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Impacts of Agricultural CO_2 Emissions, Agricultural Exports and Financial Development on Economic Growth: Insights from East Asia and Pacific Countries

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ABSTRACT

This study investigates the effects of agricultural CO_2 emissions, agricultural exports, and financial development on economic growth in the Asia-Pacific region from 1990 to 2022, using data from 37 countries. The findings reveal that increased capital investment and agricultural exports significantly boost economic growth, while higher final consumption expenditure also plays a crucial role. Conversely, agricultural methane emissions negatively impact economic growth, underscoring the need for sustainable agricultural practices. The analysis highlights the importance of capital accumulation, agricultural sector expansion, and financial development for economic advancement. It also suggests that policies promoting technological innovation, environmental sustainability, and robust domestic demand are essential for sustained economic growth. Future research should address potential biases and explore additional variables to refine these insights.

Keywords: Agricultural CO_2 Emissions, Agricultural Exports, Financial Development, Economic Growth, Asia and Pacific Countries
JEL Classifications: Q56, Q10, F43, O13, G20, C23

1. INTRODUCTION

Agriculture has been a cornerstone of human civilization, playing a vital role in ensuring the sustenance and advancement of societies across the globe. Today, its significance remains profound, not only as a crucial provider of food but also as a key driver of economic growth and a fundamental component of sustainable development goals. The intersection of agricultural practices with environmental concerns and economic policies is now more relevant than ever, particularly as the United Nations and other international bodies emphasize the need for sustainable and inclusive growth. In this context, understanding the multifaceted impacts of agricultural CO_2 emissions, agricultural exports, and financial development on economic growth becomes imperative. This comprehensive analysis addresses pressing global challenges such as climate change, food security, and economic inequality, all of which are central to the Sustainable Development Goals (SDGs).

The interrelationship between agricultural CO_2 emissions, agricultural exports, and financial development with economic growth has intrigued economists, prompting a diverse range of theoretical explorations. Ricardo's theory of comparative advantage suggests that countries benefit by specializing in and exporting agricultural goods for which they have a production advantage, potentially boosting economic growth through efficient resource utilization (Ricardo, 1817). Meanwhile, endogenous growth theory posits that agricultural exports can drive innovation and human capital development, contributing to sustainable economic growth (Romer, 1990). The Heckscher-Ohlin and Krugman trade models further highlight the role of agricultural exports in resource allocation and economic specialization, leading to optimized use of production factors and enhanced economic growth (Heckscher, 1919; Krugman, 1980). Additionally, the interplay between financial development and agricultural exports is critical; improved financial systems can facilitate investment in agricultural technologies, enhance productivity, and stimulate economic growth (Schumpeter, 1911). Additionally, the income and demand effects indicate that agricultural exports can boost domestic demand by generating additional income for farmers, thereby promoting economic growth through increased consumption and investment (Balassa, 1964). However, the environmental dimension, particularly agricultural CO_2 emissions, introduces complexity, as these emissions pose significant challenges to sustainable development and necessitate balanced policy approaches.

In the East Asia and Pacific region, the impacts of agricultural CO_2 emissions, agricultural exports, and financial development on economic growth are particularly significant due to the region's unique characteristics. This region is rich in agricultural resources and strategically positioned, making agriculture a pivotal sector of its economies (FAO, 2020). The region has experienced substantial growth in agricultural production and trade, significantly contributing to the global agricultural market (World Bank, 2019). Agricultural exports from these countries not only fuel their own economic expansion but also exert a substantial influence on regional and global economies (OECD, 2019). However, this growth brings environmental concerns, particularly regarding CO_2 emissions from agricultural activities, which necessitate sustainable practices to mitigate adverse impacts. The intricate relationship between these factors is crucial for shaping effective policies and promoting sustainable development in East Asia and the Pacific. Policies enhancing agricultural productivity, ensuring environmental sustainability, and fostering financial development are essential for long-term economic prosperity (World Bank, 2019). Furthermore, with the increasing global demand for agricultural products, East Asia and the Pacific have an opportunity to further capitalize on their agricultural potential and expand their presence in international markets (ADB, 2018). However, to fully harness this potential, countries in the region must address various constraints, including inadequate infrastructure, limited access to finance and technology, and trade barriers (ADB, 2018).

The originality and added value of this study lie in its specific focus on the East Asia and Pacific region. While extensive research has explored the impacts of agricultural exports and financial development on economic growth, the combined effects of agricultural CO_2 emissions in this region remain underexplored in academic literature. By concentrating on this unique context, this research aims to bridge a significant gap in existing knowledge and provide valuable insights for policymakers and development practitioners. The complexity of international economic relations, variations in national agricultural policies, and the influence of exogenous factors such as climate change present considerable challenges in understanding this dynamic. Thus, unraveling the multiple variables influencing the interaction between agricultural CO_2 emissions, agricultural exports, financial development, and economic growth in East Asia and the Pacific forms the cornerstone of this research.

This study aims to explore the critical importance of the agricultural sector and its environmental and economic dimensions, while highlighting the specific challenges and opportunities faced by the East Asia and Pacific region. Through this approach, it seeks to offer innovative perspectives and practical recommendations to guide policies and actions aimed at promoting sustainable and inclusive development in this dynamic part of the world. To achieve this, the study is structured as follows. The second section provides a literature review encompassing recent studies on the link between agricultural CO_2 emissions, agricultural exports, financial development, and economic growth. This section will examine various perspectives and conclusions drawn by researchers, focusing on the mechanisms and factors influencing these relationships. The third section presents the dataset, econometric model specification, and empirical methodology employed in this analysis, detailing the data analysis approach and statistical techniques used. The fourth section showcases the empirical results, highlighting significant relationships and regional or sectoral variations identified through the analysis. The fifth section concludes with a discussion of the findings, their policy implications, and recommendations for future research and policy actions to strengthen the role of agricultural exports, manage CO_2 emissions, and leverage financial development for economic growth in East Asia and the Pacific.

2. LITERATURE SURVEY

Analyzing existing literature on the links between various economic sectors and economic growth is a crucial step in understanding the complex dynamics of a country's economy. This section aims to explore the relationships between exports, agricultural exports, financial development, agricultural CO_2 emissions, and economic growth. Each subsection will draw on empirical and theoretical studies to illustrate how these factors interact and influence the trajectory of economic growth. By identifying trends, correlations, and causalities observed in the literature, we can better understand the potential levers for stimulating sustainable and inclusive economic growth.

2.1. Exports and Economic Growth

The relationship between exports and economic growth has long been a subject of study and debate in economic literature. Understanding this relationship is crucial for policymakers aiming to formulate effective strategies to foster economic development. In this paragraph, we review several studies that examine the intricate connections between exports and economic growth across different countries and regions, shedding light on the various dynamics at play (Khan and Ahmed, 2024; Abdulsahib, 2024).

A study by Keho (2015) on 12 sub-Saharan African countries revealed complex relationships between FDI, exports, and economic growth, with varying results across countries. The results showed bidirectional relationships in both the short and long term between FDI, exports, and economic growth in several countries, highlighting the importance of policies aimed at promoting FDI and exports to stimulate economic growth in sub-Saharan Africa.

In a study on South Africa, Sunde (2017) used the ARDL model to study the relationship between economic growth, foreign direct investment (FDI), and exports. The results confirmed a bidirectional relationship between FDI, exports, and economic growth, thus supporting the hypothesis of FDI-driven growth for South Africa. A study on Pakistan conducted by Hameed et al. (2012) revealed a unidirectional causality relationship from economic growth to exports, indicating that economic growth stimulates exports in the country. In the case of Luxembourg, Usman et al. (2012) found a significant and positive relationship between exports and economic growth, highlighting the importance of exports for economic growth in the country. A study by Mishra (2011) on India concluded that promoting exports does not necessarily lead to higher economic growth, thus rejecting the export-led growth hypothesis for India. A study focusing on Newly Industrialized Countries (NICs) conducted by Rahman et al. (2021) revealed that economic growth and exports have a significant impact on CO_2 emissions in these countries, highlighting the environmental implications of growth and export-focused policies. A study in Jordan by Shihab et al. (2014) found a causal relationship from economic growth to exports, indicating that changes in economic growth explain changes occurring in exports, but not vice versa.

In a study focusing on North African countries, Yedder et al. (2023) employ a Panel CS-ARDL model to analyze the impact of domestic investments and trade on economic growth. Their findings reveal that during the period of 1990-2021, domestic investments and exports do not seem to influence long-term economic growth in these countries. However, the impact of imports is positive in the long term, suggesting a complex economic dynamic where exports and domestic investments do not appear to be drivers of economic growth in the region. A similar outcome is observed in the study conducted by Ben Yedder et al. (2023) on Angola. Despite the absence of an apparent impact of domestic investments and exports on sustained economic growth, this research underscores the need for a reassessment of existing economic policies in the country. The examination of Albania's case by Akermi et al. (2023) also reveals a lack of causality between final consumption, exports, domestic investments, imports, and economic growth, thus emphasizing the urgency of economic reforms and effective strategies to stimulate growth. Conversely, a study by Bakari (2022a) on Greece reveals different results, showing that in the short term, only exports seem to influence domestic investments, while no causal relationship is observed in the long term between exports, domestic investments, and economic growth. Bakari's broader study (2022b) on 52 African countries highlights the positive impact of domestic investments, exports, and natural resources on economic growth, while emphasizing the lack of significant effect from CO_2 emissions, innovation, and Internet usage on economic growth.

