variables include

institutional indicators represented by impartial public administration, judicial independence, protection of property rights, and legal enforcement of contracts long with public spending on agricultural R&D. The regression model incorporating these variables is specified as follows:

$$CerealYield_{it} = \beta_0 + \beta_1 JudicInd_{it} + \beta_2 ProRight_{it} + \beta_3 LegalContr_{it} + \beta_4 ImpartAdmi_{it} + \beta_5 AgriR\&D_{it} + \tau_i + \mu_{it}$$

Where:

β: parameters estimated

CerealYield: Cereal Yield (Kg/hectare)

AGRIR&D: Agricultural R&D (millions in $)

JudicInd: Judicial independence, (indicator)

ProRight: Protection of property rights, (indicator)

LegalContr: Legal enforcement of contracts, (indicator)

ImpartAdmi: Impartial public administration (indicator)

τ: country fixed effect

μ_{it}: error terms

i: country, t: year

3.3. Multicollinearity and Endogeneity

A high correlation among the independent variables increases the standard errors, making some regression coefficients statistically insignificant when they should be significant. The correlation matrix presented in Table1 below shows that there is a correlation, but this correlation is low among most variables. Therefore, the risk of multicollinearity is low.

Table1. Matrix of correlation.

	Judicial independence	*Protection of property rights*	*Legal enforcement of contracts*	*Impartial public administration*	Spending in R&D
Judicial independence	1				
Protection of property rights	0.57930	1			
Legal enforcement of contracts	0.1331	0.1445	1		
Impartial public administration	0.6179	0.3965	0.0885	1	
Spending in R&D	0.2645	0.1396	0.1580	0.0858	1

Source: Author

Endogeneity represents a critical issue that can lead to biased and inconsistent estimators. To address this concern, we employed a two-stage procedure. First, we regressed the independent variable of interest on the other independent variables. Second, the residuals obtained from this regression were incorporated into the original regression model (equation 1) as a replacement for the independent variable of interest. The presence of endogeneity is empirically confirmed when the estimated coefficient of the residual independent variable exhibits statistical significance. Upon examination of the output presented in Tables in appendix, we observe that none of the estimated residual coefficients are statistically significant. Consequently, there is no evidence of endogeneity in the model, thereby supporting the validity of our initial estimators.

4. Results and Discussion

4.1. Institutions 'effect on the agricultural productivity

The analysis of institutional quality's effects on agricultural productivity across low- and middle-income countries, as presented in Table 2, reveals significant results for two of the institutional indicators included in this study. Protection of property rights and legal enforcement of contracts exhibit significant impacts on agricultural productivity at 1% and 5% significance levels, respectively. However, impartial administration and judicial independence show no statistically significant effects. Protection of property rights is positively associated with grain yields, while legal enforcement of contracts has a negative influence.

Table 2. Estimation results of institution and R&D effect on agriculture productivity.

Variable	Coefficient	Std. Error	P-value
Across low- and middle-income countries			
Constant	2,351.940	319.854	0.000
Protection of property right	91.865***	27.883	0.001
Legal enforcement of contract	-96.038**	38.347	0.012
Judicial independence	13.774	51.892	0.780
Impartial public administration	-51.125	39.729	0.198
R&D total Spending	0.915***	0.212	0.000
R Square: 0.93 Observation: 588			
Africa			
Constant	1723.475	586.130	0.003
Protection of property right	52.656	46.802	0.261
Legal enforcement of contract	14.473	62.814	0.817
Judicial independence	-17.927	103.589	0.862
Impartial public administration	-99.097	65.251	0.130
R&D total Spending	1.959	1.427	0.171
R Square: 0.89 Observation: 300			
Asia			
Constant	3408.562	304.034	0.000
Protection of property right	186.153***	46.280	0.000
Legal enforcement of contract	-281.566***	50.972	0.000
Judicial independence	-19.417	56.732	0.732
Impartial public administration	30.697	45.212	0.498
R&D total Spending	0.422**	0.196	0.043
R Square: 0.9 Observation: 156			
LAC			
Constant	-71.382	1175.489	0.951
Protection of property right	141.438***	44.910	0.002
Legal enforcement of contract	-193.107*	104.731	0.067
Judicial independence	288.791**	127.789	0.025
Impartial public administration	219.403*	130.306	0.094
R&D total Spending	1.156***	0.293	0.000
R Square: 0.92 Observation: 132			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

