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Demand-Driven Challenges to Food Security: A Developing World Perspective

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ABSTRACT

Objective: This study explores the impact of short-run and long-run demand-side drivers on the food security in developing countries.

Research Gap: The paper utilizes a rich dataset consisting on 89 nations spanning from the years 1990 to 2020. A research gap exists in the collective exploration of all four dimensions of food security. Prior to the present study, there was a scanty literature addressing this comprehensive approach.

Methodology: The present study employs Method of Moments Quantile Regression (MMQR). The application of the MMQR technique to analyze the interconnections among food security, agricultural exports, income inequality, economic growth and demand-driven forces of food security has limited in previous literature. This underscores the need for a more nuanced understanding of the relationships between these variables.

The Main Findings: The results reveal that overall population growth (PG) as well as urban population growth (UPG) serves as the persistent impediment towards the achievement of sustainable food security. However, official development assistance (ODA) shows a positive impact on availability and utilization dimensions. As well as, ODA can reduce undernourishment leading to improved access to nutritious food in developing countries.

Implications of Findings: The study recommends promoting family planning to address population pressures and emphasizes active engagement with international donors for technical and financial support in enhancing food security.

Originality/Value: The existing literature was limited in its coverage of this holistic approach prior to the current research. Additionally, this study applied the MMQR, a novel technique in this field, to assess such associations.

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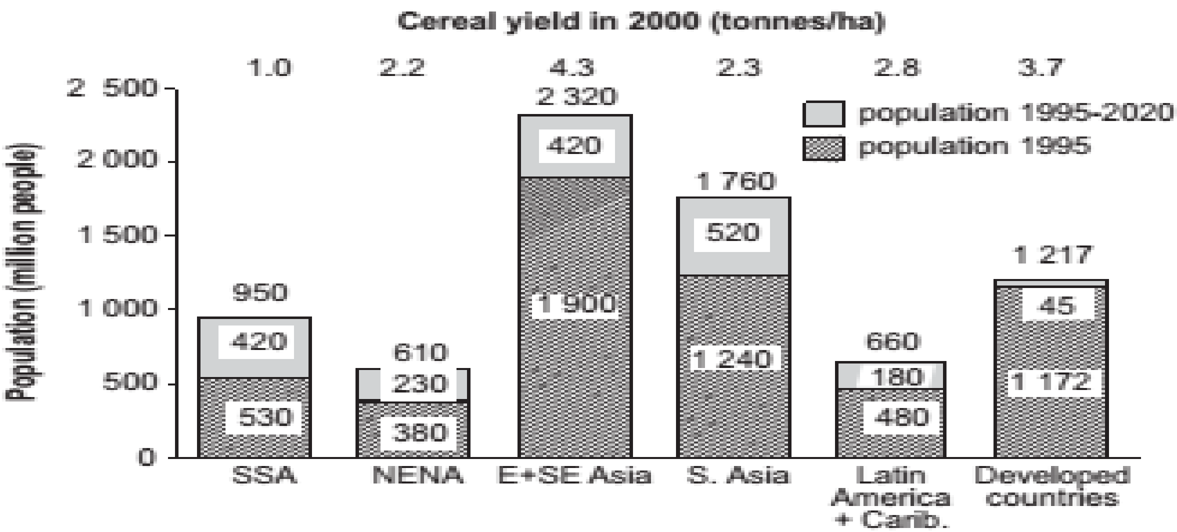
1. Introduction

The notion of food security is recognized as a fundamental human entitlement. In 1974, it was asserted by the World Food Conference that the basic right of every individual is to be relieved from hunger as well as malnutrition. Even after the period of twenty years this goal was not attained, especially in developing countries the number of individuals without sufficient food was more than 800 million. Hence, in 1996, a fresh initiative was introduced in Rome during the "World Food Summit" with the objective of eradicating hunger and malnutrition to ensure sustainable food security for all individuals. According to this Summit, a situation, where all individuals invariably enjoy physical access to safe and healthy food along with the economic access was accorded as "Food Security". The global community recognized the need for food security at international level because of the increasing interdependence of efforts regarding poverty elimination, political stability, environmental degradation, globally growing population, international trade, research and financial cooperation. The primary objective of the summit was to decrease the number of undernourished individuals to the half by the 2015. Moreover, the food production was aimed to increase by over 75 percent in the coming thirty years, so that around 8000 million individuals are fed by the year 2015. Especially, in the context of developing countries, the individuals which are undernourished aimed to decrease up to 20 million per annum at the least. But the situation worsened instead, due to globally increasing pressure of population.

The global population had undergone a doubling up within a time period of 40 years from 1960 to 2000. Despite attempts to manage the rate of expansion, projections from the United Nations (UN) utilizing a moderate-fertility framework predicts a global population of approximately 7.5 billion in 2020. Looking for future, the anticipated global population may touch 9 billion by 2050, eventually stabilizing at slightly over 10 billion after the year 2100 (IFPRI, 1997, 1999). Figure 1 shows the relation of population and cereal production in developing countries.