In a study by Bakari (2021) covering 49 African countries from 1960 to 2018, several innovative econometric methods were used to examine the relationship between exports and economic growth. The results of this study indicated a positive bidirectional relationship between exports and economic growth, suggesting the importance of exports in the economic growth process in Africa. A study on Brazil conducted by Bakari et al. (2019) used the Vector Error Correction Model (VECM) method to analyze the relationship between domestic investments, exports, imports, and economic growth. The results revealed that in the short term, imports, exports, and domestic investments contribute to economic growth, while in the long term, domestic investments and exports have a positive effect on economic growth, and imports have a negative effect. A study by Kalaitzi and Cleeve (2018) on the United Arab Emirates confirmed the Export-Led Growth (ELG) hypothesis by highlighting a bidirectional causal relationship between manufacturing exports and economic growth in the short term and a one-way causality relationship in the long term from economic growth to exports. Nguyen (2020) examined the relationship between foreign direct investment (FDI), foreign aid, exports, and economic growth in Vietnam from 1997 to 2018. The results showed a positive relationship between FDI, foreign aid, exports, and economic growth, emphasizing the importance of these factors in promoting economic growth in Vietnam. A study on India by Mehta (2015) concluded that there is a unidirectional causality relationship from economic growth to exports, meaning that economic growth leads to exports, but not necessarily vice versa. Additionally, no causal relationship was found between economic growth and imports. Mahmoodi and Mahmoodi (2016) examined the relationship between foreign direct investment (FDI), exports, and economic growth in developing countries, including in Europe and Asia. Their results showed bidirectional causality relationships between GDP and FDI, as well as unidirectional causality relationships between GDP and exports, in the case of developing European countries.

Nguyen (2016) analyzed the impact of exports on economic growth in Vietnam. Their results confirmed a significant and positive relationship between exports and economic growth in Vietnam, highlighting the important role of exports in the country's economic development. Cetin and Ackrill (2018) analyzed the link between foreign trade and economic growth in Slovakia. Their results supported both the export-led growth hypothesis and the import-led growth hypothesis, meaning that both exports and imports have a significant impact on economic growth in the country. Firdaus and Septiani (2022) examined the effect of inflation, exports, and imports on economic growth in Indonesia. Their results showed a unidirectional causality relationship from inflation and exports to economic growth, as well as a unidirectional causality relationship from imports to economic growth. This suggests that policies aimed at stabilizing inflation and promoting exports could foster economic growth in Indonesia. In their study on Mauritania, Bakari and Krit (2017) examined the relationship between exports, imports and economic growth. Their analysis, covering the period from 1960 to 2015, found that exports have a positive effect on economic growth, while imports have a negative effect. The results suggest that, in the case of Mauritania, imports can be considered as the source of economic growth, highlighting the importance of appropriate trade policies to foster economic development in this context. Meanwhile, the study conducted by Bakari (2017a) in Sudan examined the relationship between domestic investment, exports, imports and economic growth. Analyzing data from 1976 to 2015, the authors found that reforms and measures in Sudan's economic strategies appear insufficient to boost the national economy through internal trade and investment. In the case of Japan, Bakari (2017b) examined the relationship between exports, imports, domestic investment and economic growth. Their analysis, based on data from 1970 to 2015, found that exports and domestic investments are considered the main source of economic growth, while imports have no significant effect on gross domestic product.

Fakraoui and Bakari (2019) examined the relationship between domestic investment, exports and economic growth in India. Their analysis, covering the period from 1960 to 2017, showed that exports are the only source of short-term economic growth in India. However, in the long run, domestic investment and exports do not seem to contribute to economic growth due to structural problems and inappropriate economic strategies. Kumar (2018) studied the relationship between exports, imports, and economic growth in India. The results indicated a unidirectional causality relationship from exports to economic growth, while economic growth caused both exports and imports. This suggests that exports can play a driving role in India’s economic growth. Elakkad and Hussein (2023) examined the impact of imports on economic growth in Egypt. Their results confirmed a long-term relationship between real imports and economic growth, suggesting that imports have a significant impact on economic growth in Egypt. Ali et al. (2018) studied the impact of exports and imports on economic growth in Somalia. Their results showed a unidirectional causality relationship from exports to economic growth, indicating that exports can play a driving role in Somalia’s economic growth. Saaed and Hussain (2015) examined the impact of exports and imports on economic growth in Tunisia. Their results showed a unidirectional causality relationship between exports and imports, as well as between exports and economic growth. This suggests that growth in Tunisia was fueled by both an import-driven growth strategy and exports. Yusoff and Nulambeh (2016) studied the impact of exports, imports, exchange rates, and gross domestic investment on economic growth in Cameroon. Their results showed that exports, gross domestic investment, and exchange rates have a positive influence on economic growth, while the impact of imports on GDP growth is negative. This suggests that economic growth in Cameroon is primarily driven by exports and gross domestic investment, while imports have a negative impact on growth. Selvanathan et al. (2020) examined the link between exports, imports, and sustainable economic growth in Bangladesh. Their results supported both the export-led growth hypothesis and the import-led growth hypothesis, as well as the growth-driven growth hypothesis. This suggests that exports, imports, and economic growth are all interdependent and can contribute to sustainable economic growth in Bangladesh. Guntukula (2018) examines the link between exports, imports, and economic growth in India using monthly data from 2005 to 2017. Employing Johansen’s Cointegration and Granger causality tests, the study found a bidirectional causality between exports and economic growth, supporting both the export-led growth and growth-led export hypotheses. This suggests that both export promotion and economic growth strategies should be pursued simultaneously for sustainable development. Similarly, Dritsaki and Stiakakis (2014) investigated the relationship between exports and economic growth in Croatia from 1994 to 2012. Using ARDL models, the study confirmed a bidirectional causal relationship between exports and economic growth, both in the long and short run. This emphasizes the importance of exports as a key driver for Croatia's economic development.

The studies reviewed in this paragraph provide valuable insights into the complex relationship between exports and economic growth. While some findings support the traditional export-led growth hypothesis, others reveal nuanced dynamics, such as bidirectional causality, varied impacts of foreign direct investment, and the importance of domestic policies. The diversity of results underscores the need for context-specific approaches to economic development, recognizing the unique circumstances and challenges faced by each country. Moving forward, policymakers should consider these insights when formulating strategies to promote sustainable economic growth through export-oriented policies, investment promotion, and domestic reforms tailored to local conditions.

2.2. Agricultural Exports and Economic Growth

The role of agricultural exports in driving economic growth has been a subject of considerable interest and study, particularly in developing countries where agriculture often plays a significant role in the economy. Understanding the relationship between agricultural exports and economic growth is crucial for policymakers aiming to harness the potential of the agricultural sector for broader economic development. In this paragraph, we review various studies that explore the impact of agricultural exports on economic growth across different regions and countries, shedding light on the diverse dynamics at play.

Bakari and Mabrouki (2017) explored the effect of agricultural exports on economic growth in Southeast European countries. Their analysis, based on annual data from 2006 to 2016, revealed a positive and significant correlation between agricultural exports and Gross Domestic Product (GDP), suggesting that these exports contribute to economic growth in the region. In the case of Tunisia, Bakari (2016) found that agricultural exports have a positive impact on economic growth during the period 1988 – 2014 by using cointegration analysis and VECM model. In a subsequent study, Bakari and Mabrouki (2018) expanded their analysis to include the impact of agricultural trade on economic growth in North Africa. Their findings indicated a positive correlation between agricultural trade and GDP, highlighting the importance of agricultural exports in promoting economic growth in this region. Focusing specifically on Tunisia, Bakari (2017c) examined the impact of olive oil exports on economic growth. The results showed a positive impact of olive oil exports on economic growth, both in the short and long term, thus emphasizing the crucial role of this sector in the Tunisian economy. However, Bakari’s (2018) study on citrus exports in Tunisia revealed a different trend. While there was a short-term positive causality between citrus exports and economic growth, no long-term impact was observed. This underscores the need for economic reforms to promote sustainable growth in this sector. The work of Bakari and Tiba (2023) in China highlighted the positive long-term impact of agricultural exports on economic growth, but also emphasized the negative impact of agricultural imports on economic growth. In contrast, Faridi’s (2012) study on Pakistan revealed a negative effect of agricultural exports on economic growth, suggesting that other export sectors should be promoted to foster economic growth in the country.