The results vary across regions. In Latin America and the Caribbean (LAC), property rights, judicial independence, and impartial public administration positively and significantly affect agricultural productivity, whereas legal enforcement of contracts has a negative impact. In Asia, both property rights and legal enforcement of contracts have significant but opposing effects, with property rights positively associated with productivity and legal enforcement negatively associated. In contrast, none of the four institutional indicators exhibit significant effects on agricultural productivity in sub-Saharan Africa. The absence of significant impacts in sub-Saharan Africa may stem from biased agricultural policies implemented by governments in the region.

The adverse effects of legal contract enforcement on grain yields were unanticipated but can be rationalized. In developing countries, the majority of agricultural producers are smallholder farmers with limited education and resources. The significant financial and time costs associated with legal contract enforcement often deter these farmers from participating in formal legal processes. This avoidance indirectly limits their ability to access credit, secure inputs, and engage in formal economic transactions. Additionally, legal enforcement mechanisms, often characterized by excessive bureaucracy, may not be designed to address the specific needs of the agricultural sector, further reducing their relevance to farmers. Informal enforcement mechanisms, such as community-based trust systems and informal contracts, offer cost-effective and expedient alternatives, diminishing the reliance on formal contract enforcement. These barriers can hinder farmers' access to financial resources or subsidies, reducing their capacity to make optimal investments in their agricultural operations.

Conversely, the positive impact of property rights protection on agricultural productivity aligns with existing empirical evidence. Studies such as Acemoglu et al. (2005) highlight the pivotal role of secure property rights in promoting economic growth. These authors noted that countries with robust protections against expropriation by powerful actors tend to experience higher long-term growth rates, greater income levels, increased investments, and enhanced access to private-sector credit. Property rights provide essential incentives for investments in physical and human capital, as well as the adoption of more efficient technologies. Similarly, Petrakos and Arvanitidis (2008) ranked property rights as a key determinant of economic outcomes in developing countries, while Knack and Keefer (1995) and Rodrik (2000) emphasized the role of property rights institutions in influencing economic outcomes through capital investments and technological advancements. Easterly (2002) further argued that sustained economic growth is unlikely without stable and reliable institutional frameworks.

It is worth noting, however, that Hussey (2021) suggested institutional quality may play a less critical role in modern contexts, as some countries with exclusive political institutions have achieved higher incomes. For instance, China, despite its exclusive political institutions, has developed inclusive economic institutions that have contributed to its emergence as a global economic leader.

The findings of this study underscore the crucial role of property rights in fostering agricultural productivity in low- and middle-income countries. Secure property rights incentivize investments in human capital and technological advancements within the agricultural sector. While some critics argue that institutions have limited relevance to agriculture, this claim is untenable, particularly in low- and middle-income countries where agricultural performance significantly shapes overall economic outcomes. In these economies, agriculture serves as the primary livelihood for much of the population and constitutes the main source of income. Therefore, institutional quality exerts a substantial influence on the agricultural sector's productivity and overall economic performance.

4.2. Impact of public investment in Agricultural R&D on agricultural productivity

Public investment in agricultural research and development (R&D) is widely recognized as a crucial determinant of enhanced agricultural productivity, particularly in low- and middle-income countries. The analysis presented in Table 2 corroborate this assertion, demonstrating a positive and significant effect of public agricultural R&D expenditures on agricultural productivity at a 1% significance level across low- and middle-income countries. Regionally, public agricultural R&D exhibits a substantial and positive influence on agricultural productivity in Asia and Latin America and the Caribbean (LAC) at significance levels of 5% and 1%, respectively. However, in sub-Saharan Africa, public agricultural R&D spending shows no statistically significant effect on agricultural productivity.

These findings align with the existing body of empirical literature. Pardey and Beddow (2017) emphasize the pivotal role of agricultural R&D in driving sustainable productivity growth, identifying it as a cornerstone of

agricultural advancements. Fuglie and Wang (2012) argue that sustained investment in agricultural R&D is the primary factor distinguishing countries that achieve long-term agricultural productivity growth from those that do not. Their research underscores the critical importance of R&D investment in fostering agricultural progress. In a study of 43 developing countries, Fan and Rao (2003) found that agricultural research investment yields significantly greater productivity impacts than other forms of public expenditure. Similarly, Fan et al. (1999) demonstrated that in India, agricultural R&D investments over the past decade have delivered the highest productivity gains and the most substantial poverty reduction per unit of expenditure compared to other public investments.