Figure 1: Population of Developing Regions and Cereal Yields



Note: SSA = Sub-Saharan Africa, NENA = Near East + North Africa, E + SE Asia = East + Southeast Asia
Source: IFPRI (1999); Finck (2001)

Despite the fact that risk factors of food security are generally known but still to identify and realize the drivers of food security is a difficult task. A lot of factors ranging from population pressure to other socio-economic causes such as inequality and poverty are identified as responsible for such demand-side drivers. This study focuses on the impact of demand-side drivers of food security by incorporating all of its dimensions namely availability, access, stability and utilization for developing economies of world.

2. Literature Review

2.1. Studies on Food Security and Urban Population Growth (UPG)

A considerable number of studies are found which focused the impact of urbanization on food security, besides studies showing impact of UPG on overall food security is available. But scanty literature is available for the influence of UPG on specific aspects of food security. Most of the available literature has found destroying effects of UPG on food security of developing countries. Using the country level data on Food Insecurity Risk Index, Szabo (2016) revealed a strong negative role of urban growth on food security at the country level. Moreover, it confirmed that the countries with rapid urban growth and low human development levels are more exposed to threat of food insecurity. Ruel et al., (2017) in the perspective of new challenges to growing cities found that with increase in urban population state of food security turned as increasing problem especially for the poorest urban population segments. It also stated that more than half of the income of poor people usually spent on food. Miladinov (2023) also found negative impact of UPG on PUN in case of low-income and middle-income countries

Contrarily, during the period 1983 and 2012 by exploring the effects of urban population on food security for Iran, Salem (2017) showed that food security has increased in case of urban households. Kousar et al., (2021) also found that urbanization as well as population growth are positively linked with food security.

2.2. Studies on Food Security and Population Growth (PG)

Research on the relation between population growth and food security has predominantly focused on the holistic aspect rather than individual dimensions. Studies often highlight the general impact on food security status rather than specific components. For the low- and middle-income countries, Miladinov (2023) have found interesting results. It claimed that in low- and middle-income nations rural population growth has significantly positive effect on PUN, while on the other hand urban population growth negatively affects the PUN. Taking into account food security dynamics in terms of carbohydrates and protein Prosekov & Ivanova (2016) established that poverty and population growth has caused destabilization in food security in the modern world. For India Kundu (2015) explored impact of swift population growth on both Food security and economic progress. This study accorded the population growth as fundamental reason for the food insecurity and a factor hampering economic development of India. The study focused on the need of population control measures to guarantee food security of all individuals. A body of research also shows the rapid growth in population exerts pressure on public resources, encompassing FS (Jenkins and Scanlan; 2001, Scanlan; 2001a, 2003, Brady et al., 2007, Austin et al., 2012, Khan et al., 2022).

2.3. Studies on Food Security and Net official development assistance received (ODA)

Food security is a multidimensional notion that necessitates thorough assessments. A few studies have found the impact of ODA on one or two dimensions of food security. Khan et al., (2022) contributed to the literature by claiming that population growth has significant impact on PUN by increasing it but ODA helps in reducing PUN for the least developing countries. Some studies have found that ODA is positively related to water access (Botting et al., 2010, Wayland; 2013, Gomez et al., 2019).

3. Data & Methodology

For exploring the effect of short-run and long-run demand side drivers on food security present study has estimated four models based on four dimensions namely “availability”, “access”, “utilization” and “stability”.

Model-1: Short-run and Long-run Demand-side Model based on Food Availability

The generic form of an econometric equation is presented as:

$$Q_{APS_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \eta_{5,\tau} UPG_{it} + \eta_{6,\tau} PG_{it} + \eta_{7,\tau} ODA_{it} + \mu_{\tau,it} \quad (1)$$

Model-2: Short-run and Long-run Demand-side Model based on Food Access

$$Q_{PUN_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \eta_{5,\tau} UPG_{it} + \eta_{6,\tau} PG_{it} + \eta_{7,\tau} ODA_{it} + \mu_{\tau,it} \quad (2)$$

Model-3: Short-run and Long-run Demand-side Model based on Food Stability

$$Q_{PFPV_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \eta_{5,\tau} UPG_{it} + \eta_{6,\tau} PG_{it} + \eta_{7,\tau} ODA_{it} + \mu_{\tau,it} \quad (3)$$

Model-4: Short-run and Long-run Demand-side Model based on Food Utilization

$$Q_{IDW_{it}}(\tau \mid \gamma_i, \delta_t, X_{it}) = \gamma_i + \delta_t + \eta_{1,\tau} ARM_{it} + \eta_{2,\tau} GI_{it} + \eta_{3,\tau} HLIS_{it} + \eta_{4,\tau} GDPPC_{it} + \eta_{5,\tau} UPG_{it} + \eta_{6,\tau} PG_{it} + \eta_{7,\tau} ODA_{it} + \mu_{\tau,it} \quad (4)$$

Where τ represent quantiles including 10th, 25th, 50th, 75th and 90th. i = 1, ……. , N used for cross sections, and t is used for the time period starting from t = 1, ….. , T. APS is average protein supply (g/cap/day, 3-year averaged). PUN is prevalence of undernourishment (%, Yearly estimates). PFPV is Per capita food production variability (Constant 2014-2016 thousand international $ per capita). IDW is people using at least improved drinking water services (% of population). ARM is agricultural raw material exports (% of merchandise exports). GI is Gini index (Annual %). HLIS is income share ratio held by highest (20%) to lowest 20% (Annual %). GDPPC is GDP per capita growth (Annual %). UPG is urban population growth (Annual %). PG is population growth (Annual %). ODA is net official development assistance received (Current US$, Annual).

