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Analysing the Role of Food Security, Agricultural Exports and Income Inequality in Shaping Economic Growth Trajectories in Developing Countries

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Abstract

This study examines the impact of food security, agricultural exports, and income inequality on economic growth in 89 developing nations from 1990 to 2020. Employing the Method of Moments Quantile Regression (MMQR), it analyses all four dimensions of food security, which include availability, access, stability, and utilization. Key findings include the positive impact of adequate food availability on economic growth through promoting health as well as productivity. Prevalence of undernourishment negatively affects economic growth, indicating its role in reducing labor productivity and exacerbating poverty. Food stability, measured by per capita food production variability, shows a significantly negative impact on economic growth. Access to improved drinking water is positively associated with food utilization and economic growth. The study recommends interventions to promote labor force participation, infrastructure investment, reduced income inequality, and financial system development for sustainable economic growth in developing countries.

Keywords: Food security, Availability, Access, Utilization, Stability, MMQR Analysis

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1 Introduction

Food security was first formally discussed in international policy debates in the 1940s and has remained a significant concern since then (Boudreau, 1943). The concept of food security has developed substantially over subsequent decades and is now embedded in international development policy. The 1948 Universal Declaration of Human Rights recognized adequate food as part of the right to an adequate standard of living. Because food is essential to human development and well-being, increasing food production has long been a cornerstone of strategies to alleviate global food insecurity. However, despite substantial increases in global food production during the past half-century, billions of people continue to experience inadequate access to sufficient or nutritious food, while hundreds of millions experience hunger (Food and Agriculture Organization of the United Nations [FAO] et al., 2021). A wide range of factors contributes to food insecurity. In developing countries, equitable access to food is particularly constrained by population growth, climate change, poverty, income inequality, and related socioeconomic pressures. These factors affect household incomes, livelihoods, food prices, and individuals' access to sufficient and nutritious food. Therefore, food security and human development are closely interconnected, and progress in one dimension can support improvement in the other.

Food security, agricultural exports, and income inequality are central issues in discussions of economic growth. Agricultural exports provide foreign exchange earnings for many developing countries and may contribute to growth through agricultural production, trade, and employment (Faridi, 2012; Mahmood & Munir, 2018). Similarly, income inequality remains prevalent across developing economies and has important, potentially heterogeneous implications for economic growth (Barro, 2000; Hailemariam & Dzhumashev, 2019). Food security requires sustained access to sufficient, safe, and nutritious food that meets dietary needs. However, attaining food security remains challenging where poverty and unequal income distribution constrain purchasing power and access to essential resources. Consequently, food security, agricultural exports, and income inequality have become important areas of inquiry for development economists. Previous research reports complex relationships among these variables. Several studies associate improved food security with higher economic growth (Agboola, 2009; Bacilar, 2014; Manap & Ismail, 2019; Fernandes & Samputra, 2022). In addition, agricultural exports may provide economic opportunities, although their contribution depends on export composition and economic conditions (Mehrara & Baghbanpour, 2016; Mahmood & Munir, 2018). Conversely, inequality may constrain human capital accumulation, social cohesion, and the effectiveness of development policies (Mo, 2000; Breunig & Majeed, 2020). Against this background, the present study examines the relationships among income inequality, agricultural exports, food security, and economic growth in developing economies.

Several interconnected factors, including food security, agricultural exports, and income inequality, influence economic performance in developing countries. Despite efforts to promote growth, inadequate food security can restrict human capital development and labour productivity. Likewise, unequal income distribution can hinder opportunities for education, nutrition, and productive participation. Agricultural exports, by contrast, may support foreign exchange earnings and production, although the direction of their association with growth requires empirical investigation rather than prior assumption. This study examines how the different dimensions of food security, together with agricultural exports and income inequality, are associated with economic growth. By analysing these relationships, the study seeks to identify development challenges and policy opportunities relating to food security. Its principal objective is to investigate the effects of food security indicators on economic growth while accounting for agricultural exports, income inequality, and other macroeconomic characteristics. The analysis considers 89 developing countries over the period 1990–2020 and applies the Method of Moments Quantile Regression (MMQR) approach, allowing the estimated associations to vary across the conditional distribution of growth. Section 2 reviews the relevant literature; Section 3 introduces the models, data, and methodology; Section 4 presents and discusses the results for the four dimensions of food security; and Section 5 offers conclusions and policy recommendations.

1.1 Research Gap and Contribution

Although previous research has investigated the links between food security and growth, studies have examined different food security indicators, geographical contexts, and empirical specifications (Agboola, 2009; Manap & Ismail, 2019; Fernandes & Samputra, 2022). Therefore, an important question is whether the association between each dimension of food security and economic growth differs across the conditional growth distribution. This study addresses that question by considering availability, access, stability, and utilization separately within an MMQR framework, while accounting for agricultural exports and income inequality. In addition, the quantile-specific results permit a more differentiated interpretation of the reported relationships than a single mean effect. The contribution is the joint interpretation of these dimensions and macroeconomic factors in the stated sample; it does not imply that the analysis identifies causal mechanisms.

2 Literature Review

A substantial body of international research has examined the relationship between food security and economic growth. This literature considers food availability, nutritional outcomes, agricultural activity, inequality, and macroeconomic development, often from different theoretical and empirical perspectives. In particular, studies have evaluated both whether economic growth improves food security and whether more secure food supplies can support human capital formation and economic performance. However, these relationships are not necessarily uniform across countries or across different growth levels. Accordingly, the following discussion reviews the existing evidence while identifying the relevance of a multidimensional approach to food security.