The lack of a significant impact of public agricultural R&D spending in sub-Saharan Africa can be attributed to several factors. One plausible explanation is the level of R&D investment in the region has not reached the critical expenditure threshold necessary to generate measurable effects. Despite commitments made under the Maputo Declaration in 2003, wherein African nations pledged to allocate 10% of their national budgets to agricultural investment, only a minority of countries have met this target. Pernechele et al. (2021) highlighted that per capita agricultural spending in sub-Saharan Africa remains the lowest globally, underscoring the inadequacy of R&D investments to drive substantial agricultural advancements. In contrast, the Asia and LAC regions have benefited from the transformative effects of the Green Revolution, driven in large part by robust investments in agricultural R&D. Arias et al. (2017) demonstrated that public R&D investments significantly enhanced agricultural productivity in Latin America, reinforcing the critical role of such expenditures in fostering agricultural and economic development.

In conclusion, the evidence from this analysis and the broader literature underscores the indispensable role of public investment in agricultural R&D in enhancing agricultural productivity, particularly in low- and middle-income countries. However, the lack of significant impact observed in sub-Saharan Africa highlights the urgent need for increased commitment to agricultural research and development in the region to realize its potential for agricultural and economic growth.

5. Conclusion and recommendations

The analysis of the influence of institutional quality and agricultural Research and Development (R&D) on agricultural productivity in low- and middle-income countries provides significant insights with critical implications for policymakers and contributions to the existing body of literature. This study advances the understanding of the intricate relationship between institutional frameworks, R&D investments, and agricultural productivity within developing economies.

Several key findings emerge from this research. First, the study underscores the indispensable role of robust property rights institutions in fostering agricultural productivity in low- and middle-income countries. Ensuring the protection of property rights is fundamental for cultivating an environment where agricultural investments are safeguarded, thereby encouraging farmers and agribusinesses to make long-term investments and adopt advanced technologies.

Second, agricultural R&D is identified as a key driver of agricultural productivity, reaffirming the importance of continuous research efforts to enhance agricultural practices, develop improved crop varieties, and innovate farming techniques. These findings underscore the transformative potential of R&D in catalyzing sustainable productivity growth.

Third, the study highlights significant regional disparities. Unlike the Asia and Latin America and Caribbean (LAC) regions, where public agricultural R&D spending demonstrates a substantial positive effect on agricultural productivity, sub-Saharan Africa exhibits no significant impact from agricultural R&D spending. This finding underscores the urgent need for increased and strategic investments in agricultural R&D within the sub-Saharan

African context. It suggests that countries in the region must not only allocate greater resources to research but also reform and strengthen their research institutions to maximize their contributions to agricultural development.

Sub-Saharan Africa can draw critical lessons from the successes of the Green Revolution in Asia and the LAC regions, where the transformation of the agricultural sector was largely driven by effective and well-funded R&D efforts. To replicate such outcomes, sub-Saharan African nations must prioritize and scale up research activities tailored to their unique agricultural conditions and challenges.

Moreover, to address capacity constraints and enhance the effectiveness of research initiatives, sub-Saharan African countries should shift away from the current fragmentation of their research systems. Instead, regional collaboration should be fostered, with countries pooling resources to establish joint agricultural universities and R&D institutions under the regional organizations. This collaborative approach can harness shared expertise, consolidate financial and technical resources, and enable a more focused response to the specific needs of the agricultural sector in the region.

In conclusion, the findings highlight the need for targeted, strategic investments and coordinated efforts in sub-Saharan Africa to unlock the region's agricultural potential and accelerate economic development. Regional collaboration represents a promising strategy to enhance research capacity and address the distinctive challenges faced by African countries in their quest for agricultural transformation and sustained growth.