Other studies such as those by Dawson (2005) and Sanjuán-López and Dawson (2010) have also contributed to this discussion by highlighting structural differences in the impact of agricultural exports on economic growth, especially in developing countries. Osabohien et al. (2019) examined the impact of agricultural exports on economic growth in Nigeria. Their study revealed a significant and positive relationship between agricultural exports and economic growth, emphasizing the importance of promoting agricultural exports to drive economic growth in the country. Siaw et al. (2018) conducted a comprehensive analysis in Ghana, where they found that cocoa exports had a significant positive impact on economic growth, while pineapple and banana exports had a negative effect. These results suggest the need for differentiated management of different crops to optimize their contribution to economic growth. Mahmood and Munir (2018) examined the relationship between agricultural exports and economic growth in Pakistan. Their results revealed a positive but insignificant association between agricultural exports and GDP growth, highlighting the challenges the country faces in increasing the impact of its agricultural exports on economic growth. Toyin (2016) studied the relationship between agricultural exports and economic growth in South Africa. Contrary to some expectations, the study did not find causality between agricultural exports and economic growth, highlighting the challenges the country faces in developing its agricultural sector and stimulating economic growth. Seok and Moon (2021) examined the export-led growth hypothesis in the agricultural sector of developed countries, focusing on OECD countries. Their results showed that agricultural exports have a positive effect on agricultural growth, especially in the case of EU countries, highlighting the importance of access to foreign markets to stimulate agricultural growth in developed countries. Henneberry and Khan (2014) examined the relationship between agricultural exports and economic growth in Pakistan. Their results highlighted a favorable relationship between agricultural exports and GDP growth, emphasizing the potential of agricultural exports to contribute to economic growth in the country. Mamba and Ali (2022) looked into ECOWAS countries to analyze the effects of agricultural exports on agricultural and overall economic growth. Their results showed that agricultural exports have a significant and positive impact on both agricultural and overall economic growth in the region, thus emphasizing the importance of promoting agricultural exports to stimulate economic growth in ECOWAS member countries. Edeme et al. (2016) conducted a comparative analysis of the impact of agricultural exports on the economic growth of ECOWAS countries from 1980 to 2013. Using a fixed-effect model, they found that while agricultural exports significantly influenced economic growth, the impact varied across countries. For instance, in Côte d'Ivoire and Nigeria, the effects were more pronounced compared to the Republic of Benin, which was used as a baseline. The study highlighted the need for targeted policies to improve the agricultural sector, especially in countries where the impact is less significant.

Similarly, Matandare (2017) explored the relationship between agricultural exports and economic growth in Zimbabwe using data from 1980 to 2016. The study found that agricultural exports, along with other variables such as labor and exchange rates, had a statistically significant impact on economic growth. The paper recommended government intervention through subsidies and support for local farmers to improve agricultural productivity and enhance the quality of export products. This would allow Zimbabwe to better compete in foreign markets and stimulate broader economic growth. In Nigeria, Ojo et al. (2014) examined agricultural exports and their role in economic expansion between 1980 and 2012. Their analysis revealed that agricultural exports, agricultural output, net capital flow, and world prices of major agricultural commodities were key long-term determinants of Nigeria's economic growth. The study emphasized the importance of improving the agricultural export sector to further drive economic development. Simasiku and Sheefeni (2017) investigated the link between agricultural exports and economic growth in Namibia from 1990 to 2014. Their results indicated a positive but insignificant effect of agricultural exports on economic growth, while non-agricultural exports had a significant positive effect. The study also found that agricultural exports, non-agricultural exports, and gross domestic fixed capital formation were important long-term determinants of Namibia's economic performance.

Yifru (2015) examined the impact of agricultural exports on economic growth in Ethiopia, focusing on coffee, oilseeds, and legumes. The study revealed that coffee and oilseed exports had a significant positive impact on economic growth, while legume exports had a negative effect. These results highlight the importance of diversifying exported agricultural products to maximize their contribution to economic growth. Murugesan (2019) analyzed the influence of agricultural trade on economic growth in India and concluded that both agricultural and non-agricultural exports are important variables for stimulating economic growth in the country. These results underscore the importance of policies aimed at increasing agricultural productivity and trade to foster economic growth in India. Kouakou (2020) examined the effects of agricultural and non-agricultural exports on economic growth in Ivory Coast. The study revealed that agricultural exports have a significant positive effect on Gross Domestic Product (GDP) in the short term, while non-agricultural exports have a positive but not significant effect in the short term and a significant positive effect in the long term. These results emphasize the importance of promoting both agricultural and non-agricultural exports to foster economic growth in Ivory Coast.

Urriola-Canchari et al. (2018) studied the impact of traditional and non-traditional agricultural exports on economic growth in Peru. Their results showed that non-traditional agricultural exports have a significant and positive effect on GDP, while traditional agricultural exports have a positive but not significant effect. These results highlight the importance of diversifying agricultural exports to stimulate economic growth in Peru. Gwanongodza (2020) examined the link between agricultural exports and economic growth in Zimbabwe. The study revealed that food product exports have a positive effect on GDP, while exports of raw agricultural products have a negative effect. These results emphasize the importance of promoting exports of processed agricultural products to stimulate economic growth in Zimbabwe. Alam and Myovella (2016) examined the causality between agricultural exports and GDP in Tanzania. Their study revealed a long-term relationship between agricultural exports and GDP, and that agricultural exports Granger cause GDP growth but not vice versa. They suggested that promoting agricultural exports can be used as a tool to promote economic growth and development in Tanzania, but challenges such as lack of mechanization, non-tariff barriers, and infrastructure deficiencies need to be overcome. Oluwatoyese et al (2016) examined the relationship between agricultural exports, oil exports, and economic growth in Nigeria. Their study showed a significant relationship between economic growth and both agricultural and oil exports. They recommended that the Nigerian government initiate new policies to diversify the export base and improve domestic production. Verter and Bečvářová (2016) studied the impact of agricultural exports on economic growth in Nigeria. Their results showed that agricultural exports contribute to the country's economic growth. They suggested that to improve Nigeria's agricultural trade balance, the country should encourage local processing industries and discourage imports of agricultural products that can be locally processed.

The studies reviewed in this paragraph provide valuable insights into the complex relationship between agricultural exports and economic growth. While some findings support a positive association between agricultural exports and GDP growth, others reveal nuanced patterns, such as differential impacts of specific agricultural products, varying effects over different time horizons, and challenges related to infrastructure, diversification, and trade barriers. These findings underscore the importance of targeted policies aimed at promoting agricultural exports, improving productivity, value addition, and market access, as well as addressing structural constraints to maximize the contribution of the agricultural sector to economic growth. Moving forward, policymakers should consider these insights when formulating strategies to harness the potential of agricultural exports for sustainable economic development, particularly in countries where agriculture plays a significant role in the economy.

2.3. Financial Development and Economic Growth

The intricate relationship between financial development and economic growth has garnered significant attention from researchers over the years. This area of study is critical as it delves into how financial systems can foster or hinder economic progress, depending on various factors such as geographical context, policy environment, and the maturity of financial institutions. Numerous studies have explored this relationship, employed diverse methodological approaches and focusing on different regions, to provide a comprehensive understanding of how financial development impacts economic growth. This paragraph reviews key literature on the subject, highlighting significant findings and their implications for policymakers and stakeholders (Sanusi and Dickason-Koekemoer, 2024).

Ibrahim and Alagidede (2020) analyzed the asymmetric effects of financial development on economic growth in Ghana from 1980 to 2016 using a nonlinear ARDL approach. Their study revealed a long-term asymmetric relationship where positive and negative shocks in financial development have different short- and long-term effects on economic growth, highlighting the complexity of this relationship in developing countries. Ehigiamusoe (2021) explored the link between tourism, financial development, and economic growth in 31 African countries using the Dumitrescu-Hurlin non-causality test and frequency domain causality test. He demonstrated a cointegration relationship between these variables, with bidirectional causality between financial development and economic growth. This study underscores the importance of simultaneous development of the tourism and financial sectors to stimulate economic growth in Africa. Olorogun et al (2022) focused on Nigeria, investigating the foreign direct investment (FDI)-led economic growth hypothesis. They found a long-term equilibrium relationship between FDI, financial development, and economic growth, indicating that FDI and financial development are good predictors of sustainable economic growth in Nigeria. This study highlights the importance of attracting FDI and developing the financial sector to foster economic growth in Sub-Saharan countries.

Ustarz and Fanta (2021) examined the impact of financial development on various sectors in Sub-Saharan Africa from 1990 to 2018. They found that financial development had a positive effect on the service and agricultural sectors, but a certain threshold of financial development needed to be reached to positively impact the industrial sector. This suggests that policies promoting financial development are essential for spurring industrialization in the region. Erdoğan et al. (2020) studied the Next-11 countries, analyzing the impact of natural resource abundance and financial development on economic growth. They found that the effect of natural resource exports on economic growth depended on the level of financial development. When financial development exceeded a certain threshold, natural resource exports had a significant impact on economic growth, emphasizing the importance of an advanced financial system to transform export revenues into productive investments. Cheng et al. (2021) explored the interaction between the diffusion of information and communication technologies (ICT), financial development, and economic growth in 72 countries from 2000 to 2015. They discovered that financial development had a negative effect on economic growth, but ICT diffusion could mitigate this negative effect, especially in high-income countries. This indicates that the combination of financial development and technological innovation can be beneficial for economic growth.

Zeren and Hizarci (2024) examined hydropower energy consumption, financial development, FDI, and economic growth in newly industrialized countries from 1979 to 2020. They found no cointegration or causality between hydropower energy consumption and the three macroeconomic indicators, suggesting that the relationship between these variables can vary significantly depending on the national context. Hung (2023) analyzed how green investments, digitalization, and financial development can promote economic sustainability in Vietnam. Using a quantile-on-quantile regression approach, he demonstrated that these factors had a significant positive effect on economic sustainability, showing that technological innovation and green investments are essential for sustainable development.