By tracing a food security nexus, Tweeten (1999) argued that both transitory and chronic food insecurity were primarily attributable to poverty and should have been addressed through economic development. In addressing the question of how to escape the threat of hunger and famine, rather than merely seeking solutions, Timmer (2000) delved into an extensive body of literature. The study demonstrated that strategies such as pursuing growth with an unchanged income distribution and concentrating on economic growth with a focus on redistribution are viable approaches. By scrutinizing 63 developing economies during the period 1960-1970 through panel data analysis, the researchers identified a positive association between income growth and child undernutrition. A lot of research has been done at the country level that focused on the connection between average levels of earnings and resulting demand for food. Kiminami (2009) investigated the effect of economic growth on food consumption by taking the income gap into account for Asia. The study showed that in East Asia, although the degree of transition in per capita rice consumption changed, rice consumption decreased as a whole with growing incomes. The author concluded that for a sustainable economy, a minimum level of food security must be met from the present to the future. Moreover, there should be a balance between present and future levels of food security, given resource and environmental constraints. The study suggested that to realize a sustainable society, food security was a prerequisite for balancing efficiency in food production for all East Asian countries, including China.

After examining the enduring effects of food security on economic growth, Agboola (2009) used a dataset of 124 countries, including food-insecure African countries and food-secured countries from the rest of the world. The researcher used panel data from 1970/74 to 2000/09, averaging over five-year periods, to determine whether the long-run determinants of economic growth differed between food-insecure African countries and food-secured countries in the rest of the world. The results revealed that food availability was a key determinant of economic growth in the countries under consideration. Additionally, food security served as a significant differentiating factor in the economic growth of these countries. The researcher further argued that the effect of food availability on economic growth was positive for other countries in the long run, whereas for African food-insecure countries it turned negative because food availability was primarily through donations from developed nations, which disrupted the food market. Given rapid global changes and rising domestic challenges in MENA countries, Breisinger et al. (2010) used food security to identify regional challenges. The researchers concluded that, to foster development, food security and diversification were essential, enabling job creation for most people, transforming social policies to target the poor, and empowering women to participate more actively for the betterment of the economy. Based on the MDGs for poverty and hunger eradication, McMichael and Schneider (2011) compared two paradigmatic approaches to food security and their ecological and political repercussions.

The researchers examined agriculture's role in economic growth (the agricultural value-chain approach) versus its role as a multifunctional approach related to food sovereignty. By reviewing responses to the 2006-2008 food crises, the researchers sought to determine whether promoting small farmers' incorporation into global markets through value chains, in other words industrial agriculture, was a better strategy than food sovereignty politics. Using a rich dataset comprising 124 developing countries, Bacilar (2014) examined the hypothesis that food security has a vital effect on the economic growth of developing economies. The researchers concluded that improved food security contributes to improved economic growth. Ghanem (2015) conducted a study on Morocco and linked the objectives of inclusive growth with food security, keeping in view Morocco's twin problem, i.e., child malnutrition and obesity. According to the researcher, to achieve inclusive growth and food security, the government focused on a rural development strategy with two important pillars: one focused on large modern farms, and the other concentrated on supporting family farming and smallholders. Because poverty reduction required support for family farmers and smallholders, who represented most poor people in Morocco, this support increased food production and improved food security. The paper suggested that to achieve inclusive growth alongside food and nutrition security, an approach must focus on increasing food reserves, linking family farmers to national and international markets, and introducing a social protection system for the rural poor.

With the understanding that the vertices of a triangle are represented by economic growth, health, and food security, Pourreza et al. (2018) studied the association among these three factors. The researchers indicated that achieving food security was not only about providing food and nourishing people but also about practical considerations across all aspects of society and the economy. The authors claimed that health measures people's efficiency and overall well-being; thus, good health positively affects productivity, efficiency, utility, income, and ultimately economic growth. As a result, sound health has sizable, favorable effects on economic growth. The research concluded that food security was not just about supporting good health but also served as the foundation for achieving sustainable economic growth. Furthermore, the researchers emphasized that without a food security strategy, a country would face adverse effects on human capital, leading to stagnant economic growth. This could be avoided through proper coordination across sectors of the economy, including agriculture, health and nutrition, finance, and infrastructure. In their 2019 study, Chemin et al. explored CIDA's role in stimulating sustainable economic growth in two of its primary areas of concern: developing and middle-income countries.

The researchers explained the various channels through which this growth could be promoted, considering opportunities previously overlooked at different levels. At the national level, the research highlighted the judiciary's significant role in enhancing food security and fostering economic growth and development. At the local level, the research suggested that enhancing food security required formulating policies that effectively bridge the economic and social dimensions of micro, small, and medium-sized businesses. The paper recommended that CIDA could improve food security by adopting strategies to reduce food price volatility. Moreover, food aid was considered an alternative way to enhance food security globally. Berchin et al. (2019) examined a vast literature to explore the effect of Brazilian government policies focused on boosting family farming to improve food security. "Poverty" was identified as the major reason for food insecurity. The results found that, to ensure access to food and a stable food supply, poverty should be addressed properly.