4. Results & Discussion

This section represents the detailed results.

4.1. Descriptive statistics of key variables

The complete descriptive overview of the variables that have been utilized in the analysis is represented in the Table 1.

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

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	JB	Probability
APS	64.46	118.10	30.00	13.88	0.64	3.25	175.24	0.00
PUN	19.77	80.80	-45.20	14.14	0.65	4.18	314.80	0.00
PFPV	10.44	107.40	-6.10	10.93	3.70	23.79	49806.99	0.00
IDW	75.09	107.10	1.60	19.03	-0.75	2.94	233.08	0.00
ARM	6.91	98.95	-5.25	12.59	3.25	14.51	17875.48	0.00
GI	42.48	84.41	-11.93	9.48	-0.15	4.74	318.70	0.00
HLIS	9.90	68.78	0.60	6.19	2.41	13.57	13780.34	0.00
GDPPC	2.04	53.97	-64.99	5.67	-0.93	24.66	54315	0.00
UPG	3.10	17.50	-6.51	1.76	0.36	8.71	3385.53	0.00
PG	1.94	8.12	-6.77	1.11	-0.93	9.35	4467.10	0.00
ODA	0.06	1.35	-0.006	0.08	3.68	30.35	92055.32	0.00

Source: Authors' computations

4.2. Cross-Sectional Dependence and Slope Homogeneity Tests

Table 2 demonstrates the findings concerning cross-sectional dependency and slope uniformity, while Table 3 displays them respectively.

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

Variable	CD-test	p-value
APS	195.1040	0.0000
PUN	101.3140	0.0000
PFPV	-1.0920	0.2750
IDW	163.2440	0.0000
ARM	38.9990	0.0000

GI	22.4950	0.0000
HLIS	23.8500	0.0000
GDPPC	57.4530	0.0000
UPG	58.8230	0.0000
PG	61.7270	0.0000
ODA	99.1890	0.0000

Source: Author's computations

Table 3: Slope Homogeneity Test

Models	DV	(Pesaran and Yamagata, 2008)		(Blomquist and Westerlund, 2013)	
		Delta Test	P-Value	HAC Robust Adjusted Delta Test	P-Value
Short-run and Long-run Demand-side Drivers of FS Models	APS	45.6470	0.0000	-13.9660	0.0000
	PUN	42.0050	0.0000	-13.0950	0.0000
	PFPV	22.0230	0.0000	-10.1820	0.0000
	IDW	45.9300	0.0000	-14.2910	0.0000

Source: Author's computations

4.3. Unit Root Tests

The outcomes of the Im-Pesaran-Shin (CSDIPS) unit root test are outlined in Table 4 ascertain the presence of a genuine long-term association.

Table 4: Second Generation Panel Unit Root Test Results

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
APS	0	-7.3920	0.0000	0	-3.3610	0.0000
PUN	0	1.5410	0.9380	1	-16.1310	0.0000
PFPV	0	-4.5260	0.0000	0	-5.9170	0.0000
IDW	0	3.8820	1.0000	0	-0.9460	0.1072
ARM	0	-6.9180	0.0000	0	-3.495	0.0000
GI	0	-5.9380	0.0000	0	-4.7610	0.0000
HLIS	0	-6.5850	0.0000	0	-3.1020	0.0010
GDPPC	0	-17.3310	0.0000	1	-5.7600	0.0000
UPG	0	-3.1030	0.0010	1	-7.4760	0.0000
PG	0	-4.0100	0.0000	0	3.1200	0.0999
ODA	0	-8.9250	0.0000	1	-5.4100	0.0000

Source: Authors' computations

4.4 Panel Cointegration Analysis

To ascertain the presence of a genuine long-term association within the study's variables that there is indeed a long-term connection, we have performed three cointegration tests i.e. Kao test, Pedroni test and Westerlund test. From obtained results of Table 5, leading us to refute the null hypothesis of no cointegration and conclude that long-run relationship exist in all models.

Table 5: Cointegration Tests Results: Short-run and Long-run Demand-side Drivers of Food Security Models

DV	Kao Test		Pedroni Test				Westerlund Test			
	DF test	Augmented DF test	Modified DF test	PP test	Modified PP test	Augmented DF test	Gt	Ga	Pt	Pa
APS	3.71 (0.0001)	4.72 (0.000)	4.49 (0.000)	-0.84 (0.199)	8.09 (0.000)	1.21 (0.112)	-1.23 (0.001)	-2.06 (0.033)	-4.861 (0.021)	-8.00 (0.0001)

PUN	2.55	4.04	4.53	0.74	9.04	2.54	-1.26	-2.151	-9.445	-1.45
	(0.005)	(0.000)	(0.000)	(0.228)	(0.000)	(0.005)	(0.0001)	(0.045)	(0.02)	(0.006)
PFPV	-1.95	-2.78	-1.81	-1.58	7.89	-3.40	-2.62	-4.57	-14.646	-3.45
	(0.025)	(0.002)	(0.034)	(0.0561)	(0.000)	(0.006)	(0.041)	(0.000)	(0.0004)	(0.0007)
IDW	3.86	3.85	2.93	-0.32	7.33	-0.51	-1.02	-1.38	-7.21	-1.26
	(0.0001)	(0.0001)	(0.0017)	(0.3756)	(0.000)	(0.305)	(0.000)	(0.655)	(0.0000)	(0.0010)

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

4.5 MM-QR Results of Short-run and Long-run Demand-side Drivers of FS Models

In this section, the results of MMQR of the study are presented and discussed in detail by considering short-run and long-run demand-side drivers of FS for all dimensions.