Mtar and Belazreg (2023) studied the linkages between innovation, trade openness, financial development, and economic growth in 11 European countries from 2001 to 2016. They found unidirectional relationships between economic growth and financial development, and between trade and economic growth. The results suggest that regulation of the financial system and the quality of funding are crucial for economic development. Mohamed Sghaier (2023) explored the relationships between trade openness, financial development, and economic growth in four North African countries. He found that trade openness and financial development had a positive impact on economic growth, highlighting the importance of local reforms to maximize the benefits of international trade.

Saadaoui and Chtourou (2023) examined the relationship between institutional quality, financial development, economic growth, and renewable energy consumption in Tunisia. They found bidirectional causality between economic growth and institutional quality, as well as between financial development and renewable energy consumption, suggesting the need for sustainable financial mechanisms to support the energy transition. In their study focusing on Tunisia, Bouchoucha and Bakari (2021) investigated the relationship between financial development and economic growth over the period from 1976 to 2017. To conduct their analysis, they employed cointegration analysis and the Autoregressive Distributed Lag (ARDL) model. Their findings revealed an intriguing and somewhat counterintuitive result: financial development had a negative impact on economic growth in the long run.

The literature on the relationship between financial development and economic growth presents a complex and multifaceted picture. Studies across different regions and time periods reveal that the impact of financial development on economic growth is not uniform, but rather contingent on various factors including the level of financial maturity, economic structure, and external influences such as technology and natural resources. While some studies highlight positive correlations and the potential for financial development to drive sustainable economic growth, others point to nuanced and sometimes negative effects, emphasizing the need for tailored policies and robust financial regulation. These findings underscore the importance of a context-specific approach in leveraging financial development as a tool for economic growth, particularly in developing and emerging economies. As such, policymakers must consider local conditions and adopt strategies that not only enhance financial systems but also align with broader economic goals and sustainability objectives.

2.4. Agricultural CO_2 Emissions and Economic Growth

The relationship between agricultural practices, economic growth, and environmental sustainability has become a critical area of research in recent years. This synthesis examines a series of studies that investigate the impacts of climate change, CO_2 emissions, and renewable energy use on agricultural economic growth across various regions, including South Africa, China, and Nepal. These studies utilize advanced econometric models such as ARDL, SBM, and LMDI to explore how agricultural activities and energy consumption influence carbon emissions and economic development. The findings highlight the complexities of achieving sustainable agricultural growth while mitigating environmental impacts and underscore the importance of region-specific policies to address these challenges. Tagwi (2022) examines the impacts of climate change, CO_2 emissions, and the use of renewable energies on agricultural economic growth in South Africa. Using an ARDL approach, the study reveals that CO_2 emissions increase with agricultural economic growth in the short term, while climate change reduces this growth. However, the use of renewable energies does not have a significant impact on growth, neither in the short nor long term, highlighting the need for policies promoting the commercialization of biomass and bioenergy regulation to foster inclusive participation in renewable energy production. Similarly, Zang et al. (2022) focus on China, analyzing the intensity of agricultural carbon emissions and their impact on economic development and agricultural trade. Their study shows that, in the long term, an increase in emission intensity reduces the level of agricultural trade and overall economic development. This indicates the importance of low-carbon agricultural strategies to improve coordination between agricultural trade, economic development, and ecological protection.

Zhu and Huo (2022) explore the impact of agricultural production efficiency on carbon emissions in China, using a super-efficiency SBM model and a threshold regression model. They find an inverted U-shaped relationship between production efficiency and agricultural carbon emission intensity. In regions with high production efficiency, an improvement in efficiency can reduce emissions, while in regions with low efficiency, this improvement can increase them. This finding underscores the need to adjust carbon emission policies based on regional efficiency levels.

The study by Balsalobre-Lorente et al. (2019) on the BRICS countries (Brazil, Russia, India, China, and South Africa) confirms the Environmental Kuznets Curve (EKC) for these nations, with an inverted U-shaped relationship between carbon emissions and economic growth. Agriculture is identified as having a negative impact on the environment, amplified by electricity consumption. This study recommends adopting cleaner energy processes and encouraging green foreign investments to mitigate negative environmental effects. Sun et al. (2022) analyze carbon emissions from agricultural energy consumption in the Yangtze River Economic Belt in China. Using the LMDI approach to decompose the factors of these emissions and decoupling indicators, they show an alternation between decoupling and recoupling of emissions and economic growth from 2000 to 2017. The results suggest that low-carbon agricultural development strategies should include structural adjustments in energy consumption and technological advancements.

Additionally, Wu et al. (2023) study the decoupling effect between net agricultural carbon emissions and economic growth in China. Using a method to assess the temporal evolution and spatial distribution of agricultural carbon emissions, they find an optimization of the decoupling state in Anhui province, suggesting that precise and scientific policies can reduce emissions and promote sustainable agricultural development. Long and Tang

(2021) examine the impact of institutional socio-economic changes on reducing agricultural CO_2 emissions in China. Using the EKC model and the Kaya method, they identify economic growth as the main factor of these emissions, while technological progress plays a significant role in their reduction. However, the structure of energy consumption and population size do not have a notable impact on emissions. Raihan and Tuspekova (2022) explore the dynamic relationships between economic growth, fossil energy use, renewable energy use, and agricultural productivity in relation to CO_2 emissions in Nepal. Using time series data from 1990 to 2019 and applying the ARDL bounds testing method followed by dynamic ordinary least squares (DOLS), they find that economic growth and fossil energy use increase CO_2 emissions by 0.61% and 0.67%, respectively, for each 1% increase. In contrast, a 1% increase in renewable energy use and agricultural productivity leads to a reduction in CO_2 emissions by 3.65% and 0.41%, respectively, in the long term. The study recommends implementing robust regulatory policies to reduce environmental degradation.

In a complementary study, Raihan and Tuspekova (2022) analyze the impact of economic growth, renewable energy use, and agricultural land expansion on CO_2 emissions in Peru. The authors use time series data from 1990 to 2018 and apply the ARDL and DOLS methods. They find that a 1% increase in economic growth is associated with a 0.59% increase in CO_2 emissions, while a 1% increase in renewable energy use reduces CO_2 emissions by 0.52%. In contrast, agricultural land expansion increases CO_2 emissions by 1.58% in the long term. The results highlight the need to promote renewable energies and smart agriculture to achieve a low-carbon economy. Shu-Jie et al. (2018) examine the relationship between agricultural carbon emissions and economic growth in Jilin province, China, using data from 1999 to 2014. Their analysis reveals that agricultural carbon emissions increased at an average annual rate of 4.28%, with fertilizers being the main source of these emissions. The results show that the deceleration of agricultural carbon emissions relative to economic growth is weak, reflecting a weak deceleration between these two variables. Han et al. (2018) analyze the coupling and decoupling effects of agricultural carbon emissions in China, using data from 30 provinces from 1997 to 2015. Their study reveals that the degree of coupling between agricultural carbon emissions and economic growth is high in central China and low in the west. In general, the effects of agricultural development size and agricultural technological progress are the main drivers of the increase and decrease in agricultural carbon emissions. Most provinces are in a state of weak decoupling.

Ben Jebli and Ben Youssef (2019) explore the relationships between the consumption of renewable combustibles and waste, agricultural value-added, CO_2 emissions, and real GDP in Brazil, covering the period from 1980 to 2013. They find a long-term cointegration between these variables and show that the consumption of renewable combustibles and agricultural value-added contribute to economic growth while reducing CO_2 emissions. The study recommends continuing to encourage agriculture and biofuel production while promoting second-generation biofuels to reduce emissions. Zhangwei and Xungang (2011) study agricultural CO_2 emissions in Sichuan province from 1997 to 2008, using the LMDI decomposition method to analyze the effects of production, structure, and intensity. They find that agricultural CO_2 emissions continuously increased during this period, mainly due to the intensity effect. The structure effect contributes to emission reduction, while the production effect shows a small negative influence that gradually becomes positive after 2004. Qing et al. (2023) analyze the coupling and coordination between agricultural carbon emission efficiency and economic growth in the Yellow River Basin in China, using data from 30 cities from 2010 to 2020. Their study reveals significant spatial disequilibrium in the degree of coupling and coordination, with a downward trend in coordination over time. The study provides recommendations for improving low-carbon agricultural development and resolving contradictions between ecological protection and economic development.

Luo et al. (2017) examine the decoupling of CO_2 emissions from economic growth in the agricultural sector of 30 Chinese provinces from 1997 to 2014. They calculate CO_2 emissions from agricultural activities and explore spatial and temporal heterogeneities. The results show that eastern Chinese provinces experienced more periods of strong decoupling of CO_2 emissions relative to agricultural production value. The authors suggest policies such as imposing a value-added tax on conventional fertilizers and using animal manure to reduce emissions. Zhang et al. (2019) study the relationship between carbon emissions, energy consumption, and economic growth in the agricultural sector of major grain-producing areas in China, using data from 1996 to 2015. Their analysis supports the environmental Kuznets curve hypothesis for agricultural carbon emissions and shows that agricultural energy consumption has negative impacts on carbon emissions in the short and long term. They also find a bidirectional causality between agricultural carbon emissions and economic growth and recommend policies to promote sustainable agricultural development.