Moreover, the study concluded that, alongside government policies focused on education, poverty reduction, and healthcare, household farming is highly beneficial for food security. This, in turn, increases incomes through economic growth and poverty reduction, which helps improve quality of life. The study recommended that Brazil's approach can be an example for other developing countries as well. Other developing nations can design policies focused on strategies such as technical and financial assistance, food provision, adoption of land tenure systems, and capacity building. These policies have enhanced food security most effectively. For a panel dataset from 1970 to 2016 for 75 dry-land developing countries, Manap and Ismail (2019) estimated the direct impact of food security on economic growth as well as its impact through various factors, including total employment and poverty. The authors found that, in dry-land developing countries, food security significantly affected economic growth. Enhanced food security resulted in a reduction. By employing MMQR Sheikh et al. (2022) estimated the nexus between food security, food wastage, the environment, and economic growth for developing nations. Using data from 1990 to 2021, the researchers found that economic growth increased as a result of improved food security in developing countries.

2.1 Theoretical Framework

The relationship between food security and economic growth can be understood through complementary channels. Adequate nutrition and access to clean water may support health, educational participation, and labor productivity, thereby linking food security with human capital formation (Correa & Cummins, 1970; Pourreza et al., 2018). Similarly, more stable food production may reduce uncertainty in agricultural livelihoods and food consumption (Sahn & Von Braun, 1987). Agricultural trade may generate foreign exchange earnings and incentives for production; however, export dependence and exposure to external shocks can produce different outcomes across countries (Faridi, 2012; Mahmood & Munir, 2018). Income inequality may also shape the distribution of economic opportunities and the relationship between growth and household welfare (Barro, 2000; Mo, 2000). Accordingly, the four dimensions of food security are examined as distinct indicators rather than assumed to exert identical effects. These mechanisms provide a theoretical interpretation of the empirical models, but the proposed pathways are not identified individually in the present estimates.

3 Model, Data, and Methodology

Model-1: Economic Growth Model based on Food Availability

$$Q_{GDPPC_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} LFPR + \eta_{2,\tau} GFCF_{it} + \eta_{3,\tau} APS_{it} + \eta_{4,\tau} GI_{it} + \eta_{5,\tau} ARM_{it} + \eta_{6,\tau} SSE_{it} + \eta_{7,\tau} M2_{it} + \eta_{8,\tau} TAX_{it} + \mu_{\tau,it} \quad \textbf{(1)}$$

Model-2: Economic Growth Model based on Food Access

$$Q_{GDPPC_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} LFPR + \eta_{2,\tau} GFCF_{it} + \eta_{3,\tau} PUN_{it} + \eta_{4,\tau} GI_{it} + \eta_{5,\tau} ARM_{it} + \eta_{6,\tau} SSE_{it} + \eta_{7,\tau} M2_{it} + \eta_{8,\tau} TAX_{it} + \mu_{\tau,it} \quad (2)$$

Model-3: Economic Growth Model based on Food Stability

$$Q_{GDPPC_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} LFPR + \eta_{2,\tau} GFCF_{it} + \eta_{3,\tau} PFPV_{it} + \eta_{4,\tau} GI_{it} + \eta_{5,\tau} ARM_{it} + \eta_{6,\tau} SSE_{it} + \eta_{7,\tau} M2_{it} + \eta_{8,\tau} TAX_{it} + \mu_{\tau,it} \quad (3)$$

Model-4: Economic Growth Model based on Food Utilization

$$Q_{GDPPC_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} LFPR + \eta_{2,\tau} GFCF_{it} + \eta_{3,\tau} IDW_{it} + \eta_{4,\tau} GI_{it} + \eta_{5,\tau} ARM_{it} + \eta_{6,\tau} SSE_{it} + \eta_{7,\tau} M2_{it} + \eta_{8,\tau} TAX_{it} + \mu_{\tau,it} \quad (4)$$

where τ indicates quantiles such as 10th, 25th, 50th, 75th and 90th

i = 1, ……. N represent cross sections, and t shows the time period starting from t **= 1, ….. T,** $GDPPC_{it}$ is the dependent variable.

Where:

LFPR = Labor force participation rate, (total % of total population ages 15-64)

GFCF = Gross fixed capital formation (% of GDP)

APS = Average protein supply (g/cap/day, 3-year averaged)

PUN = Prevalence of undernourishment (%, Yearly estimates)

PFPV = Per capita food production variability (Constant 2014-2016 thousand international $ per capita)

IDW = People using at least improved drinking water services (% of population)

GI = Gini index (Annual %)

ARM = Agricultural raw material exports (% of merchandise exports)

SSE = School enrolment, secondary (% gross, Annual)

M2 = Broad money (% of GDP, Annual)

TAX = Tax revenue (% of GDP, Annual)

3.1 Data and Methodology

The empirical analysis draws on two established data repositories: the Food Security Indicators (FSI) database and the World Development Indicators (WDI) database. The study selects 89 developing countries from an initial pool of 121 countries according to the availability of the variables required for estimation. The reported World Bank income-group allocation in the original study requires reconciliation because the stated counts of 26 low-income, 54 lower-middle-income, and 54 upper-middle-income countries exceed the sample of 89. Therefore, the classification should be checked against the original country list before income-group conclusions are drawn. The analysis covers 1990–2020. Furthermore, the Method of Moments Quantile Regression (MMQR) estimator introduced by Machado and Santos Silva (2019) is employed to examine how the associations among food security, agricultural exports, income inequality, and economic growth differ across conditional quantiles. The four food security dimensions are represented by separate indicators: average protein supply, prevalence of undernourishment, food production variability, and improved drinking water services. The reported estimates should be interpreted as conditional associations unless the assumptions needed for causal interpretation are established.

4 Results and Discussion

This section presents the results of the study in detail. It encompasses summary statistics of key variables.

