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The Dynamics of Food Supply and Undernourishment in Sub-Saharan Africa

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Abstract: Food insecurity and malnutrition is the most fundamental challenge in Sub-Saharan Africa (SSA). This paper examines the dynamics of food supply in SSA for a panel of 42 countries over the period 1994-2009. Ordinal measures of national food supply status of SSA countries are generated from daily calorie supply per capita. The dynamics of food supply status, transition rates, and the associated forces underpinning this dynamic process are analyzed and stylized by parametric and non-parametric measures. Economic and socio-demographic factors and unobserved regional heterogeneities determining the dynamics of food supply are identified by random-effects ordered probit model. The transition rates suggested that, each year, 54 percent of the countries with very low food supply remained in the same food insecurity situation for five years while only 15 percent with low food supply shifted up to medium food supply level. However, the vast majority of the countries (81%) with low food supply situation remained in the same food supply status and the rest 5 percent rather faced a downturn in food supply. In conclusion, the econometric model outputs confirm that the food supply of SSA countries is improved by agricultural production and industrial GDP, but adversely affected by military expenditure, price inflation, proportion of rural population, age dependency ratio, and unobserved regional heterogeneities.

Keywords: Calorie supply per capita; Undernourishment; Random-Effects Ordered Probit; SSA

1. Introduction

Food insecurity remains the most fundamental challenge for human welfare and economic growth in Sub-Saharan Africa (SSA). Evidences by Maxwell and Slater (2003), Benson (2004), Mwaniki (2005), and Kidane *et al.* (2006) verify the underlying factors contributing to either insufficient national food availability or insufficient access to food by households and individuals. Unstable social and political environments that preclude sustainable economic growth, war and civil strife, macroeconomic imbalances in trade, and natural resource constraints are the major challenges constraining food security in SSA. Other challenges include underdeveloped agricultural sector, barriers to market access, effects of globalization, disease and infection, handicapping policies,poor human resource base, gender inequality, inadequate education, natural disasters, and the absence of good governance (Maxwell and Slater, 2003; Benson, 2004; Kidane *et al.*,2006).

The physical availability of food is a function of productive agriculture, effective trade infrastructure, and efficient food aid logistics while economic access is a function of prices and incomes (Abele *et al.*, 2007). According to this evidence, economic growth and social security policies are important for generating and preserving the entitlements to food., calorie intake may be affected by the socio-demographic characteristics of households, the endowment of resources to produce own food, the factors affecting food production and the available off-farm income to purchase food from the market.

The right of access to food in SSA is generally determined by availability of agricultural resources; increase in the demand for food as a result of the increase in population, increase in personal income, development of transportation and storage facilities, macroeconomic and socio-political stability; seasonal fluctuation in availability of food due to natural disaster, access to safe water, access to health care services, and access to sanitation facilities (Adeyemi *et al.*, 2009).

Broad-based economic growth is suggested to reduce hunger and malnutrition in SSA (Benson, 2004; Zhang, 2004; World Bank, 2008). It could be achieved through enhanced economic productivity, which in turn comes about through broad improvements in the intellectual and technical capacity of the population. The potential intellectual and technical capacity of the population is dependent on improved nutrition and the effective utilization of such capacity. In this regard, agriculture is believed to be the leading candidate to bring about rapid growth and broad-based economic development in SSA and other developing countries.

Agriculture holds a prominent place in these economies and constitutes the primary source of export earnings, employment, poverty reduction, stimulates development of rural non-farm activities, generates capital surplus, release labor for other sectors and provides a stable food supply at affordable prices, thus contributing to the competitiveness of the economy as a whole and acting as a major source of stimulus for the demand for goods and services of other sectors (Kidane *et al.*, 2006).

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The food security benefits of food price stabilization policies through competitive and efficient trade and the efficiency gains from a shift to market orientation is the other possible policy imperative in SSA (Dorosh, 2009). This evidence alsodocuments the absence of sufficient instruments or resources to achieve objectives that relate to the level and stability of prices, the volume of food transfers to the poor, and the level of stocks. Empirical evidence suggests that a rapid growth in staple production, together with more integrated regional markets, would reduce food prices for both consumers and producers in SSA (Diao *et al*., 2008). This translates into a large rise in farm revenues, higher annual agricultural growth rate, broader income growth and food security, and poverty reduction. While policies promoting broad-based economic growth are fundamental to overall social development in SSA, the distribution of benefits of growth to the poorest and the most marginalized is strongly argued (Devereux and Sabates-Wheeler, 2004; UNICEF, 2008; Devereux, 2009). There is a need to initiate comprehensive social protection programs and interventions to provide income or consumption transfers to the poor, protect the vulnerable against livelihood risks, and enhance the social status and rights of the marginalized. This is partly verified by recent crises in low-income SSA countries which were triggered by a decline in agricultural production and exacerbated by food price spikes and asset price collapses (Devereux and Sabates-Wheeler, 2004).