Table 6: MM-QR Results of Short-run and Long-run Demand-side Model based on Food Availability

DV= APS (APS)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
ARM	-0.152***	-0.0459***	-0.0835***	-0.110***	-0.145***	-0.192***	-0.231***
	(0.0189)	(0.0116)	(0.0205)	(0.0180)	(0.0183)	(0.0246)	(0.0321)
GI	-0.297***	-0.166***	-0.0490	-0.146***	-0.270***	-0.442***	-0.579***
	(0.0564)	(0.0348)	(0.0612)	(0.0537)	(0.0547)	(0.0738)	(0.0957)
HLIS	-0.364***	-0.138***	-0.585***	-0.471***	-0.339***	-0.250***	-0.161***
	(0.0466)	(0.0490)	(0.104)	(0.0698)	(0.0369)	(0.0314)	(0.0472)
GDPPC	0.565***	-0.180***	0.865***	0.703***	0.516***	0.388***	0.329***
	(0.0845)	(0.0613)	(0.171)	(0.121)	(0.0744)	(0.0627)	(0.0667)
UPG	-1.996***	-0.390***	-1.412***	-1.641***	-1.932***	-2.338***	-2.663***
	(0.201)	(0.124)	(0.217)	(0.191)	(0.194)	(0.262)	(0.341)
PG	-1.248***	0.370*	-1.802***	-1.585***	-1.308***	-0.923**	-0.615
	(0.330)	(0.203)	(0.357)	(0.313)	(0.319)	(0.429)	(0.560)
ODA	0.0161***	0.00514***	0.00722**	0.0123***	0.0167***	0.0208***	0.0238***
	(0.00175)	(0.00122)	(0.00326)	(0.00230)	(0.00169)	(0.00162)	(0.00190)
Constant	88.15***	18.79***	60.04***	71.06***	85.07***	104.6***	120.2***
	(1.867)	(1.151)	(2.063)	(1.806)	(1.832)	(2.539)	(3.145)
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

Here, the paper has used APS as dependent variable. Among the various independent variables, UPG and PG are linked with the long-run demand-side drivers of FS however, ODA is used for the short-run demand-side driver of FS.

From the Table 6, it becomes clear that ARM has significantly negative impact on APS for all quantiles. This result aligns with the existing literature, which highlights negative effect of agricultural trade on FS because there exists a competition between cash and food crops production, changes in production structure, and increased dependence on food imports (Braun and Kennedy, 1986; Gacitua and Bello, 1991; Wimberley and Bello, 1992; Jenkins and Scalan, 2001; Abdullateef and Ijaiya, 2010; Austin et al., 2012, Ivanic and Martin, 2014). Drèze and Sen (1989), Watts & Bohle (1993), Devereux (2009), and FAO (2015) have all presented arguments discussing the potential negative repercussions of ARM on FS.

The MMQR analysis found a significant and adverse relation between APS and the variables of income inequality i.e. GI and HLIS. Notably, Wu et al., (2020) and Hossain et al., (2020) observed food supply decreases due to income inequality, as evidenced by a decline in the average dietary protein supply. Similarly, Chegini et al. (2021) revealed that income inequality mainly affects low-income and less developed countries' ability to maintain FS. Therefore, we must address income inequality to reduce food insecurity, as economic growth alone cannot solve this issue. These researchers have highlighted concerns such as reduced food availability due to heightened incentives for export (Heerink & Folmer, (1994); Wu et al., 2020; Hossain et al., 2020). Generally, these results emphasize the crucial significance of addressing the problem of income inequality to improve FS in developing countries.

The study shows positive impact for the variable of economic growth (GDPPC) on APS of developing countries. Our findings are consistent with previous studies by Nelson et al., (2018), and Hossain et al., (2020), which demonstrated a rise in GDP per capita growth is positively linked to APS. The study concludes that income distribution, in addition to GDPPC, is a critical factor affecting FS. This study supports the idea that the economic growth structure is critical towards addressing hunger (OECD, 2013).

Coming to the relationship of UPG and PG, both of the long-run related independent variables of demand-side of FS have shown negative and statistically significant impact on APS. It shows that an increase in population affects the APS adversely. The production of protein-rich foods requires resources such as land, water, and feed for livestock. The demand for these resources increases as the population grows, resulting in scarcity of resources. Moreover, decline in availability of land and land degradation can have negative impacts on the supply of protein-rich foods by reducing the land resources available for production and limiting the productivity of agricultural lands. These factors can lead to decreased supply of protein-rich foods and impact their availability negatively and hence FS is endangered in the developing countries. A body of research also shows the rapid growth in population exerts pressure on public resources, encompassing FS (Jenkins and Scanlan; 2001, Scanlan; 2001a, 2003, Brady et al., 2007, Austin et al., 2012).