4.1 Descriptive Statistics of Key Variables

Table 1 reports descriptive statistics for the principal variables in the four food security models, including the mean, maximum, minimum, standard deviation, skewness, kurtosis, and the Jarque–Bera test. The relatively

large standard deviation of broad money (M2) indicates considerable dispersion in this variable, whereas per-capita GDP growth (GDPPC) exhibits a smaller standard deviation in the reported dataset. However, the variables do not all display approximately symmetric distributions: several exhibit pronounced skewness and high kurtosis. In addition, some reported minima and maxima appear inconsistent with the stated measurement scales, including negative values for the prevalence of undernourishment and the Gini index and percentages above 100 for certain coverage measures. These figures require verification against the original data and variable definitions before substantive interpretation; the numerical entries in Table 1 have been retained without alteration.

Table 1: Descriptive Statistics of Key Variables of Food Security Models (1990-2020)

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
GDPPC	2.04	53.97	-64.99	5.67	-0.93	24.66	54315.00	0.00
LFPR	61.71	128.06	25.90	13.11	0.05	2.96	1.04	0.60
GFCF	22.81	93.55	-2.42	9.17	1.21	7.35	2535.86	0.00
APS	64.49	118.10	30.00	13.89	0.64	3.24	172.74	0.00
PUN	19.77	80.80	-45.20	14.15	0.65	4.18	314.21	0.00
PFPV	10.43	107.40	-6.10	10.92	3.71	23.88	50195.15	0.00
IDW	75.09	107.10	1.60	19.05	-0.75	2.93	232.35	0.00
GI	42.48	84.41	-11.93	9.47	-0.15	4.74	319.87	0.00
ARM	6.91	98.95	-5.25	12.60	3.25	14.51	17848.11	0.00
SSE	52.81	142.02	5.22	27.44	0.22	2.10	103.64	0.00
M2	39.38	211.89	-47.63	27.86	1.90	8.57	4642.78	0.00
TAX	15.18	147.66	0.91	12.47	5.60	42.35	171115.40	0.00

Source: Authors' computations

Table 2 presents Pesaran's cross-sectional dependence (CD) test. With the exception of labour force participation (LFPR) and per-capita food production variability (PFPV), the reported tests reject cross-sectional independence for the included variables. Therefore, consider common shocks and interdependence among developing countries when selecting estimators and interpreting statistical significance. The absence of statistically significant dependence for LFPR and PFPV in these tests does not, by itself, establish complete independence among countries.

Table 2: Pesaran's Cross-Sectional Dependence (CD)Test

Variable	CD-test	p-value
GDPPC	57.45	0.00
LFPR	-0.87	0.38
GFCF	24.46	0.00
APS	196.00	0.00
PUN	102.20	0.00
PFPV	-1.09	0.27
IDW	167.46	0.00
GI	22.49	0.00
ARM	40.03	0.00
SSE	205.88	0.00
M2	159.53	0.00
TAX	10.92	0.00

Source: Authors' computations

However, cross-sectional dependence and country-specific dynamics can coexist. Imposing homogeneous slope coefficients when responses differ across countries may yield misleading conclusions (Pesaran & Yamagata, 2008). Therefore, slope homogeneity is examined using the Delta test and a heteroskedasticity- and autocorrelation-consistent adjusted version. Since the findings indicate heterogeneous slopes, interpreting pooled relationships should acknowledge differences across economies and potential dependence generated by common shocks.

4.2 Slope Homogeneity Test

Table 3 presents the results of the homogeneity/heterogeneity test for all four models of economic growth.

Table 3: Slope Homogeneity Test

Model	(Pesaran and Yamagata, 2008)		(Blomquist and Westerlund, 2013)	
	Delta Test	P-Value	HAC Robust Adjusted Delta Test	P-Value
		0.00		
GDPPC/ LFPR, GFCF, APS, GI, ARM, SSE, M2, TAX	37.08	0.00	-15.55	0.00
GDPPC / LFPR, GFCF, PUN, GI, ARM, SSE, M2, TAX	44.62	0.00	-14.66	0.00
GDPPC / LFPR, GFCF, PFPV, GI, ARM, SSE, M2, TAX	44.97	0.00	-14.92	0.00
GDPPC / LFPR, GFCF, IDW, GI, ARM, SSE, M2, TAX	46.18	0.00	-15.00	0.00

Source: Authors' computations

For the food availability model, both reported slope homogeneity tests reject the null hypothesis of homogeneous slopes. Similarly, the tests indicate heterogeneous slopes in the food access, food stability, and food utilization models. Consequently, the evidence in Table 3 suggests that the relationships between the regressors and economic growth are not constant across all countries. These findings provide an additional justification for investigating heterogeneous associations, although they do not by themselves demonstrate that a particular estimator fully addresses cross-sectional dependence or endogeneity.

4.3 Unit Root Tests

Given the evidence of cross-sectional dependence, this section examines the unit root properties of the variables using the reported cross-sectionally augmented panel testing approach. Such tests help determine whether the variables appear stationary under specifications with and without a time trend. The selection and interpretation of long-run modelling approaches should remain consistent with the resulting integration properties.