This study has some limitations related to the timeframe and methodological approach. The 12-year period, constrained by data availability, is insufficient to draw definitive conclusions regarding the institutional effect. A longer timeframe would be required for a more thorough investigation of the impact of institutional quality. Moreover, the use of an alternative model to the linear regression applied may yield different results.

Funding Statement

This research received no external funding.

Acknowledgments

Acknowledgments to anonymous referees' comments and editor's effort.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

Conceptualization, data curation, formal analysis, methodology, software, writing original draft and review: Agossou Justin Tovilode.; supervision, validation, review and editing: Wanki Moon.

Appendix

A1. Test of endogeneity (Legal contract enforcement).

Dependent Variable: CEYIELD Method: Panel Least Squares Sample: 2000 2011 Cross-sections included: 49 Total panel (balanced) observations: 588				
Variables	Coef	Std. Error	t-Statistic	Prob
C	2488.530	287.51160	8.655408	0.0000
Residual of legal contract enforcement	-42.43487	38.13629	-1.112716	0.2663
Impartial Public Administration	-65.18415	38.67823	-1.685293	0.0925
Justice independence	43.26562	50.90344	0.849955	0.3957
Property Rights	-17.91980	31.59123	-0.567240	0.5708
R&D Spending	0.561016	0.213901	2.622778	0.0090
Effects Specification				
Cross-section fixed (dummy variables) Period fixed (dummy variables)				
Root MSE	352.4997	R-squared	0.939875	
Mean dependent var	2416.098	Adjusted R-squared	0.932517	
S.D. dependent var	1438.798	Sum squared resid	373.7633	
Akaike info criterion	14.78907	Log likelihood	73062564	
Schwarz criterion	15.27289	F-statistic	127.7423	
Hannan-Quinn criter	14.97758	Prob(F-statistic)	0.000000	
Durbin-Watson stat	0.830139			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

A2. Test of endogeneity (Impartial Public Administration).

Dependent Variable: CEYIELD Method: Panel Least Squares Sample: 2000 2011 Cross-sections included: 49 Total panel (balanced) observations: 588				
Variables	Coef	Std. Error	t-Statistic	Prob
C	2325.114	260.5333	8.924438	0.0000
Residual impartial Public Administration	-64.59905	38.61281	-1.672995	0.0949
Legal contract enforcement	-33.98516	37.87533	-0.897290	0.3700
Justice independence	28.15759	49.84236	0.564933	0.5724
Property Rights	-8.848961	32.73617	-0.270311	0.7870
R&D Spending	0.551597	0.212805	2.592030	0.0098
Effects Specification				
Cross-section fixed (dummy variables) Period fixed (dummy variables)				
Root MSE	352.4997	R-squared	0.939875	
Mean dependent var	2416.098	Adjusted R-squared	0.932517	
S.D. dependent var	1438.798	Sum squared resid	373.7633	
Akaike info criterion	14.78907	Log likelihood	73062564	
Schwarz criterion	15.27289	F-statistic	127.7423	
Hannan-Quinn criter	14.97758	Prob(F-statistic)	0.000000	
Durbin-Watson stat	0.830139			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

A3. Test of endogeneity (R&D Spending).

Dependent Variable: CEYIELD Method: Panel Least Squares Sample: 2000 2011 Cross-sections included: 49 Total panel (balanced) observations: 588				
Variables	Coef	Std. Error	t-Statistic	Prob
C	2397.459	329.9832	7.265398	0.0000
Residual R&D Spending	0.578073	0.213306	2.710071	0.1169
Legal contract enforcement	-17.59111	39.24931	-0.448189	0.6542
Justice independence	113.2307	57.71874	1.961767	0.0503
Property Rights	-18.77168	33.02938	-0.568333	0.5701
Impartial Public Administration	-80.88155	39.48320	-2.048506	0.0410
Effects Specification				
Cross-section fixed (dummy variables) Period fixed (dummy variables)				
Root MSE	352.4997	R-squared	0.939875	
Mean dependent var	2416.098	Adjusted R-squared	0.932517	
S.D. dependent var	1438.798	Sum squared resid	373.7633	
Akaike info criterion	14.78907	Log likelihood	73062564	
Schwarz criterion	15.27289	F-statistic	127.7423	
Hannan-Quinn criter	14.97758	Prob(F-statistic)	0.000000	
Durbin-Watson stat	0.830139			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

A4. Test of endogeneity (Property Right).