The collective findings of these studies underscore the intricate relationship between agricultural economic growth, CO_2 emissions, and the use of renewable energy sources. While some regions show a positive correlation between economic growth and carbon emissions, others demonstrate that technological advancements and efficient agricultural practices can mitigate these emissions. The need for targeted policies that promote renewable energy, technological improvements, and sustainable agricultural practices is evident. Such measures are crucial for balancing economic growth with environmental protection, ensuring long-term sustainability in the agricultural sector. As the global community continues to confront climate change, these insights provide valuable guidance for policymakers aiming to foster low-carbon agricultural development and economic resilience.

3. DATA AND METHODOLOGY

In the third section, we will present our dataset, outlining its sources and variables, and detail the specification of our econometric model along with the empirical methodology chosen. This step is critical for understanding our approach to data analysis and the statistical techniques used to explore the relationship between agricultural exports and economic growth across East

Table 1: Description of variables

No	Variables	Indicator Name	Sources
1	AM	Agricultural machinery, tractors	Food and Agriculture Organization
2	AME	Agricultural methane emissions (thousand metric tons of CO_2 equivalent)	Climate Watch Historical GHG Emissions
3	ANOE	Agricultural nitrous oxide emissions (thousand metric tons of CO_2 equivalent)	Climate Watch Historical GHG Emissions
4	AL	Arable land (hectares)	Food and Agriculture Organization
5	FD	Broad money (constant 2015 US$)	International Monetary Fund
6	OX	Others exports of goods and services (constant 2015 US$)	World Development Indicators
7	FCE	Final consumption expenditure (constant 2015 US$)	World Development Indicators
8	FX	Agricultural exports (constant 2015 US$)	World Development Indicators
9	FPI	Food production index (2014-2016=100)	Food and Agriculture Organization
10	Y	GDP (constant 2015 US$)	World Development Indicators
11	K	Gross fixed capital formation (constant 2015 US$)	World Development Indicators
12	M	Imports of goods and services (constant 2015 US$)	World Development Indicators
13	RP	Rural population	World Development Indicators
14	UP	Urban population	World Development Indicators
15	FC	Fertilizer consumption (kilograms per hectare of arable land)	Food and Agriculture Organization
16	TR	Tax revenue (constant 2015 US$)	International Monetary Fund

Asia and the Pacific. We will provide transparency regarding the selection criteria for countries and time periods, ensuring the reliability of our analysis. Additionally, we will explain the theoretical underpinnings guiding our model, including the choice of dependent and independent variables, as well as any adjustments made to meet model assumptions. Furthermore, we will elaborate on the estimation techniques employed. This section will offer a comprehensive insight into our analytical framework, facilitating a deeper understanding of our empirical investigation.

3.1. Data

In order to investigate the impact of agricultural CO_2 emissions, agricultural exports and financial development on economic growth in the East Asia and the Pacific region, we have undertaken a meticulous selection process of 37 countries spanning from 1990 to 2022. These countries include American Samoa, Australia, Brunei Darussalam, Cambodia, China, Fiji, French Polynesia, Guam, Hong Kong SAR (China), Indonesia, Japan, Kiribati, Korea, Dem. People's Rep., Korea, Rep., Lao PDR, Macao SAR (China), Malaysia, Marshall Islands, Micronesia, Fed. Sts., Mongolia, Myanmar, Nauru, New Caledonia, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, and Viet Nam.

Regarding the selection of variables, we have chosen a diverse set based on data availability and relevance to the analysis. These variables include Agricultural machinery, tractors, Agricultural methane emissions (thousand metric tons of CO_2 equivalent), Agricultural nitrous oxide emissions (thousand metric tons of CO_2 equivalent), Arable land (hectares), Broad money (constant 2015 US$), Exports of goods and services (constant 2015 US$), Final consumption expenditure (constant 2015 US$), Food exports (constant 2015 US$), Food production index, GDP (constant 2015 US$), Gross fixed capital formation (constant 2015 US$), Imports of goods and services (constant 2015 US$), Rural population, Urban population, Fertilizer consumption (kilograms per hectare of arable land), and Tax revenue (constant 2015 US$). Table 1 provides a detailed description of each selected variable along with their respective sources, ensuring transparency and reliability in our analysis.

3.2. Model Specification

This statement outlines the methodology and approach to studying the impact of agricultural CO_2 emissions, agricultural exports and financial development on economic growth in East Asia and Pacific Countries. The main goal is to understand how agricultural CO_2 emissions, agricultural exports and financial development affect the overall economic growth of countries in the East Asia and Pacific region. The chosen method to investigate this relationship is by employing an estimation technique based on a production function. A production function is a mathematical representation of how inputs (such as labor, capital, and technology) combine to produce output. In this case, the production function chosen is suitable for countries characterized by open economies, meaning they engage in significant international trade and interactions. The basic model, represented by equation (1), captures the relationship between various factors (inputs) and economic output. These factors include not only agricultural exports but also other key variables such as agricultural machinery, arable land, broad money, and many others listed in the equation. The model development process involves specifying the functional form and including relevant variables that are expected to influence economic growth. By including agricultural exports as one of the variables, the model aims to assess its impact on economic growth while accounting for other important factors.

$$Y=F\,(AM,AME,ANOE,AL,FD,X,FCE,FX,FPI,K,M,RP,UP,FC,TR) \tag{1}$$

This statement outlines the plan to investigate the impact agricultural CO_2 emissions, agricultural exports and financial development on economic growth in East Asia and Pacific Countries using a production function approach tailored for open economies. The model considers various factors beyond just agricultural CO_2 emissions, agricultural exports and financial development to provide a comprehensive analysis of economic growth dynamics in the region.

Equation (2) presents an augmented production function, which serves as a fundamental tool for analyzing and understanding the complex dynamics of economic growth in East Asia and Pacific Countries. This equation encapsulates a multitude of variables, each representing critical aspects of the economy that influence overall output. At the heart of this equation lies the constant (A), denoting the technological level inherent in the country. This variable embodies the cumulative effect of technological advancements, innovations, and efficiencies that drive economic productivity over time. In this model, returns to scale, a crucial concept in economics, are intricately linked to a diverse array of factors. Agricultural machinery (AM), agricultural methane emissions (AME), and agricultural nitrous oxide emissions (ANOE) represent facets of agricultural production and environmental impact, highlighting the intricate balance between agricultural productivity and sustainability. The availability of arable land (AL) underscores the importance of natural resources in driving economic growth, particularly in agricultural-based economies.

Furthermore, broad money (FD) and tax revenue (TR) provide insights into the financial infrastructure and fiscal policies that shape economic activities. Exports of goods and services (X) and imports of goods and services (M) reflect the country's integration into the global market, emphasizing the significance of international trade in driving economic growth. Moreover, variables such as final consumption expenditure (FCE) and urban and rural population (UP, RP) shed light on consumption patterns and demographic shifts, which play pivotal roles in shaping economic dynamics. The inclusion of food exports (FX), food production index (FPI), gross fixed capital formation (K), and fertilizer consumption (FC) further enriches the model by capturing specific aspects of the agricultural sector and investment activities.

$$Y_{it}=A\ AM^{\beta1}\ AME^{\beta2}\ ANOE^{\beta3}\ AL^{\beta4}\ FD^{\beta5}\ X^{\beta6}\ FCE^{\beta7}\ FX^{\beta8}\ FPI^{\beta9}\ K^{\beta10}\ M^{\beta11}\ RP^{\beta12}\ UP^{\beta13}\ FC^{\beta14}\ TR^{\beta15} \quad (2)$$

Each variable in Equation (2) is associated with a coefficient (β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9, β_{10}, β_{11}, β_{12}, β_{13}, β_{14}, and β_{15}) signifying the magnitude and direction of its impact on economic output. Estimating these coefficients allows for a quantitative assessment of the contributions of various factors to overall economic growth, facilitating informed policy decisions and strategic interventions to foster sustainable development in East Asia and Pacific Countries. Thus, Equation (2) serves as a comprehensive framework for analyzing the intricate interplay between diverse economic factors and their collective influence on economic growth in the region.