Table 4: Second-Generation Panel Unit Root Test

Second Generation Panel Unit Root Test						
Cross-Section-Dependence based Im-Pesaran-Shin (CSDIPS) Unit Root Test						
Variables	**Without Trend**			**With Trend**		
	Lags	**Zt Statistics**	**P-Value**	**Lags**	**Zt Statistics**	**P-Value**
LGDP	0	-17.33	0.00	1	-5.76	0.00
LFPR	0	-3.19	0.00	0	-1.79	0.00
GFCF	0	-6.36	0.00	1	-4.13	0.00
APS	0	-7.39	0.00	0	-3.36	0.00
PUN	0	1.54	0.93	1	-16.13	0.00
PFPV	0	-4.52	0.00	0	-5.91	0.00
IDW	0	3.88	1.00	0	-0.94	0.10
GI	0	-5.93	0.00	0	-4.76	0.00
ARM	0	-6.91	0.00	0	-3.49	0.00
SSE	0	-3.23	0.00	1	-2.07	0.01
M2	0	-5.81	0.00	0	-0.32	0.00
TAX	0	5.98	1.00	1	0.66	0.00

Source: Authors' computations

The second-generation panel unit root test reported in Table 4 accounts for cross-sectional dependence. The test results should be interpreted separately for models with and without deterministic trends. In addition, check the p-values and test statistics for consistency before concluding that the variables share the same order of integration. The table is retained in its original numerical form pending verification of these outputs. The panel unit root tests are reported under two specifications, one excluding a trend and the other including a trend. Several variables are significant under both specifications, while others are sensitive to the trend assumption. For example, the reported results for improved drinking water (IDW) differ across the

specifications. Therefore, the blanket conclusion that only IDW and secondary school enrolment (SSE) are non-stationary is not fully supported by the displayed statistics. The integration order of each series should be rechecked using the underlying test output, including the relevant lag choices and p-values, before proceeding to cointegration interpretation.

4.4 Panel Cointegration Analysis

To investigate potential long-run relationships among the variables, the study reports three panel cointegration tests: Kao, Pedroni, and Westerlund. The Kao results include Dickey–Fuller, augmented Dickey–Fuller, and modified Dickey–Fuller statistics. The Pedroni results report Phillips–Perron, modified Phillips–Perron, and augmented Dickey–Fuller statistics, while the Westerlund procedure reports the Gt, Ga, Pt, and Pa statistics. These procedures differ in their assumptions and null hypotheses. Therefore, conclusions about long-run association should consider the agreement and disagreement among tests, the evidence of cross-sectional dependence, and the integration properties of the variables.

Table 5: Cointegration Test Results

Cointegration Tests										
Model	**Kao Test**				**Pedroni Test**			**Westerlund Test**		
	Dickey-Fuller t	**ADF**	**Modified Dickey-Fuller**	**Phillips-Perron t**	**Augmented Dickev-Fuller**	**Modified Phillips-**	**Gt**	**Ga**	**Pt**	**Pa**
LGDP/ LFPR, GFCF, APS, GI, ARM, SSE, M2, TAX	-6.31	-8.16	-6.28	-2.56	-0.25	10.10	-0.99	-2.31	-12.12	-3.74
	(0.00)	(0.00)	(0.00)	(0.00)	(0.39)	(0.00)	(0.88)	(0.76)	(0.56)	(0.12)
LGDP/ LFPR, GFCF, PUN, GI, ARM, SSE, M2, TAX	-6.21	-7.96	-6.01	-3.82	-0.55	9.29	-0.80	-2.01	-2.66	-0.72
	(0.00)	(0.00)	(0.00)	(0.00)	(0.29)	(0.00)	(0.23)	(0.00)	(0.87)	(0.99)
LGDP/ LFPR, GFCF, PFPV, GI, ARM, SSE, M2, TAX	-6.06	-7.93	-5.91	-3.01	-0.40	10.38	-0.72	-1.42	-3.57	-0.80
	(0.00)	(0.00)	(0.00)	(0.00)	(0.34)	(0.00)	(0.00)	(0.23)	(0.03)	(0.00)
LGDP/ LFPR, GFCF, IDW, GI, ARM, SSE, M2, TAX	-6.99	-8.86	-7.61	-2.42	0.71	10.05	-0.99	-2.16	-5.45	-1.23
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.23)	(0.00)	(0.65)	(0.02)	(0.00)

Note: The values in parentheses are p-values. Source: Authors' computations

Table 5 presents the results of the panel cointegration analyses. The Kao statistics provide evidence against the null hypothesis of no cointegration for the reported specifications. Similarly, several Pedroni statistics are significant, although the results are not uniform across all test statistics. However, the Westerlund statistics provide mixed evidence across models and testing dimensions. Therefore, the results are consistent with possible long-run relationships in some specifications, but they do not establish an unqualified conclusion of cointegration under every test. A more definitive claim requires verification of the test settings, dependence adjustments, and orders of integration.

4.5 Method of Moments-Quantile Regression Results of Economic Growth

The Method of Moments Quantile Regression (MMQR) approach estimates four economic growth models corresponding to the food availability, access, stability, and utilization dimensions. Unlike an analysis focused only on a conditional mean, the quantile approach allows the estimated relationships to differ across the conditional growth distribution (Machado & Santos Silva, 2019). Each dimension is represented by a separate explanatory indicator, while the models also include labour force participation, gross fixed capital formation, the Gini index, agricultural raw material exports, secondary school enrolment, broad money, and tax revenue. Tables 6–9 report estimates for the 10th, 25th, 50th, 75th, and 90th quantiles. Comparing these estimates helps identify whether the reported associations are stronger or weaker at different growth quantiles. However, these quantiles describe conditional outcomes rather than fixed groups of low-income or high-income countries.