Dependent Variable: CEYIELD Method: Panel Least Squares Sample: 2000 2011 Cross-sections included: 49 Total panel (balanced) observations: 588				
Variables	Coef	Std. Error	t-Statistic	Prob
C	2588.668	313.9075	8.246595	0.0000
Residual property Rights	-12.78696	32.88305	-0.388862	0.6975
Legal contract enforcement	-43.20278	37.50146	-1.152029	0.2498
Justice independence	38.27465	46.85905	0.816804	0.4144
impartial Public Administration	-65.02980	38.73712	-1.678747	0.0938
R&D Spending	0.578688	0.213363	2.712219	0.0069
Effects Specification				
Cross-section fixed (dummy variables) Period fixed (dummy variables)				
Root MSE	352.4997	R-squared	0.939875	
Mean dependent var	2416.098	Adjusted R-squared	0.932517	
S.D. dependent var	1438.798	Sum squared resid	373.7633	
Akaike info criterion	14.78907	Log likelihood	73062564	
Schwarz criterion	15.27289	F-statistic	127.7423	
Hannan-Quinn criter	14.97758	Prob(F-statistic)	0.000000	
Durbin-Watson stat	0.830139			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

A5. Test of endogeneity (Justice independence).

Dependent Variable: CEYIELD Method: Panel Least Squares Sample: 2000 2011 Cross-sections included: 49 Total panel (balanced) observations: 588				
Variables	Coef	Std. Error	t-Statistic	Prob
C	2762.161	263.9503	10.46470	0.0000
Residual Justice independence	44.36999	50.86814	0.872255	0.3835
Legal contract enforcement	-41.98737	38.15298	-1.100500	0.2716
Property Rights	-3.609417	30.25523	-0.119299	0.9051
impartial Public Administration	-58.07132	37.83314	-1.534933	0.1254
R&D Spending	0.569515	0.213158	2.671795	0.0078
Effects Specification				
Cross-section fixed (dummy variables) Period fixed (dummy variables)				
Root MSE	352.4997	R-squared	0.939875	
Mean dependent var	2416.098	Adjusted R-squared	0.932517	
S.D. dependent var	1438.798	Sum squared resid	373.7633	
Akaike info criterion	14.78907	Log likelihood	73062564	
Schwarz criterion	15.27289	F-statistic	127.7423	
Hannan-Quinn criter	14.97758	Prob(F-statistic)	0.000000	
Durbin-Watson stat	0.830139			

*Note: *, **, *** significant indices at 10%, 5% and 1% respectively*

References

Abrams, L. (2018). Unlocking the potential of enhanced rain-fed agriculture. *Report no. 39. SIWI, Stockholm.*

Acemoglu, D. (2008). *Introduction to modern economic growth*. Princeton university press.

Acemoglu D., Johnson, S., and Robinson, J. A. (2005). Institutions as a Fundamental Cause of Long-Run Growth. Chapter 06 in Handbook of Economic Growth. (2005). vol. 1, Part A, 385-472. https://doi.org/10.1016/S1574-0684(05)01006-3

Acemoglu, D., Johnson, S., and Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American economic review*, *91*(5), 1369-1401.

ADB. (2011). Environment Program: Greening growth in Asia and the Pacific. Mandaluyong City. Asian Development Bank.

Adelman, I. (1984). Beyond export-led growth. *World development*, *12*(9), 937-949. https://doi.org/10.1016/0305-750X(84)90050-0

Arias, D., Vieira, P. A., Contini, E., Farinelli, B., and Morris, M. (2017). Agriculture Productivity Growth in Brazil: Recent trends and future prospects. http://dx.doi.org/10.1596/29437

Bates, R. (1981). Markets and States in Tropical Africa: The Political Basis of Agricultural Policies. Online at https://mpra.ub.uni-muenchen.de/86293/ MPRA Paper No. 86293, posted 18 Jul 2018 12:33 UTC.