Equation (3) represents a pivotal transformation in the analysis of economic relationships, particularly in the context of the Cobb-Douglas production function. The transformation involves taking the natural logarithm of all variables within the model. This process is commonly employed in econometrics to linearize nonlinear relationships, making them more amenable to statistical analysis. In this case, the transformation aims to convert the multiplicative relationship among the variables into an additive one, thereby facilitating a linear interpretation of the Cobb-Douglas production function. The Cobb-Douglas production function is a widely used model in economics, describing how multiple inputs combine to produce output. Traditionally, it is represented as a multiplicative function, which can make it challenging to analyze and estimate using conventional linear regression techniques. However, by applying logarithms to the variables, Equation (3) transforms this nonlinear function into a linear one, simplifying the analysis and interpretation of the underlying relationships. The transformation involves taking the natural logarithm of both the dependent variable (economic output or growth) and each of the independent variables (factors influencing output) within the production function. This logarithmic transformation results in a model where the relationship between the variables becomes additive, allowing for a more straightforward interpretation of their effects on economic output. Each coefficient in the transformed equation represents the marginal effect of the corresponding variable on economic output, facilitating comparative analysis and policy evaluation. By employing this logarithmic transformation, economists can leverage well-established linear regression techniques to estimate the coefficients of the production function and assess the significance of each factor in driving economic growth. Additionally, the linearized form of the Cobb-Douglas production function enables researchers to conduct hypothesis testing, assess model fit, and derive meaningful insights from empirical data.

$$Log(Y_{it})=Log(A)+\beta_1 Log(AM_{it})+\beta_2\ Log(AME_{it})+\beta_3\ Log(ANOE_{it})+\beta_4\ Log(AL_{it})+\beta_5\ Log(FD_{it})+\beta_6\ Log(X_{it})+\beta_7\ Log(FCE_{it})+\beta_8\ Log(FX_{it})+\beta_9\ Log(FPI_{it})+\beta_{10}\ Log(K_{it})+\beta_{11}\ Log(M_{it})+\beta_{12}\ Log(RP_{it})+\beta_{13}\ Log(UP_{it})+\beta_{14}\ Log(FC_{it})+\beta_{15}\ Log(TR_{it})+\varepsilon_{it} \quad (3)$$

Moreover, the transformation enhances the interpretability and robustness of the model, enabling policymakers and researchers to gain deeper insights into the determinants of economic growth in East Asia and Pacific Countries. The resulting linearized model provides a powerful framework for analyzing the complex interactions among various economic factors and formulating evidence-based policies to promote sustainable economic development in the region. Thus, Equation (3) represents a crucial step in the econometric analysis of production functions, facilitating rigorous empirical investigations into the drivers of economic growth.

The logarithmic transformation utilized in Equation (4) is a fundamental technique in econometrics, employed to enhance the analysis of economic relationships. This transformation holds considerable significance as it simplifies complex multiplicative relationships into more easily interpretable additive forms. By taking the natural logarithm of both the dependent and independent variables, the resulting model becomes linearized, allowing for a more straightforward application of regression analysis techniques. This transformation is particularly advantageous in the context of the Cobb-Douglas production function, where it aids in disentangling the intricate interplay of various economic factors on output or growth.

$$Log(Y_{it})=\beta_0+\beta_1\ Log(AM_{it})+\beta_2\ Log(AME_{it})+\beta_3\ Log(ANOE_{it})+\beta_4\ Log(AL_{it})+\beta_5\ Log(FD_{it})+\beta_6\ Log(X_{it})+\beta_7\ Log(FCE_{it})+\beta_8\ Log(FX_{it})+\beta_9\ Log(FPI_{it})+\beta_{10}\ Log(K_{it})+\beta_{11}\ Log(M_{it})+\beta_{12}\ Log(RP_{it})+\beta_{13}\ Log(UP_{it})+\beta_{14}\ Log(FC_{it})+\beta_{15}\ Log(TR_{it})+\varepsilon_{it} \quad (4)$$

The logarithmic transformation employed in Equation (4) exemplifies a fundamental practice in econometrics, offering a systematic approach to analyzing economic relationships. By transforming variables into logarithmic forms, the model facilitates a more convenient and interpretable analysis of the underlying economic dynamics. This technique contributes to the robustness of the econometric model, enabling researchers to derive meaningful insights and inform evidence-based policymaking efforts. As such, maintaining the logarithmic transformation technique underscores its enduring relevance and utility in advancing our understanding of economic phenomena.

3.3. Empirical Methodology

In the domain of panel data analysis, researchers encounter a theoretical challenge in formulating equations that effectively capture individual effects within their models. This challenge arises from the need to account for heterogeneity among individual entities over time, such as firms, households, or countries. Theoretical discussions abound regarding the appropriate treatment of these individual effects, with fixed effects and random effects emerging as the two primary approaches. However, our aim here isn't to delve into a comprehensive exploration of the various theories surrounding individual effects within panel data analysis. Instead, our focus lies in elucidating these two predominant types of individual effects: fixed effects and random effects.

Fixed effects models are designed to accommodate individual-specific characteristics that remain constant over time, capturing unobserved heterogeneity among individual entities. These models are particularly useful when researchers are interested in controlling for individual-specific factors that do not vary over time. On the other hand, random effects models allow for individual-specific characteristics that vary over time, treating them as random variables. This approach is suitable when researchers assume that individual-specific effects are uncorrelated with observed and unobserved factors in the model.

Navigating the decision between fixed effects and random effects estimation poses a significant challenge for researchers. To address this challenge, the widely used Hausman test emerges as a critical tool. The Hausman test serves as a diagnostic tool for assessing the suitability of employing either fixed effects or random effects estimates. This test compares the estimates from the fixed effects and random effects models and determines whether the differences between them are statistically significant.

In practical terms, the interpretation of the Hausman test results guides researchers in selecting the most appropriate model for their analysis. If the probability resulting from the Hausman test is at least 5%, indicating statistical significance, the fixed-effects model is considered suitable and retained. Conversely, if the probability exceeds 5%, suggesting insignificance, the random effects model is deemed appropriate and retained. This systematic approach aids in the judicious selection of the most suitable model for analyzing the panel data under consideration, ensuring robust and reliable empirical results. In summary, the theoretical quandary surrounding individual effects in panel data analysis necessitates careful consideration and empirical testing to determine the most suitable modeling approach. Fixed effects and random effects models offer distinct methods for accounting for individual-specific characteristics, with the Hausman test serving as a vital tool for model selection. By systematically evaluating the differences between fixed effects and random effects estimates, researchers can make informed decisions about the appropriate modeling strategy, ultimately enhancing the validity and reliability of their empirical analyses.

4. EMPIRICAL RESULTS

Descriptive statistics play a crucial role in empirical analyzes preceding estimation based on the static gravity model of Panel data. Indeed, these statistics allow us to understand the general structure of the data, revealing trends, distributions and relationships between variables. They provide an overview of data characteristics, which helps identify patterns and potential anomalies. This preliminary information is essential to guide the specification of the gravity model, helping researchers select relevant variables and determine necessary transformations. In addition, descriptive statistics make it possible to assess the validity of the assumptions underlying the gravity model, such as the homogeneity of observations or the normality of distributions. By providing deep insight into data, descriptive statistics establishes a solid foundation for the accurate and robust estimation of severity models in empirical analyses.

Table 2 presents the results of descriptive statistics for a set of variables, including Ln (Y), Ln (K), Ln (RP), Ln (UP), Ln (FX), Ln (OX), Ln (M), Ln (AL), Ln (AM), Ln (AME), Ln (ANOE), Ln (FC), Ln (FCE), Ln (FD), Ln (FPI), and Ln (TR). A key observation is the large difference between the maxima and minima of each variable, thus suggesting substantial variation over time. This variability demonstrates the dynamic evolution of variables, which is essential to consider in the estimation of empirical models. Furthermore, the differences between the means and medians of the variables suggest the potential presence of causal relationships between them, thus highlighting the importance of their inclusion in the static gravity model. Furthermore, the significance of the Jarque Bera tests for all variables, with values below 5%, reinforces the validity of the assumptions underlying the gravity model, such as the homogeneity of observations and the normality of distributions. This confirmation allows us to continue the empirical analysis with complete confidence, knowing that the statistical bases are solid for the estimation of the gravity model. These descriptive statistics provide essential insights into the nature of the variables studied and their relevance in the context of the empirical analysis, thus reinforcing the credibility and reliability of the results obtained.

Correlation analyzes are also of fundamental importance in empirical analyzes preceding estimation based on the static gravity model of Panel data. These analyzes make it possible to identify linear relationships between the variables of interest, thus providing crucial insights into potential interdependencies between different factors. By understanding these correlations, we can better understand the mechanisms underlying the evolution of the phenomena studied, which facilitates the specification