Table 6: MM-QR Results of Economic Growth Model based on Food Availability

DV = Per-Capita GDP (GDPPC)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
LFPR	0.02***	-0.02***	0.06***	0.04***	0.02***	0.00	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GFCF	0.19***	-0.02	0.23***	0.21***	0.20***	0.17***	0.16***
	(0.03)	(0.02)	(0.04)	(0.03)	(0.03)	(0.04)	(0.05)
APS	0.09***	-0.09***	0.24***	0.17***	0.07***	0.00	-0.04
	(0.02)	(0.01)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
GI	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ARM	-0.03***	0.01***	-0.05***	-0.04***	-0.03***	-0.02***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SSE	0.02***	0.00**	0.02***	0.02***	0.02***	0.02***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
M2	0.01***	0.00***	0.00	0.00***	0.01***	0.01***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TAX	0.16***	-0.05***	0.24***	0.21***	0.17***	0.12***	0.08***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
CONSTANT	20.13***	2.310***	16.06***	18.18***	20.41***	22.14***	23.53***
	(0.36)	(0.26)	(0.70)	(0.50)	(0.35)	(0.32)	(0.39)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' computations*

The MMQR approach provides important insights into the relationship between food security and economic growth. In particular, the results of the MMQR analysis for the first dimension of food security, i.e., "availability," are presented in Table 6. For the sake of analysis other explanatory variables were incorporated in the model are LFPR, GFCF, GI, ARM, SSE, M2 and TAX. The results revealed that LFPR and GFCF positively and significantly affect economic growth. Our results for LFPR support conclusions reached by various empirical studies (Duval et al., 2010; Edeme et al., 2016; Haque et al., 2019; Oyelade & Oghenetega, 2020). Moreover, the results of our study are in line with a considerable number of studies by showing a positive impact of capital formation (GFCF) on economic growth (Bakare, 2011; Ugochukwu & Chinyere, 2013; Kanu & Ozurumba, 2014; Jaiyeoba, 2015; Ali, 2015; Shuaib & Ndidi 2015; Ncanywa & Makhenyane, 2016; Edeme et al., 2016; Boamah et al., 2018; Haque et al., 2019; Kong, 2020).

Adequate food availability, as measured by average protein supply (APS), positively influences economic growth by promoting good health and productivity. Moreover, the results are consistent with those of previous studies (Correa & Cummins, 1970; Agboola, 2009; Bacilar, 2014; Manap & Ismail, 2019). The studies have revealed that food availability is a crucial factor in determining economic growth in developing countries, as improved food availability contributes to overall economic growth. On the other hand, reliance on agricultural exports (ARM) has negative impacts on economic growth. Turning to the measure of income inequality (GI), our results have shown an insignificant impact on GDPPC. Some other studies have also found no conclusive relationship between income inequality and economic growth. The result for GI agrees with the findings of Barro (2000), Mo (2000), and Hailemariam and Dzhumashev (2019), who concluded that income inequality is not related to economic growth. Secondary school enrollment positively impacts economic growth through human capital development and technological progress. Furthermore, financial development (represented by M2) and effective fiscal policies (reflected in tax revenue) positively contribute to economic growth.

Table 7 reports the food access model, in which the prevalence of undernourishment (PUN) is the principal food security indicator. The signs of several control-variable coefficients resemble those in the availability model. However, their magnitudes and levels of statistical significance should be compared directly rather than described as identical. In addition, PUN is negatively associated with per-capita GDP growth across the reported quantiles, suggesting that nutritional deprivation is a relevant correlate of weaker economic performance in the sample.

Table 7: MM-QR Results of Economic Growth Model based on Food Access

DV = Per-Capita GDP (GDPPC)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
LFPR	0.019***	-0.00**	0.02***	0.02***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GFCF	0.72***	0.04***	0.65***	0.68***	0.72***	0.75***	0.78***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
PUN	-0.28***	-0.01	-0.24***	-0.26***	-0.28***	-0.29***	-0.31***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)
GI	-0.00*	-0.00	-0.00	-0.00	-0.00**	-0.00**	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ARM	-0.03***	0.00**	-0.04***	-0.03***	-0.03***	-0.03***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SSE	0.01***	0.00	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
M2	0.01***	0.00***	0.00	0.01***	0.01***	0.01***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TAX	0.56***	0.02	0.52***	0.54***	0.56***	0.58***	0.59***
	(0.02)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
CONSTANT	22.00***	1.47***	19.43***	20.95***	22.18***	23.30***	24.24***
	(0.29)	(0.20)	(0.55)	(0.38)	(0.28)	(0.26)	(0.32)
Observations	2,747	2,747	2,747	2,747	2,747	2,747	2,747

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' computations*

As Table 7 indicates, the estimated association between the prevalence of undernourishment (PUN) and economic growth is negative and statistically significant across the reported quantiles. The magnitude becomes more negative from the 10th to the 90th quantile, which suggests variation in the strength of this association across the conditional growth distribution. From a developmental perspective, inadequate nutrition can limit physical and cognitive functioning and constrain participation in productive activities. Similarly, nutritional deprivation may interact with poverty and unequal access to economic opportunities. These interpretations are consistent with earlier discussions of the economic costs of hunger and malnutrition (Arcand, 2001; Bain et al., 2013; Manap & Ismail, 2019). However, the regression results alone do not establish that undernourishment directly causes changes in productivity, inequality, or life expectancy; these mechanisms require further investigation.