UPG's negative impact on APS demonstrates that as a result of increase in the urban population the APS decreases in developing countries. Urban population growth in developing countries can lead to a decrease in the APS by constraining land availability as rapid UPG leads to the conversion of arable agricultural land into commercial and residential areas which reduces agricultural production and availability of protein rich food. Secondly, UPG can exacerbate environmental issues like deforestation, soil degradation and pollution. These factors can collectively contribute to a decrease in production and availability of protein-rich food stuff in urban areas, thereby impacting the FS negatively by reducing food availability. Our results concerning the second long-run demand-side driver of FS are also in line with the previous research. UPG is associated with decrease in food availability (Hossain, 2020). Regarding UPG our results contradict a body of research.[1]

Turning to the short-run demand-side driver of FS of our study i.e. ODA, our results have shown positive impact on food availability. This implies that as ODA increases it will result in an increase in investment in agriculture, infrastructure development and improved access to markets resulting in increase in APS, which in turn enhance food availability in developing countries. FS improves as a result of increased food availability. Our finding about the impact of ODA seconds the findings of a recent study (Gicharu; 2021). The study indicates positive impact of ODA on agricultural productivity and concludes FS boosted as a result of increased productivity.

Table 7: MM-QR Results of Short-run and Long-run Demand-side Model based on Food Access

DV= Prevalence of Undernourishment (PUN)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
ARM	0.136*** (0.0323)	0.112*** (0.0217)	-0.00796 (0.0284)	0.0330 (0.0267)	0.102*** (0.0293)	0.220*** (0.0436)	0.333*** (0.0619)
GI	0.113** (0.0441)	0.0623** (0.0296)	0.0336 (0.0389)	0.0563 (0.0366)	0.0944** (0.0398)	0.160*** (0.0594)	0.222*** (0.0848)
HLIS	0.0889 (0.0679)	-0.0958** (0.0456)	0.212*** (0.0598)	0.177*** (0.0563)	0.118* (0.0612)	0.0176 (0.0914)	-0.0786 (0.130)
GDPPC	-0.149* (0.0845)	-0.0516 (0.0888)	-0.0666 (0.209)	-0.109 (0.141)	-0.159** (0.0739)	-0.192*** (0.0626)	-0.226** (0.0946)
UPG	1.719*** (0.210)	-0.0554 (0.141)	1.790*** (0.185)	1.770*** (0.174)	1.736*** (0.189)	1.678*** (0.283)	1.622*** (0.404)
PG	0.782** (0.331)	0.347 (0.222)	0.337 (0.292)	0.463* (0.275)	0.676** (0.298)	1.041** (0.446)	1.389** (0.636)

[1] Urbanization is generally associated with improvements in FS (Jenkins and Scanlan, 2001; Scanlan, 2003; Austin et al., 2012; Brady; 2007).

ODA	-0.247***	-0.0176	-0.220***	-0.233***	-0.246***	-0.262***	-0.274***
	(0.0305)	(0.0202)	(0.0363)	(0.0300)	(0.0301)	(0.0393)	(0.0499)
Constant	5.052***	7.733***	-4.859***	-2.045*	2.681**	10.80***	18.56***
	(1.419)	(0.954)	(1.255)	(1.178)	(1.292)	(1.920)	(2.729)
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

The MMQR results for our second model of short-run and long-run demand-side drivers of FS based on second dimension of FS i.e. food access are shown in Table 7. Here, we have used prevalence of undernourishment (PUN) as dependent variable, while the independent variables are same as our previous model. Starting with agricultural exports variable, the results have shown a positive impact of ARM on PUN. It means that as agricultural exports increase it results in increased undernourishment i.e. increase in ARM decreases FS. Our analysis aligns with numerous previous studies (Shandra et al., 2009a, Shandra et al., 2009b, Austin; 2010a, Austin et al., 2010b, Austin et al., 2012, Mejia., 2022, Mejia., 2023, Sumner., 2000, Tiongco & Francisco; 2011). These studies highlight the harmful impact of primary sector exports from developing countries on undernourishment rates.

As expected, here undernourishment increases as a result of increased income inequality shown by the results of both variables related to income inequality i.e. GI and HLIS. In other words, the results imply that as income inequality increases it deteriorates the state of FS in developing countries by augmenting the prevalence of undernourishment. Our study supports similar findings from previous research conducted by Subramanian et al., (2007) and Grzelak (2017), both of which suggest that income inequality is positively associated with the risk of malnutrition and undernourishment. Previous research based on relative income has predicted that rising income inequality within a group result in a drop in the number of individuals with higher incomes and an increase in those with lower incomes. As a consequence, this can negatively affect the nutrition as well as healthiness of individuals, particularly those in the low-income bracket (Armstrong, 2003; Liu et al., 2021).