Food security could be measured at national, household, and individual levels (Radimer *et al.,* 1990; Bickel *et al*., 2000; FAO, 2009). Measuring food security at the national level entails determining the amount of food available in the country and the extent to which it provides the recommended minimum calorie intake per person per day (FAO and WHO, 1985; FAO, 1996; Jacobs and Sumner, 2002). The central defining features of food security comprises adequacy of food availability, stability of supply, physical and economic accessibility of food, and quality and safety of food (Ruel, 2002, 2003; Swindale and Ohri-Vachaspati, 2005). Availability of food at national level is a necessary condition for achieving food security but it is not sufficient to ensure food security at household and individual levels (Smith and Subandoro, 2007). The percentage of population that are food energy deficient is the indicator used to monitor countries' progress in meeting international goals such as the Millennium Development Goal (MDG) of halving the proportion of people who suffer from hunger by 2015 (UN, 2009). This study makes use of daily calorie supply per capita as the conventional outcome indicator of aggregate food availability at a national level. Daily calorie supply per capita could be measured based on consumption per equivalent male adult or consumption based on age and sex without converting into equivalent male adult, as first recommended by WHO and FAO (1985) and later improved by FAO (2001, 2008). Aggregate food balance sheet of countries in SSA could serve this purpose.

The primary limiting factor in analyzing food supply dynamics of countries is data availability for employing standard and robust methodologies of food security analysis. The annual timeseries dataset on food supply and other development indicators available at the FAO and the World Bank global databases are recent experiences with limited samples and missing values. To account for these problems, this study constructs a panel dataset of SSA countries over the period 1994-2009 for four rounds with five-year intervals. This method creates more data points and accounts for problems associated with analysis of simple timeseries or simple cross-sectional units.

The study contributes to the empirical literature of food policy analysis in developing countries in general and in SSA in particular. First, stylized facts on the food supply performance of SSA and the economic, socio-demographic and regional heterogeneities determining food supply levels of countries are documented. Following FAO and WHO (1985), Hoddinott (1999), Bouis and Hunt (1999), FAO (2001), and Smith and Subandoro (2007), countries were categorized into three groups based on their food supply levels as *very low* (less than 2050 kcal), *low* (between 2050 and 2500 kcal), and *medium* (between 2500 and 3000 kcal). This approach is relevant to identify some commonalities within groups of countries for differentiated food policy formulation and intervention strategies ideally suited to countries of common factor. The stylized facts generated from non-parametric analysis point out that most SSA countries have markedly exhibited monotonically increasing trends in their calorie supply, leading to declining prevalence of undernourishment. The mean regional and inter-temporal daily calorie supply in SSA over the years are increasing but significantly different across regions.

Second, the forces affecting the spatial and inter-temporal dynamics of national food supply per capita are consistently identified and the likelihood of SSA to face the incidence of falling in each of the food supply levels is predicted. The parametric model results, after controlling for country and regional fundamentals, suggest that food supply levels of countries (*very low*, *low*, and *medium*) are significantly associated with agricultural production, industrial GDP, military expenditure, inflation level, proportion of rural population, age dependency ratio, and regional heterogeneities.

2. Methodology

2.1. The Dataset

The current measure of food insecurity is based on the measure of undernourishment developed by FAO (Naiken, 2003). It is a direct measure of the diet quantity aspect of the definition of food security related to access to sufficient food for an active, healthy life. One of these groups of indicators is daily calorie supply per capita. FAO (2011) defines calorie supply per capita as the amount of food available for consumption, measured in kilocalories (kcal) per capita per day. This figure is reached by dividing the total available food supply for human consumption by the population. The FAO global dataset tracks the calorie supply per capita in each country for calories available from crop products. This indicator shows the per capita supply of total calories and the split between calories from animal and vegetal products.

While daily calorie supply per capita serves as a measure of calorie availability, the distribution of available food across a country's population per capita energy requirement are usually employed to predict estimates of the prevalence of undernourishment. Prevalence of undernourishment is the percentage of people in a population group or country who are food energy deficient. The prevalent of undernourishment has been used to monitor progress toward the Millennium Development Goal of halving the proportion of people in extreme poverty and hunger by 2015. Percent of people severely food energy deficient is benchmarked at 2,050 kilocalories for a very low value of this indicator (Smith and Subandoro, 2007).

The annual timeseries data on daily calorie supply per capita and the African development indicators used in this study were obtained from FAO and The World Bank (FAO, 2012; World Bank, 2012). Africa development indicators are the primary collection of such development indicators on Africa, compiled by the World Bank from official sources since 1960 (World Bank, 2014). The indicators present current and accurate global development data available, which include national, regional and global estimates of indicators of development in SSA. Statistical information on these indicatorsis crucial for conceptual and policy-planning tools based on facts and for providing improved support for policy implementation, monitoring of progress, and assessment of the results and impact of development initiatives in SSA (UNECA, 2012).

In this study, country and regional fundamentals such as economic, socio-demographic and regional indicators were hypothesized to be potential sources of dynamics associated with national food availability in SSA over the years. A panel dataset of 42 SSA countries was constructed in four rounds with five-year intervals since 1994 (1994, 1999, 2004 and 2009). Accordingly, a database of 168 data points was generated for this purpose.