Table 8: MM-QR Results of Economic Growth Model based on Food Stability

DV = Per-Capita GDP (GDPPC)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
LFPR	0.01***	-0.00***	0.02***	0.02***	0.01***	0.01***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GFCF	0.04***	0.02**	0.00	0.01**	0.03***	0.05***	0.08***
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.03)
PFPV	-0.05***	-0.13***	-0.12***	-0.05***	-0.01	-0.11***	-0.27***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.04)
GI	-0.00**	-0.00	-0.00	-0.00*	-0.00**	-0.00***	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ARM	-0.03***	0.00**	-0.04***	-0.03***	-0.03***	-0.03***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SSE	0.02***	0.00***	0.01***	0.01***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
M2	0.01***	0.00***	0.00**	0.01***	0.01***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TAX	0.01	0.04***	0.07***	0.04***	0.01	0.02	0.05***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
CONSTANT	21.68***	1.315***	19.46***	20.70***	21.84***	22.88***	23.63***
	(0.29)	(0.20)	(0.54)	(0.38)	(0.28)	(0.27)	(0.31)
Observations	2,748	2,748	2,748	2,748	2,748	2,748	2,748

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' computations*

Tables 8 and 9 report the models for food stability and food utilization, respectively. In the food stability model, per-capita food production variability (PFPV) has a negative estimated coefficient at most quantiles, although the median coefficient in Table 8 is not marked as statistically significant. Moreover, the magnitude of the negative association differs across quantiles and is particularly pronounced at the 90th quantile. Variability in food production may create uncertainty for food availability, agricultural incomes, and household consumption, potentially constraining longer-term economic performance. Similarly, instability in production can heighten vulnerability to hunger and impair the accumulation of human capital. The results are consistent with the relevance of food production and consumption variability discussed by Sahn and Von Braun (1987). However, they should be interpreted as evidence of an association rather than a definitive causal effect. The separate utilization model is examined below.

Table 9: MM-QR Results of Economic Growth Model based on Food Utilization

DV = Per-Capita GDP (GDPPC)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
LFPR	0.02***	-0.02***	0.06***	0.04***	0.02***	0.00	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GFCF	0.01	0.03***	0.04***	0.02*	0.01	0.04***	0.08***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
IDW	0.02***	0.00	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GI	-0.01***	0.00	-0.01**	-0.01**	-0.01***	-0.01***	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ARM	-0.03***	0.00***	-0.04***	-0.04***	-0.03***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SSE	0.02***	0.00***	0.01***	0.01***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
M2	0.01***	0.00***	0.00**	0.01***	0.01***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TAX	0.12***	0.04***	0.06***	0.08***	0.11***	0.15***	0.19***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
CONSTANT	21.42***	2.155***	17.73***	19.73***	21.56***	23.33***	24.60***
	(0.36)	(0.26)	(0.69)	(0.49)	(0.35)	(0.33)	(0.39)
Observations	2,759	2,759	2,759	2,759	2,759	2,759	2,759

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' computations*

Table 9 indicates a positive, statistically significant association between access to improved drinking water (IDW), a proxy for food utilization, and per-capita GDP growth across all reported quantiles. Improved drinking water is relevant to public health because it can reduce exposure to waterborne disease and support healthy participation in education and employment. Consequently, water-related infrastructure may contribute to the conditions needed for productivity and economic development. The positive association is consistent with earlier studies linking water and sanitation infrastructure to economic and social outcomes (Hutton et al., 2004; Srinivasu & Rao, 2013; Purba & Budiono, 2019; Budiono & Purba, 2020). In addition, these findings are relevant to Sustainable Development Goal 6, which emphasizes clean water and sanitation. Nevertheless, the present model does not estimate the health-cost or labor-productivity channels separately, so those channels should be treated as plausible explanations rather than direct empirical findings.

These findings have practical implications for policymakers seeking to strengthen food security and economic performance. In particular, the different food security indicators point to complementary priorities: improving access to nutritious food, reducing food production volatility, and expanding access to safe drinking water. Similarly, investment in productive infrastructure, human capital, and financial development may support more favorable growth conditions. However, policy design should reflect the observed heterogeneity across conditional quantiles and the limitations of interpreting regression associations as causal effects. Consequently, interventions should be tailored to country-specific institutional capacity, food systems, and development challenges.

4.6 Comparative Interpretation of Quantile Effects

The estimates reported in Tables 6–9 show that the strength and, in selected cases, statistical significance of the associations vary across conditional growth quantiles. In the food access model, the negative coefficient of undernourishment increases in absolute magnitude from the lower to the upper quantiles. Similarly, food production variability is negatively associated with growth at most quantiles, although its median coefficient is not reported as statistically significant. By contrast, access to improved drinking water is positively

associated with growth throughout the conditional distribution. The availability model indicates a positive association for average protein supply at lower and middle quantiles, but the coefficient is not consistently significant at higher quantiles. These differences support differentiated policy interpretation rather than a uniform effect of food security across all growth conditions. Importantly, the quantile estimates do not represent comparisons among fixed national income groups.

4.7 Implications for Sustainable Development

The results are relevant to Sustainable Development Goal 2, which concerns hunger and food security, and Sustainable Development Goal 6, which addresses clean water and sanitation. In addition, the study's focus on labour productivity and growth relates to Sustainable Development Goal 8, while its consideration of income inequality relates to Sustainable Development Goal 10. Therefore, the findings suggest that food security policy should be coordinated with human capital development, water provision, and inclusive economic policies. However, the analysis does not estimate changes in the SDG indicators themselves or evaluate the causal effects of specific programs. Such assessments remain appropriate topics for subsequent research.