Most of the quantiles indicate a significant and negative impact of GDPPC on PUN. It shows that increase in GDPPC is associated with decrease in PUN in case of developing countries. As GDPPC increases it leads to higher incomes of individuals and their purchasing power. These bring about an increase in improved access to healthy and nutritious food and ultimately to increased productivity. Such increased productivity can be translated into greater incomes as healthy and nutritious individuals are capable to work more effectively and efficiently. This can again improve the purchasing power of individuals and their access to food, consequently increased FS in developing countries. The result is agreeing by prior research conducted by Lee & Brown (1989), Thiele & Weiss (2003), and Annim & Frempong (2018), which show increased incomes as a result of better-quality diets. We also find some studies which complements the role of economic growth in improving food accessibility and decreasing undernourishment (Soriana & Garrido, 2016; O'Connell & Smith, 2016; Jaworska, 2018).

Both variables of the long-run demand-side drivers of FS i.e. UPG & PG have unveiled positive influence on PUN. The positive effect of UPG on PUN indicates that rise in urban population growth gives rise to nourishment in developing countries. The increase in UPG results in a rise in PUN by changing livelihoods, increased costs of living, environmental challenges and income inequality. These economic determinants can hamper the right to healthy and nourishing food by contributing to undernourishment. Especially the vulnerable urban populations with reduced ability to afford adequate and diverse sources of nutrition due to limited purchasing power are affected. Such undernourishment can cause the cognitive and physical abilities to decrease which results in decreased productivity and earning capabilities. Due to such reduced productivity and decreased income access to food can be limited. Our results are same as the conclusion of Fathelrahman et al., (2022), which also confirmed that undernourishment is caused by urbanization due to nutritional transition.

As regards, the effect of population growth is analyzed; it also has positive impact on the prevalence of undernourishment. This result suggests that PG causes undernourishment in developing countries. The already limited resources in developing countries such as water, land and energy can drain by rapidly growing population. Agricultural productivity decreases in this way and result in limited access to food due to increase in food prices. All this limits the availability and affordability of nutritious foods, leading to undernourishment. Population growth can also exacerbate environmental degradation along with income inequality and poverty in developing countries. All these factors collectively worsen the undernutrition in developing countries. A body of research complements our result of positive impact of population growth on PUN. Food security and undernourishment is caused by population growth (Dawson et al., 2016; Hall et al., 2017; Mughal & Fontan, 2020).

Finally, the short-run demand-side driver of FS has depicted a negative and significant impact on PUN. It implicates that increase in ODA reduces PUN or in other words increase in ODA increases FS in case of developing countries. ODA can play a vital role in reducing undernourishment by providing funding for nutrition interventions such as food assistance programs, nutrition education and micronutrient supplementation, supporting agricultural and rural development, enhancing social protection measures and by strengthening health systems. This is also consistent with the result of a recently conducted empirical study (Gicharu, 2021; Khan et al., 2022).

Table 8 is showing the MMQR results of short-run and long-run demand-side drivers of FS based on its third dimension known as food stability. Here, the food stability is measured through PFPV. According to the results, depicted by Table 8, MMQR results show that the effect of Agricultural exports captured by the ARM on PFPV is statistically significant across the quantiles with the positive impact. The positive results show that when developing countries give precedence to the agricultural exports, they may shift resources from the food production for local consumption which results in food shortages and higher prices.

Table 8: MM-QR Results of Short-run and Long-run Demand-side Model based on Food Stability

DV= Per-Capita Food Production Variability (PFPV)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
ARM	0.225***	0.0785***	0.111***	0.152***	0.214***	0.294***	0.358***
	(0.0177)	(0.0106)	(0.0184)	(0.0166)	(0.0172)	(0.0230)	(0.0298)
GI	0.168**	0.00250	0.164*	0.166**	0.168**	0.170	0.172
	(0.0857)	(0.0518)	(0.0902)	(0.0802)	(0.0829)	(0.110)	(0.145)
HLIS	0.162**	0.0233	0.128	0.141*	0.159**	0.183*	0.202
	(0.0780)	(0.0468)	(0.0810)	(0.0729)	(0.0757)	(0.101)	(0.131)
GDPPC	-0.377***	-0.153***	-0.155***	-0.235***	-0.356***	-0.511***	-0.636***
	(0.0574)	(0.0345)	(0.0597)	(0.0538)	(0.0558)	(0.0746)	(0.0968)
UPG	-0.576	-0.608	0.116	-0.0321	-0.293	-0.791	-1.588
	(0.892)	(1.185)	(0.471)	(0.202)	(0.347)	(1.295)	(2.831)
PG	-1.863	-0.812	-0.937	-1.136***	-1.484**	-2.150	-3.215
	(1.611)	(2.139)	(0.852)	(0.366)	(0.627)	(2.342)	(5.120)
ODA	0.00255	0.00569*	-0.00728	-0.00168	0.00326	0.00777*	0.0111**
	(0.00443)	(0.00308)	(0.00827)	(0.00581)	(0.00428)	(0.00409)	(0.00481)
Constant	17.98***	12.97	3.205	6.374***	11.93***	22.55**	39.55**
	(6.627)	(8.802)	(3.303)	(1.432)	(2.448)	(9.090)	(19.88)
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

Results of Table 8 indicates that both variables used for income inequality i.e. GI and HLIS has shown positive and significant impact on food stability which is measured through PFPV. It demonstrates that as income inequality increases it results in increased variability in food production per capita. Our results implicates that an increase in GI and HLIS (higher income inequality) may result in low or limited access of majority of population of developing countries to agricultural inputs like fertilizers, seeds, investment opportunities and technology. All these factors contribute in increased variability in food production and ultimately food stability is decreased and food security is compromised.