Bautista, R., Robinson, S., and El-Said, M. (1999). Alternative Industrial Development Paths for Indonesia: SAM and CGE Analyses. TMD Discussion Paper no. 42. International Food Policy Research Institute, Washington DC. http://dx.doi.org/10.22004/ag.econ.97538

Beegle, K., and Christiaensen, L. (Eds.). (2019). *Accelerating poverty reduction in Africa*. World Bank Publications

Berdegué, J.A. (2009). Estrategias y programas de reducción de la pobreza rural. In: M. Piñeiro (ed.) La Institucionalidad Agropecuaria en América Latina: Estado Actual y Nuevos Desafíos. Rome: FAO. 420-446.

Berdegué, J. A., and Fuentealba, R. (2011). Latin America: The state of smallholders in agriculture. In *IFAD conference on new directions for smallholder agriculture* 24, 25.

Braconier, H. (2000). Do Higher Per Capita Incomes Lead to More R&D Expenditure? *Review of Development Economics*, 4(3), 244–257.

Bozkurt, C. (2015). R&D expenditures and economic growth relationship in Turkey. *International Journal of Economics and Financial Issues*, *5*(1), 188-198.

CAADP "Comprehensive African Agriculture Development Program". (2015). Results Framework 2015-2025.Going for results and impacts.

Christiaensen, L. J., and Demery, L. (2007). Down to Earth: Agriculture and Poverty in Africa. World Bank, Washington, DC.

Christiaensen, L., Demery, L., and Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction—An empirical perspective. Journal of development economics, 96(2), 239-254. https://doi.org/10.1016/j.jdeveco.2010.10.006

Christiaensen L., Demery, L., and Kühl, J. (2006). The Role of Agriculture in Poverty Reduction, an Empirical Perspective. World Bank Policy Research Working Paper 4013, World Bank Publications.

Collier, P. (2003). Primary commodity dependence and Africa's future. In *Annual World Bank conference on development economics*, 139-62.

Deininger K., Byerlee, D., Lindsay, J., Norton, A., Selod, H., and Stickler M. (2011). Rising Global Interest in Farmland: Can It Yield Sustainable and Equitable Benefits? World Bank Publications.

De Janvry, A., and Sadoulet, E. (2010). Agricultural growth and poverty reduction: Additional evidence. *The World bank research observer*, *25*(1), 1-20.

Dercon, S. (2009). Rural poverty: Old challenges in new contexts. *The World Bank Research Observer*, *24*(1), 1-28.

Diao, X., Hazell, P., and Thurlow, J. (2010). The role of agriculture in African development. *World development*, *38*(10), 1375-1383. https://doi.org/10.1016/j.worlddev.2009.06.011

Diao, X., Hazell, P. B., Resnick, D., and Thurlow, J. (2007). *The role of agriculture in development: Implications for Sub-Saharan Africa*. Research reports 153, International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896291614RR153

Easterly, W. (2002). The elusive quest for growth: economists' adventures and misadventures in the topics. The MIT Press, 360, ISBN 9780262260657.

FAO. (2020). Asia and the Pacific Regional Overview of Food Security and Nutrition 2020. Maternal and Child diets at the heart of improving nutrition.

Fan, S. (2002). Agricultural research and urban poverty in India. Environment and Production Technology Division Discussion. Paper No. 94, Washington, DC, International Food Policy Research Institute.

Fan, S., and Rao, N. (2003). Public spending in developing countries: Trends, determination, and impact. Environment, Production, and Technology Division Discussion Paper 99. Washington, DC: International Food Policy Research Institute

Fan, S., Zhang, L., and Zhang, X. (2008). Public Expenditure, Growth and Poverty Reduction in Rural Uganda. https://doi.org/10.1111/j.1467-8268.2008.00194.x

Fan S., Hazell, P., and Thorat, S. (1999). Linkages between government spending, growth, and poverty in rural India. IFPRI Research Report No. 110, Washington, DC, International Food Policy Research Institute.

Fuglie, K., and Wang, S. L. (2012). Productivity growth in global agriculture shifting to developing countries. *Choices*, *27*(4), 1-7.