Table 2: Descriptive statistics and correlation analysis

	Ln (Y)	Ln (K)	Ln (RP)	Ln (UP)	Ln (FX)	Ln (OX)	Ln (M)	Ln (AL)	Ln (AM)	Ln (AME)	Ln (ANOE)	Ln (FC)	Ln (FCE)	Ln (FD)	Ln (FPI)	Ln (TR)
Descriptive statistics																
Mean	23.24	23.13	13.49	13.66	24.16	21.58	23.44	11.55	7.903	7.111	6.527	4.419	24.45	23.87	4.423	22.46
Median	23.12	24.15	13.19	13.17	24.98	22.50	23.77	11.66	8.441	8.398	7.575	4.811	25.29	24.28	4.512	23.45
Maximum	30.42	29.16	20.54	20.61	28.46	24.90	28.32	18.64	14.57	12.86	12.78	8.630	29.80	31.19	5.941	27.86
Minimum	16.88	16.58	4.394	8.224	12.39	9.854	18.50	4.382	0.000	−5.991	−1.567	−7.168	19.09	18.18	2.778	16.39
SD	3.255	2.949	3.316	3.051	2.826	2.665	2.667	3.818	3.881	3.739	3.599	2.143	2.787	3.405	0.354	2.935
Skewness	0.083	−0.440	0.054	0.222	−1.562	−1.168	−0.230	0.053	−0.291	−0.556	−0.460	−1.133	−0.263	0.036	−1.512	−0.335
Kurtosis	1.984	2.122	2.054	1.905	5.459	3.826	1.676	1.649	2.385	2.426	2.221	5.054	2.000	1.867	7.843	2.031
Jarque-Bera	47.58	39.45	41.47	71.07	338.7	131.8	56.51	82.93	8.611	56.66	52.23	302.7	34.45	42.87	1432	29.45
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Correlation analysis																
	Ln (Y)	**Ln (K)**	**Ln (RP)**	**Ln (UP)**	**Ln (FX)**	**Ln (OX)**	**Ln (M)**	**Ln (AL)**	**Ln (AM)**	**Ln (AME)**	**Ln (ANOE)**	**Ln (FC)**	**Ln (FCE)**	**Ln (FD)**	**Ln (FPI)**	**Ln (TR)**
Ln (Y)	1															
Ln (K)	0.99	1														
Ln (RP)	0.07	0.06	1													
Ln (UP)	0.88	0.86	0.45	1												
Ln (FX)	0.95	0.94	0.01	0.78	1											
Ln (OX)	0.68	0.70	0.52	0.74	0.73	1										
Ln (M)	0.97	0.96	0.01	0.80	0.99	0.74	1									
Ln (AL)	−0.14	−0.13	0.91	0.16	−0.14	0.45	−0.14	1								
Ln (AM)	0.62	0.60	−0.35	0.26	0.71	0.40	0.70	−0.30	1							
Ln (AME)	−0.09	−0.09	0.97	0.27	−0.12	0.47	−0.11	0.96	−0.36	1						
Ln (ANOE)	0.24	0.25	0.97	0.60	0.18	0.65	0.19	0.86	−0.28	0.90	1					
Ln (FC)	0.92	0.92	−0.10	0.80	0.87	0.61	0.91	−0.34	0.57	−0.26	0.07	1				
Ln (FCE)	0.99	0.98	0.04	0.88	0.94	0.66	0.96	−0.17	0.62	−0.12	0.22	0.93	1			
Ln (FD)	0.97	0.95	0.09	0.83	0.97	0.72	0.97	−0.07	0.71	−0.04	0.24	0.85	0.97	1		
Ln (FPI)	0.81	0.78	−0.31	0.55	0.83	0.36	0.83	−0.45	0.74	−0.42	−0.16	0.78	0.82	0.82	1	
Ln (TR)	0.99	0.99	0.12	0.89	0.95	0.73	0.97	−0.08	0.59	−0.03	0.30	0.92	0.99	0.97	0.78	1

Table 3: Estimation of panel statistic gravity model

Variable	Dependent variable: Ln (Y)											
	Panel static gravity model				Panel static gravity model: Fixed effect				Panel static gravity model: Random effect			
	Coefficient	SE	t-Statistic	Prob.	Coefficient	SE	t-Statistic	Prob.	Coefficient	SE	t-Statistic	Prob.
C	0.783770	0.681262	1.150468	0.2571	0.520274	0.841533	0.618246	0.5434	0.711787	0.654876	1.086904	0.2839
Ln (K)	0.197934	0.022636	8.744050	0.0000	0.129569	0.041814	3.098688	0.0057	0.198421	0.021765	9.116715	0.0000
Ln (AL)	−0.078467	0.038219	−2.053061	0.0470	0.028230	0.064041	0.440809	0.6641	−0.079203	0.037067	−2.136741	0.0391
Ln (AM)	0.028033	0.009097	3.081739	0.0038	0.014443	0.015951	0.905494	0.3760	0.028769	0.008800	3.269152	0.0023
Ln (AME)	−0.244754	0.041884	−5.843570	0.0000	−0.247459	0.062368	−3.967724	0.0008	−0.251352	0.040980	−6.133444	0.0000
Ln (ANOE)	0.180469	0.048394	3.729174	0.0006	0.067694	0.073786	0.917441	0.3698	0.177548	0.046800	3.793751	0.0005
Ln (FC)	−0.004054	0.019253	−0.210571	0.8343	−0.043604	0.025136	−1.734706	0.0982	−0.006991	0.018781	−0.372256	0.7118
Ln (FCE)	0.673396	0.077829	8.652305	0.0000	0.554656	0.102858	5.392444	0.0000	0.675092	0.075213	8.975716	0.0000
Ln (FD)	0.025924	0.018449	1.405136	0.1681	0.041688	0.023184	1.798165	0.0873	0.022709	0.017767	1.278183	0.2089
Ln (FPI)	−0.039545	0.033366	−1.185208	0.2433	0.082183	0.056037	1.466585	0.1580	−0.037670	0.031968	−1.178359	0.2460
Ln (FX)	0.206710	0.028266	7.313147	0.0000	0.300341	0.050059	5.999757	0.0000	0.208953	0.027381	7.631216	0.0000
Ln (M)	−0.138663	0.029194	−4.749630	0.0000	−0.161870	0.036279	−4.461837	0.0002	−0.139554	0.028519	−4.893391	0.0000
Ln (OX)	−0.009167	0.012220	−0.750159	0.4578	−0.004636	0.014313	−0.323907	0.7494	−0.007521	0.011718	−0.641876	0.5248
Ln (RP)	0.217730	0.055139	3.948780	0.0003	0.082462	0.084760	0.972888	0.3422	0.224433	0.052334	4.288499	0.0001
Ln (TR)	0.006384	0.029551	0.216023	0.8301	0.023352	0.037024	0.630722	0.5354	0.005414	0.028552	0.189618	0.8506
Ln (UP)	−0.059164	0.063092	−0.937740	0.3543	0.170589	0.108735	1.568853	0.1324	−0.056695	0.061956	−0.915097	0.3659

of the gravity model by selecting the appropriate variables and determining their relative impact. In addition, the preliminary correlation analysis makes it possible to identify possible collinearities between the explanatory variables, which can distort the model estimates. Thus, by providing crucial information about the relationships between variables, correlation analyzes shed light on the gravity model estimation process, thereby contributing to more accurate and robust empirical results.

Within the framework of the results of the correlation analyzes presented in Table 2, where the variable to be explained is Ln (Y), several observations can be made. First of all, we notice a strong positive correlation between Ln(Y) and several explanatory variables such as Ln (K) (0.99), Ln (FX) (0.95), Ln (M) (0.97), Ln (FC) (0.92), Ln (FCE) (0.99), Ln (FD) (0.97), and Ln (TR) (0.99). This suggests that economic growth is strongly influenced by factors such as capital, agricultural exports, money supply, final expenditure, tax revenues and capital flows. Additionally, a significant correlation is observed with Ln (UP) (0.88), indicating that economic growth is also influenced by changes in urban and rural population. On the other hand, some variables like Ln (AL) (−0.14) and Ln (AME) (−0.09) show negative correlations, suggesting an inverse relationship with economic growth. This could indicate that in some contexts, an increase in the availability of arable land or a reduction in agricultural methane emissions can dampen economic growth. Finally, moderate correlations are observed with Ln (FPI) (0.81) and Ln (OX) (0.68), highlighting the relative importance of food production and imports in stimulating economic growth.

Table 3 reveals the detailed estimation results of the fixed effect static gravity model. The variable Ln (K), representing gross fixed capital formation, displays a coefficient of 0.129569 with a probability of 0.0057, indicating that a 1% increase in capital investment is associated with an increase of 0.129569% in economic growth, with statistical significance at 99%. For Ln (AL), Ln (AM), and Ln (OX), the respective coefficients are 0.028230 (P = 0.6641), 0.014443 (P = 0.3760), and -0.004636 (P = 0.7494), but none of these coefficients is statistically significant. In contrast, Ln (AME) displays a coefficient of −0.247459 (P = 0.0008), suggesting that agricultural methane emissions are associated with a decrease in economic growth. Ln (FCE) and Ln (FX) show significant coefficients of 0.554656 (P = 0.0000) and 0.300341 (P = 0.0000) respectively, indicating a significant increase in economic growth with the increase in final consumption expenditure and agricultural exports. The other variables such as Ln (M), Ln (RP), Ln (UP), Ln (FC), and Ln (TR) have respective coefficients of −0.161870 (P = 0.0002), 0.082462 (P = 0.3422), 0.170589 (P = 0.1324), −0.043604 (P = 0.0982), and 0.023352 (P = 0.5354), but none are statistically significant, suggesting that they do not have a significant impact on economic growth in this model.

Table 3 reveals the results of the estimation of the random effect static gravity model. The variable Ln (K), representing gross fixed capital formation, reveals a significant coefficient of 0.198421 (P = 0.0000), suggesting that a 1% increase in capital investment is associated with an increase of 0.198421% in Economic Growth.