Our results have shown negative and significant impact of GDPPC on PFPV. It implicates that as GDP per capita of developing countries increases the individuals of such countries have more incomes at their disposal that can be invested in agricultural sector such as in more sophisticated and advanced techniques of production. More investment and adoption of technology can be opted so that the decrease in variability of food production can be ensured. As a result of decrease in food production variability, stability of food is increased and food security can be enhanced.

According to our results there is insignificant impact of UPG (demand side factor) on PFPV, while Population growth (PG) has negative impact on PFPV for 25th and 50th quantiles. It shows that as population increases it results in increased per capita food production variability. It can be justified that as population grows demand for food will also rise. As a result of such increased demand output is also increased. When agricultural output is increased it automatically causes a fall in per capita food production variability. Due to decrease in PFPV, stability of food increases and food security improves.

Results of Table 8 have shown that ODA positively impact PFPV of developing countries. It means that when developing countries receive ODA it results in increased variability in food production. There might be some reasons for such effect. Firstly, it is possible that the execution of ODA initiatives encompasses a period of change during which modifications are being implemented in the realm of agricultural methods, infrastructure or technology. Throughout this transitional phase, there could potentially be momentary disruptions that result in heightened variability. ODA has the potential to be assigned to sectors beyond agriculture that possess an indirect impact on food production. In the event that resources are diverted away from agriculture, it could potentially translate into a rise in PFPV despite the aid provided for overall development. Results of studies conducted by Schultz (1960) and Gao (2016) compliments the results of our study. As food aid exerted disincentive effect on food production through depression in food markets resulted by fall in the prices of food stuff due to increase in local food supplies.

The MMQR results for our last model of short-run and long-run demand-side drivers of FS based on its fourth dimension i.e. food utilization by taking people using improved drinking water (IDW) as proxy variable have depicted in Table 9.

Table 9: MM-QR Results of Short-run and Long-run Demand-side Model based on Food Utilization

DV= People Using Improved Drinking Water (IDW)							
Variables	**Location**	**Scale**	**Q 0.10**	**Q 0.25**	**Q 0.50**	**Q 0.75**	**Q 0.90**
ARM	-0.239***	0.0652	-0.347***	-0.285***	-0.218***	-0.177***	-0.152**
	(0.0496)	(0.0398)	(0.0890)	(0.0609)	(0.0491)	(0.0572)	(0.0661)
GI	-0.288***	0.0124	-0.308**	-0.296***	-0.284***	-0.276***	-0.271**
	(0.0833)	(0.0668)	(0.149)	(0.102)	(0.0826)	(0.0963)	(0.111)
HLIS	0.448***	-0.000312	-0.449***	-0.448***	-0.448***	-0.448***	-0.448***
	(0.0306)	(0.0202)	(0.0363)	(0.0300)	(0.0302)	(0.0393)	(0.0499)
GDPPC	0.650***	0.116***	0.472***	0.554***	0.643***	0.748***	0.828***
	(0.0207)	(0.0137)	(0.0247)	(0.0205)	(0.0205)	(0.0265)	(0.0336)
UPG	-2.548***	0.405	-3.221***	-2.834***	-2.418***	-2.161***	-2.011***
	(0.380)	(0.305)	(0.681)	(0.466)	(0.376)	(0.438)	(0.507)
PG	-2.795***	1.608***	-5.470***	-3.930***	-2.281***	-1.260**	-0.661
	(0.549)	(0.440)	(0.985)	(0.673)	(0.542)	(0.629)	(0.727)
ODA	0.0382***	0.00455***	0.0304***	0.0349***	0.0386***	0.0422***	0.0448***
	(0.00228)	(0.00160)	(0.00427)	(0.00299)	(0.00222)	(0.00208)	(0.00243)
Constant	99.53***	8.936***	84.67***	93.22***	102.4***	108.1***	111.4***
	(2.626)	(2.105)	(4.720)	(3.228)	(2.607)	(3.034)	(3.506)
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

MMQR results of the present study indicate a significantly negative relationship between ARM and IDW, across all quantiles. This suggests that an increase in ARM leads to limited access to safe drinking water, that attributes to water pollution caused by agricultural activities such as the use of fertilizers and pesticides. Moreover, agriculture, being a water-intensive industry, consumes a significant amount of water in producing crops for export, thereby straining local water resources and reducing attainment of safe drinking water for the local population. This drop in the access to IDW has repercussions for the utilization dimension of FS which includes nutritional quality, safety and sanitation attributes of food consumption. In general, the study identifies that increase in agricultural production for export reason can cause water pollution and limited access to safe drinking water, eventually worsening FS challenges in developing countries. These findings are aligned with an earlier study's results by Rudra (2011), who also highlights the damaging impact of agricultural exports on availability of IDW in developing countries.