Gollin, D. (2010). Agricultural productivity and economic growth. *Handbook of agricultural economics*, *4*, 3825-3866. https://doi.org/10.1016/S1574-0072(09)04073-0

Gollin, D., Hansen, C. W., and Wingender, A. (2019). *Two blades of grass: Agricultural innovation, productivity, and economic growth*. Working Paper. May 2019. https://files.webservices.illinois.edu/6984/gollinhansenandwingenderjperesubmissioncorrected.pdf

Gumus, E., and Celikay, F. (2015). R&D expenditure and economic growth: new empirical evidence. *Margin: The Journal of Applied Economic Research*, 9(3), 205-217. https://doi.org/10.1177/0973801015579753

Hafeez, A., Syed, K. B. S., and Qureshi, F. (2019). Exploring the Relationship between Government R & D Expenditures and Economic Growth in a Global Perspective: A PMG Estimation Approach. *International Business Research*, *12*(4), 163-174. https://doi.org/10.5539/ibr.v12n4p163

Haggblade, S., Hazell, P. B., and Reardon, T. (Eds.). (2007). *Transforming the rural nonfarm economy: Opportunities and threats in the developing world*. Intl Food Policy Res Inst.

Heisey, P. W. (2001). Agricultural Research and Development, Agricultural Productivity, and Food Security. AgriEcon search Agriculture Information Bulletin Number 765-10.

Hussey, A. J., Jetter, M., and McWilliam, D. (2021). The fundamental determinants of economic inequality in average income across countries: The declining role of political institutions. *Review of Income and Wealth*, *67*(1), 104-133. https://doi.org/10.1111/roiw.12459

Ivanic, M., and Martin, W. (2018). Sectoral productivity growth and poverty reduction: National and global impacts. *World Development*, *109*, 429-439. https://doi.org/10.1016/j.worlddev.2017.07.004

Jorgenson, D.G. (1961). The development of dual economics. *The Economics journal*, 71 (282), 309-334. https://doi.org/10.1016/j.worlddev.2017.07.004

Johnston, B. F., and Mellor, J. W. (1961). The role of agriculture in economic development. *The American Economic Review*, 51(4), 566-593.

Knack, S., and Keefer, P. (1997). Does social capital have an economic payoff? A cross-country investigation. *The Quarterly journal of economics*, *112*(4), 1251-1288.

Knack, S., and Keefer, P. (1995). Institutions and economic performance: cross-country tests using alternative institutional measures. *Economics & politics*, *7*(3), 207-227.

Kuznets, S. (1966). Modern Economic Growth: Rate, Structure, and Spread. Yale University Press, New Haven, CT.

Ladha, J. K., Dawe, D., Pathak, H., Padre, A. T., Yadav, R. L., Singh, B., Singh, Y., Singh, P., Kundu, A. L., Sakal, R., Ram, N. Regmi, A. P., Gami, S. K., Bhandari, A. L., Amin, R., Yadav, C. R., Bhattarai, E. M., Das, S., Aggarwal, H. P., Gupta, R. K. and Hobbs, P. R. (2003). How extensive are yield declines in long-term rice: Wheat experiments in Asia? *Field Crops Research*, 81,159–180. https://doi.org/10.1016/S0378-4290(02)00219-8

Lal, M. (2011). Implications of climate change in sustained agricultural productivity in South Asia. *Regional environmental change*, *11*(Suppl 1), 79-94. https://doi.org/10.1007/s10113-010-0166-9

Lederman, D., and Maloney, W. F. (2003). R&D and development. *Available at SSRN 402480*.

Lewis, W. A. (1954). Economic Development with an unlimited supply of labor. *Manchester School of Economic and Social Studies*, 22, 139–191.

Mellor, J. W. (2001). Faster more equitable growth – agriculture, employment multipliers, and poverty reduction. Agricultural Policy Development Project Research Report 4, Cambridge, MA.

Moon, W. (2022). The lack of dynamic competition and the market insufficiency for agricultural productivity growth: Implications for the role of the state. *Journal of the Agricultural and Applied Economics Association*, *1*(4), 374-384. https://doi.org/10.1002/jaa2.31

Morris, M., Sebastian, A. R., and Perego, V. M. E. (2020). Future Foodscapes Re-imagining Agriculture in Latin America and the Caribbean. International Bank for Reconstruction and Development / The World Bank 1818 H Street NW.

NEPAD. (2013). Agriculture in Africa Transformation and Outlook.