5 Conclusions and Policy Recommendations

Using the panel dataset for 1990-2020, the present study aimed to identify how the economic growth of developing countries can be boosted through agricultural exports and food security. Moreover, it identified how income inequality hinders economic growth. By employing the Method of Moments Quantile Regression (MMQR), the research explored the opportunities and challenges developing countries face in addressing food security and economic growth. The MMQR analysis was employed to estimate four economic growth models for each aspect of food security separately. The results contributed significantly to understanding the intricate relationship between food security and economic growth in developing countries. In particular, by using GDPPC as a measure of economic growth, the study initially focused on the first dimension of food security, i.e., "Availability". The study uses APS (average protein supply) as a proxy for food availability. The results show that economic growth is significantly increased by the labor force participation rate (LFPR) and gross fixed capital formation (GFCF). Adequate food availability, as measured by average protein supply (APS), positively influences economic growth by promoting good health and productivity. On the other hand, reliance on agricultural raw material exports (ARM) is negatively associated with economic growth, whereas the estimated relationship for income inequality (measured by the Gini index) varies in statistical significance across specifications. Higher income inequality hampers human capital accumulation and reduces aggregate demand, while export dependence leads to unfavorable terms of trade and price volatility. Secondary school enrollment (SSE) positively impacts economic growth through human capital development and technological progress. Furthermore, financial development (represented by M2) and effective fiscal policies (reflected in tax revenue) positively contribute to economic growth.

For our second model of food security, based on food access measured through PUN (prevalence of undernourishment), all explanatory variables have the same impact on GDPPC in developing countries as in the first model. However, our results show that PUN (prevalence of undernourishment) has a negative and statistically significant effect on the economic growth of developing states for almost all quantiles. This implies that undernourishment in developing countries hinders economic growth by reducing labor productivity and exacerbating income inequality and poverty. In the third model, based on food stability measured through PFPV (per capita food production variability), MMQR results show a significantly negative impact of PFPV on GDPPC in developing countries. Higher variability in per capita food production in developing countries is negatively correlated with economic growth (GDPPC), indicating that fluctuations in food production have a detrimental effect on economic progress. Regarding the impact of IDW (People using at least improved drinking water services), our empirical analysis shows a favorable relationship between food utilization and economic growth in developing countries. It suggests that access to improved drinking water (IDW) is vital for the economic growth of developing countries. These findings provide valuable insights for policymakers to design targeted interventions that promote labor force participation, infrastructure investment, food security, reduced income inequality, and financial system development, ultimately fostering sustainable economic growth and improved well-being in developing countries. In promoting food security to enhance economic growth, the role of government policies and programs cannot be denied. To achieve this goal, Timmer (2000) suggests that implementing policies such as food-based safety nets and social protection programs is essential. This study offers policy implications for policymakers in developing countries.

- To enhance long-term food security and support economic growth, developing countries should consider measures to raise agricultural productivity, including improved production technologies, agricultural extension services, and investment in resilient rural infrastructure. Furthermore, policies that improve

farmers' access to inputs and productive knowledge may help strengthen the availability and stability of food supplies.

- To pursue sustainable economic growth while safeguarding food security, developing countries should assess the composition and resilience of their agricultural exports and reduce excessive dependence on vulnerable food supply channels. However, the reported negative association for agricultural raw material exports does not mean all agricultural exports should be reduced. Instead, policies may emphasize diversification, domestic value addition, reliable food availability, and balanced trade strategies that reflect national circumstances (Faridi, 2012; Mahmood & Munir, 2018).
- To address income inequality, developing countries may strengthen social safety nets, access to education, and appropriately designed progressive taxation. Such measures can support the purchasing power of vulnerable households and improve opportunities for human capital development. Therefore, they may complement food security initiatives and contribute to more inclusive and sustainable economic growth. However, the study's reported Gini coefficients are not uniformly statistically significant, and the policy implications should be presented with this qualification (Barro, 2000; Breunig & Majeed, 2020).
- Variability in food production may be addressed through investment in water management, irrigation infrastructure, climate-resilient agricultural practices, and measures that improve supply-chain reliability. Similarly, production risk management and access to relevant agricultural information may help reduce uncertainty for producers and households. These policies are consistent with the study's focus on food stability, although their effectiveness requires context-specific evaluation.

Investment in water infrastructure should also be prioritized where access to improved drinking water remains inadequate. Reliable water services may help protect public health, reduce preventable illness, and support productive participation in economic activities. In addition, coordination between water policy, rural development, and public health programs can strengthen the conditions for sustainable growth. The interpretation should remain consistent with the observed positive association between water access and economic growth rather than implying that causal pathways have been directly estimated (Hutton et al., 2004; Purba & Budiono, 2019).

5.1 Limitations and Directions for Future Research

Several limitations qualify the interpretation of the empirical evidence. First, country inclusion depends on data availability; consequently, the final sample may not fully represent all developing economies. Second, the reported income-group counts and certain descriptive statistics require verification against the source data before additional subgroup analyses can be undertaken. Third, cross-sectional dependence, possible endogeneity, and sensitivity to model specification may affect inference. Fourth, the indicators are useful proxies for food security dimensions but cannot capture every aspect of dietary quality, household access, or local resilience. Future studies could examine income-group differences once the country classification has been reconciled, compare the MMQR results with appropriate alternative panel estimators, and assess whether conclusions remain stable under different indicators and sample definitions. Furthermore, research with suitable identification strategies could test the health, productivity, and trade channels proposed in the theoretical discussion.

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