Consistent with the impact of ARM, study indicates that GI has a negative effect on the "utilization" dimension of FS across all quantiles. The outcomes suggest that as income inequality rises, access to improved drinking water diminishes. These findings are similar with the results of previous research (Sassi, 2006; Rudra, 2011), which also emphasize the damaging effects of income inequality on IDW. Our study highlights the detrimental impact of income inequality on IDW, and its resulting effects on the FS of developing countries.

For the effect of HLIS on utilization dimension measured through IDW is significant and negative. It suggests that income inequality measured by the income share ratio of the top 20% and the bottom 20%, corresponds to decreased access to IDW for the developing countries. Higher HLIS values indicate a decrease in income share for the poorest segments of the population, suggesting that IDW primarily benefits those in the upper income distribution. This supports previous studies that have found that IDW is significantly divided between the wealthiest and poorest quintiles in low- and middle-income countries (Hong et al., 2006, Yang et al., 2013).

Our MMQR study has shown that there is significant and positive association of GDPPC and FS in developing countries. This suggests that as the GDP per capita increases, people have access to IDW, which leads to improved utilization of food. The findings of our study indicate that as developing countries experience economic growth, they invest more resources in infrastructure and awareness campaigns to provide IDW, resulting in increased access to improved drinking water. This, in turn, contributes to FS as more people are able to utilize food effectively. These results align with previous research that has demonstrated that economic growth is beneficial for food utilization through increased access to improved drinking water, as it leads to decreased undernourishment through investments in health, education, and water access (Soriano & Garrido, 2016).

The results of long-run demand side drivers of FS included in our research for this model are same as the results of previous models based on food availability and food access. As the impact of UPG is negative and statistically significant for all quantiles, which indicate that due to the urban population growth the use of IDW developing countries decreases. The expansion of urban populations exerts stress on existing infrastructure, particularly on water supply and sanitation systems. Often, these systems are cannot keep up with the rapidly rising requirements, leading to unreliable or inadequate access to clean drinking water. Furthermore, developing countries often lack the financial means to invest in and uphold the essential infrastructure required to meet the escalating demand for potable water, thereby presenting obstacles in providing access to improved drinking water for their citizens. Our results align with previous studies by contending that informal urbanization developments, such as slums, have adverse impacts on water supply and sanitation conditions due to the challenges faced by local authorities in managing and organizing the substantial influx of people migrating from rural areas (Dondeynaz et al., 2012, Saladini et al., 2018).

For the second long-run demand-side driver of FS i.e. PG (population growth), our results have also shown negative impact on IDW. It implicates that population growth serves as an impediment for improved drinking water access by the population of developing countries. As the population grows, the demand for water increases, and the available sources of improved drinking water become scarce. In many developing countries, usually the existing water supply infrastructure, including water treatment and distribution networks, is unable to keep up with the increasing demand. Hence, increasing population growth can result in decreased access to improved drinking water, negatively impacting people's health, hygiene, and quality of life. As a result, due to decrease in access to improved drinking water, utilization of food decreases and ultimately FS status of developing countries intensifies. Our results seem to support Saladini et al., 2018, who found that with population growth as a factor, the demand for municipal and agricultural water is increasing, even as available water resources continue to decline.

Finally, the impact of ODA on IDW is positively significant for all quantiles. This conveys that ODA allocation towards water and sanitation infrastructure projects and programs can lead to a significant improvement in access to IDW in developing countries. ODA can support the construction and maintenance of water supply infrastructure, such as wells, boreholes, pipelines, and treatment plants. This can help improve access to clean water for communities in remote or underserved areas, where safe drinking water may be lacking or inadequate. ODA can also support the establishment of water distribution systems to ensure that clean water reaches the intended beneficiaries. Due to increase in the usage of IDW by the people of developing countries, the food utilization is enhanced leading to improved FS. These results seem coherent with results of Botting et al., (2010); Wayland, (2013) and Gomez et al., (2019), who found that ODA is positively related to water access. We also found two studies that contradict the findings of our study.[2]

5. Conclusions and Policy Implications

This study explored the impact of demand-side drivers on all dimensions of food security for developing countries. By employing MMQR the analysis carried out for 1990-2020. The results of our research validate the Malthusian theory of population growth by showing negative impact of both long-run demand-side drivers on all FS dimensions. The study has found a positive impact of short-run demand-side driver (ODA) on FS i.e. on availability and utilization. As well as, ODA can reduce undernourishment by funding nutrition interventions, supporting agricultural and rural development, enhancing social protection measures, and strengthening health systems, leading to improved access to nutritious food in developing countries. Moreover, ODA can improve access to clean water through construction and maintenance of water supply infrastructure, enhancing food utilization and FS in developing countries. Moreover, the present research suggests that ODA has a positive effect on agricultural productivity, leading to improved FS due to increased productivity.

Bades on the results of the present study, here are some policy implications for developing countries to enhance their food security:

- To avoid the detrimental effects of population growth on FS the developing nations are required to promote family planning. In this regard, these nations must provide incentives to the families who opt for family planning. Moreover, this can be achieved through peoples' access to education, financial incentives or preferential access to healthcare services.
- As ODA (official development assistance) play major role in improving food security of developing countries, so developing countries should actively engage with international donors to secure technical and financial assistance for food security initiatives, agricultural development and nutrition programs.

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