Niang, I., Ruppel, O.C., Abdrabo, M.A., Essel, A., Lennard, C., Padgham, J., Urquhart, P., and Descheemaeker, K. K. E. (2014) Chapter 22: Africa. In: Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D. and Mach, K.J., Eds., Climate Change 2014: Impacts, Adaptation and Vulnerability, Cambridge University Press, Cambridge, 1199-1266. https://doi.org/10.1007/978-3-030-74262-1_16

OECD/FAO. (2019). OECD-FAO Agricultural Outlook 2019-2028, OECD Publishing, Paris/Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.1787/agr_outlook-2019-en

Ouru, L., and Mose, N. (2021). Impact of agricultural R&D on sectoral economic growth. *Asian journal of economics, Business and Accounting.* https://doi.org/10.9734/AJEBA/2021/v21i530379

Pal, S. (2017). Agricultural R&D Policy in India. ICAR–National Institute of Agricultural Economics and Policy Research.

Pardey P. G., and Beddow, J. M. (2017). Revitalizing agricultural research and development to sustain US competitiveness.

Pernechele, V., Fontes, F., Baborska, R., Nkuingoua, J., Pan, X., and Tuyishime, C. (2021). Public expenditure on food and agriculture in sub-Saharan Africa: trends, challenges, and priorities. Rome, FAO. https://doi.org/10.4060/cb4492en

Petrakos, G., and Arvanitidis, P. (2008). Determinants of economic growth. *Economic alternatives*, *1*(1), 12-30.

Piesse, J., and Thirtle, C. (2010). Agricultural R&D, technology and productivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 3035-3047. https://doi.org/10.1098/rstb.2010.0140

Rangarajan, C. (1982). Agricultural growth and industrial performance in India. Research Report 33. Washington DC: IFPRI.

Ranis, G., and Fei, J. C. (1961). A theory of economic development. *The American economic review*, 533-565.

Ravallion, M., and Datt, G. (1996). How important to India's poor is the sectoral composition of economic growth? *The World Bank Economic Review*, *10*(1), 1-25.

Remmer, K. L. (1991). The political impact of economic crisis in Latin America in the 1980s. *The American Political Science Review*, 85(3), 777–800.

Rodrik, D. (2000). Institutions for High-Quality Growth: What They Are and How to Acquire Them. *Studies in Comparative International Development*, 35(3), 3-31.

Subramanian, M. A., Trebbi, M. F., and Rodrik, M. D. (2002). Institutions Rule: The Primacy of Institutions over Integration and Geography in Economic Development. IMF Working Paper.

Rosegrant, M. W., and Hazell, P. B. (2001). Transforming the rural Asia economy: The unfinished revolution. Hong Kong: Oxford University Press.

Schultz, T. W. (1964). Transforming Traditional Agriculture. Yale University Press, New Haven, CT.

Singer, H. (1979). Policy implications of the Lima target. Industry and Development 3, 17–22.

Singh R. B. (2002). The State of Food and Agriculture in Asia and the Pacific: Challenges and Opportunities, The State of Food and Agriculture in Asia and the Pacific published by IFA and FAO Paris, France.

Stads, G., and Beintema, N. (2010). Public Agricultural R&D Investments and Capacities in Developing Countries recent evidence for 2000 and beyond. Note prepared for the Global Conference on Agricultural Research for Development (GCARD), Montpellier.

Stads, G. J., Beintema, N., Perez, S., Flaherty, K., and Falconi, C. (2016). A Cross-Country Analysis of Institutions, Investment, and Capacities. Inter-American Development Bank (IDB).

Thirtle, C., Lin, L., and Piesse, J. (2003). The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development*, *31*(12), 1959-1975. https://doi.org/10.1016/j.worlddev.2003.07.001

Timmer, P. (2005). Agriculture and pro-poor growth: What the literature says. *Draft paper, Agricultural and Rural Development Dept., World Bank, Washington, DC*.

Tung, L. T., and Hoang, L. N. (2024). Impact of R&D expenditure on economic growth: evidence from emerging economies. *Journal of Science and Technology Policy Management*, *15*(3), 636-654. https://doi.org/10.1108/JSTPM-08-2022-0129

Vogel, S. (1994). Structural Changes in Agriculture: Production Linkages and Agricultural Demand-Led Industrialization. Oxford Economic Papers, 46(1), 136–156.

World Bank. (2013). Unlocking Africa's Agricultural Potential. Sustainable Development Series.