Table 4: Hausman test

Test Summary	Chi-Square. Statistic	Chi-Square. d.f.	Prob.
Period random	17.525624	15	0.2884

Similarly, Ln (AL), which represents the availability of arable land, displays a negative significant coefficient of −0.079203 (P = 0.0391), indicating that the 1% increase in arable land is associated with a 0.079203% decrease in Economic Growth. Ln (AM), representing the use of agricultural machinery, presents a positive significant coefficient of 0.028769 (P = 0.0023), suggesting that a 1% increase in the use of agricultural machinery is associated with an increase of 0.028769% in Economic Growth. Furthermore, Ln (AME), which represents agricultural methane emissions, reveals a significant coefficient of −0.251352 (P = 0.0000), indicating that an increase of 1% in agricultural methane emissions is associated with a decrease of 0.251352% of economic growth. Regarding Ln (ANOE), representing agricultural nitrous oxide emissions, it displays a significant coefficient of 0.177548 (P = 0.0005), suggesting that a 1% increase in agricultural nitrous oxide emissions is associated to an increase of 0.177548% in economic growth. The other variables, such as Ln (FC), Ln (FD), Ln (FPI), Ln (OX), Ln (TR), and Ln (UP), do not present significant coefficients, which suggests that they have no significant impact on economic growth (P > 0.05). However, Ln (FCE), representing final consumption expenditure, and Ln (FX), representing agricultural exports, reveal significant coefficients of 0.675092 (P = 0.0000) and 0.208953 (P = 0.0000) respectively, indicating a significant positive association with economic growth. Finally, Ln (M), which represents imports of goods and services, presents a negative significant coefficient of −0.139554 (P = 0.0000), suggesting that an increase of 1% in imports is associated with a decrease of 0.139554% in economic growth.

Table 4 shows the conclusions of the Hausman test, where the probability of the Hausman test exceeds 5% (28.84%). This observation confirms the adoption of the random effect gravitational model. In this context, several significant results emerge, highlighting the importance of the agricultural and rural sectors as well as exports in other areas: The variable Ln (K), which represents gross fixed capital formation, is distinguished by a significant coefficient of 0.198421 (P = 0.0000). This suggests that a 1% increase in capital investment is correlated with a 0.198421% increase in economic growth. On the other hand, Ln (AL), which reflects the availability of arable land, presents a negative significant coefficient of −0.079203 (P = 0.0391). This observation indicates that a 1% increase in arable land is associated with a 0.079203% reduction in economic growth. In the same vein, Ln (AM), illustrating the use of agricultural machinery, displays a positive significant coefficient of 0.028769 (P = 0.0023). This implies that a 1% increase in the use of agricultural machinery results in a 0.028769% increase in economic growth. However, Ln (AME), representing agricultural methane emissions, reveals a significant coefficient of −0.251352 (P = 0.0000). This data indicates that a 1% increase in agricultural methane emissions is linked to a 0.251352% decrease in economic growth. Likewise, Ln (ANOE), corresponding to agricultural nitrous oxide emissions, reveals a significant coefficient of 0.177548 (P = 0.0005). This observation suggests that a 1% increase in agricultural nitrous oxide emissions is associated with a 0.177548% increase in economic growth. Concerning the other variables such as Ln (FC), Ln (FD), Ln (FPI), Ln (OX), Ln (TR) and Ln (UP), they do not present significant coefficients, suggesting that they do not have no significant impact on economic growth (P > 0.05). In contrast, Ln (FCE), which represents final consumption expenditure, and Ln (FX), representing agricultural exports, reveal respective significant coefficients of 0.675092 (P = 0.0000) and 0.208953 (P = 0.0000). This highlights a significant positive association with economic growth. Finally, Ln (M), which represents imports of goods and services, presents a negative significant coefficient of -0.139554 (P = 0.0000). This suggests that a 1% increase in imports is associated with a 0.139554% decrease in economic growth.

The results of the analysis highlight the significant importance of agricultural exports as well as variables associated with the agricultural sector in the countries of the East Asia and Pacific region. First, increased agricultural exports "Ln (FX)" are strongly correlated with increased economic growth, as shown by the significant coefficient of 0.208953 (P = 0.0000). This positive association highlights the crucial role of the agricultural sector in driving economic growth in the region. An expansion of agricultural exports could result from a variety of factors, including increased productivity, investments in agricultural technologies, and pro-trade policies. Second, several other variables related to the agricultural sector show significant effects on economic growth. For example, the use of agricultural machinery "Ln (AM)" has a significant positive coefficient of 0.028769 (P = 0.0023), suggesting that the adoption of modern agricultural technologies contributes to economic growth by increasing efficiency and productivity agricultural. Furthermore, the emission of agricultural methane "Ln (AME)" and agricultural nitrous oxide "Ln (ANOE)" show negative significant coefficients of −0.251352 (P = 0.0000) and 0.177548 (P = 0.0005) respectively. These results highlight the importance of environmental sustainability in the agricultural sector, as a reduction in greenhouse gas emissions could be essential to maintaining long-term economic growth in the region. Finally, regarding final consumption expenditure "Ln (FCE)," the significant coefficient of 0.675092 (P = 0.0000) indicates that the increase in final consumption expenditure stimulates economic growth. This can be interpreted as an indication of robust domestic demand in the East Asia and Pacific region, which supports economic growth through an increase in demand for locally produced goods and services. These findings highlight the importance of the agricultural sector in the economies of the East Asia and Pacific region, particularly with regard to agricultural exports and sustainable agricultural practices. They highlight the need for policies that promote technological innovation, environmental sustainability and the stimulation of domestic demand to support sustainable and inclusive economic growth in the region.

5. CONCLUSIONS AND RECOMMENDATIONS

This extensive study has meticulously explored the intricate dynamics between agricultural CO_2 emissions, agricultural exports, financial development, and economic growth within the Asia-Pacific region over a significant period spanning from 1990 to 2022. Utilizing a robust dataset encompassing 37 countries, the analysis employed both static gravity and random effect models to unveil comprehensive insights into how these variables influence economic growth.

Our findings reveal several critical insights. Firstly, the positive impact of capital investment on economic growth is evident. Specifically, the data indicate that a 1% increase in gross fixed capital formation corresponds to a 0.198421% rise in economic growth. This substantial effect underscores the importance of capital accumulation in fostering economic expansion. The results align with existing literature that highlights the pivotal role of investment in driving economic growth by enhancing productive capacities and infrastructure.

Similarly, agricultural exports emerged as a significant driver of economic growth. The analysis shows that a 1% increase in agricultural exports is associated with a 0.208953% increase in economic growth. This finding highlights the crucial role of the agricultural sector in the region's economic development. Expanding agricultural exports can be attributed to improved productivity, technological advancements, and favorable trade policies. These factors contribute to enhanced economic performance and regional integration into global markets.

In addition to these factors, the study investigated the impact of financial development on economic growth. While the static gravity model did not initially emphasize financial development, the random effect model provided valuable insights. Notably, final consumption expenditure (Ln (FCE)) emerged as a significant determinant of economic growth. The significant coefficient of 0.675092 indicates that an increase in final consumption expenditure is associated with a considerable boost in economic growth. This finding underscores the importance of domestic demand and consumption in driving economic expansion. It suggests that robust financial systems and policies promoting consumer spending are crucial for sustaining economic growth.

The analysis also considered the environmental dimension by examining the effects of agricultural CO_2 emissions. Agricultural methane emissions (Ln (AME)) were found to have a significant negative impact on economic growth, with a 1% increase in emissions correlating with a 0.251352% decrease in economic growth. This result highlights the adverse environmental impact of agricultural practices on economic performance. It underscores the need for sustainable agricultural practices and policies aimed at reducing greenhouse gas emissions to mitigate their negative effects on economic growth.

In terms of originality, this study provides a unique contribution to the literature by integrating a diverse set of variables-agricultural emissions, exports, financial development, and capital formation-into a comprehensive analysis. The use of both static gravity and random effect models offers a nuanced understanding of how these factors interact and influence economic growth. The findings present a significant advancement in the field by highlighting the multifaceted relationships between these variables and their collective impact on economic performance.

Economically, the results suggest several critical implications. The positive association between capital investment and economic growth reinforces the importance of investment in enhancing productive capacities and infrastructure. The significant role of agricultural exports emphasizes the need for policies that support and promote agricultural productivity and market access. Furthermore, the impact of financial development, particularly through final consumption expenditure, highlights the significance of robust financial systems and domestic demand in driving economic growth. However, the study also reveals that agricultural CO_2 emissions have a detrimental effect on economic growth, pointing to the need for environmentally sustainable practices. Policymakers should focus on implementing strategies that balance economic objectives with environmental considerations to ensure long-term sustainability.

In terms of recommendations, the study suggests several actionable strategies. Policymakers should prioritize enhancing agricultural productivity and export capabilities through technological advancements and supportive trade policies. Additionally, fostering domestic consumption through financial development and consumer-friendly policies can further stimulate economic growth. Concurrently, it is crucial to implement regulations and incentives aimed at reducing greenhouse gas emissions from agricultural activities to promote environmental sustainability.

The study acknowledges certain limitations, such as potential omitted variable bias and challenges in accurately measuring emissions and economic growth over long periods. Future research should address these limitations by incorporating additional variables and employing alternative methodologies. Additionally, further investigation into specific financial development policies and technological innovations could provide deeper insights into their impact on economic growth.

This comprehensive study offers a detailed understanding of the interplay between agricultural CO_2 emissions, agricultural exports, financial development, and economic growth in the Asia-Pacific region. By highlighting significant impacts and offering practical recommendations, it provides valuable insights for policymakers and stakeholders seeking to achieve sustainable and inclusive economic growth. Future research should continue exploring these dynamics, considering evolving economic and environmental contexts to further enhance our understanding and inform effective policymaking.

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