Economic factors including agricultural production and industrial GDP were assumed to improve national food availability while military expenditure and annual inflation level (as a proxy for economic access to food) were hypothesized to depress national per capita food supply. Socio-demographic factors like proportion of rural population, age dependency ratio and HIV prevalence rate were expected to adversely affect food supply per capita. Region-specific factors such as instability of social and political environments, war and civil strife, natural resource constraints, natural disasters, and the absence of good governance or weak democratic system were proxied by four regional dummies in SSA (Southern, Western, Eastern and Middle Africa). Western Africa, the most likely outcome comprising 16 countries, was used as a base category of regional comparison of food supply level.

2.2. Conceptual Framework and Empirical Model

Most SSA countries are in a dynamic process to improve their food security situation. There are economic, socio-demographic, and regional heterogeneities influencing this dynamic process. The empirical knowledge on the factors determining the level of daily calorie per capita supply of countries from lower to higher category (*very low*, *low*, and *medium*) is relevant to food security policy formulation and implementation. Moreover, the likelihood of countries falling in one of the three categories and the factors associated with this food supply situation is a central policy imperative.

A sizeable literature on food policy analysis suggests the importance of stratifying daily calorie supply per capita into four distinct categories or levels (FAO and WHO, 1985; Bouis and Hunt, 1999; Hoddinott, 1999; FAO, 2001; Smith and Subandoro, 2007). Accordingly, the minimum cut-off point for daily calorie supply per capita is regarded as *very low* (below 2050). The other levels of food security situation measured by daily calorie supply per capita are *low* (between 2050 and 2500), *medium* (between 2500 and 3000), and *high* (3000 and above). Simplifying the food supply continuum into such small set of categories, each one representing a meaningful range of food supply situation, and explaining the proportion of countries falling in each of these categories is useful information both for policy and research purposes.

The key strength of such categorical measures employed in this study is that it captures and distinguishes the variouslevels of food availability throughout the full range of the food supply continuum with which the phenomenon of foodshortage is experienced in SSA. This feature is critical for accurately assessing theprevalenceand likelihood of sufficient food availability. It enables to identify the masked heterogeneities in the mean value of food energy continuum and to characterize some commonalities of countries falling in each category of food supply situation. In addition, estimation of problems related to endogeneity expected in linear

panel estimators can easily be controlled by using nonlinear models of such categorical outcome measures.

The distribution of daily calorie supply per capita in SSA depicted by the kernel density estimate is shown (Figure 1). The two vertical long and short dashes denote the threshold calorie levels separating *very low* or severe undernourishment (below 2050 kcal), low or moderate undernourishment, and medium-to-highundernourishment. The figure illustrates the proportion of countries falling in each food supply category. For consistent and unbiased estimation of models of categorical outcomes, sufficient number of observations should fall in each category. The distribution clearly reflects the relevance of modelling the dynamics of daily calorie supply status in SSA using these ordinal outcome models.

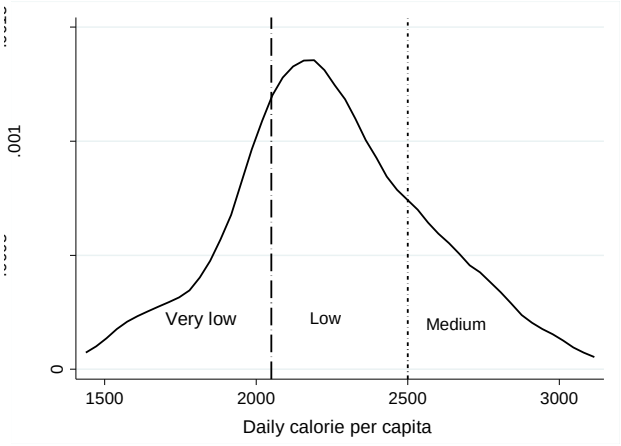

Figure 1: Distribution of daily calorie supply per capita in SSA.

Food availability, be it at global, national, or local community level, is an essential and universal dimension of household and personal well-being (Bickel *et al*., 2000). Each stage of calorie supply level is assumed consisting of characteristic conditions and experiences of food sufficiency and of the proactive responses of countries to these conditions. Analyzing national and regional food energy supply per capita can help identify and comprehend this basic aspect of well-being of populations and to recognize population subgroups or regions which are exceptionally worse-off or better-off with the associated forces influencing this dynamic process.

While many different models have been designed for ordinal outcomes introduced by McKelvey and Zavoina in 1975, this study employs the probit version of the ordinal regression model in terms of an underlying latent variable but extends to panel data estimators. The dynamics of food supply level and the factors associated with this dynamic process in SSA over the period could be estimated by ordered panel probit models (Arellano, 2003; Skrondal and Rabe-Hesketh, 2004; Pfarr *et al.,* 2011; Rabe-Hesketh and Skrondal, 2012; Twisk, 2013).

This study employs the random-effects ordered probit estimator and uses the new estimation commands in-built in Stata 13. The structural model of the random-effects ordered probit regression is presented as a latent variable model, where observed ordinal responses y_{it} are generated from the latent continuous responses (Kaiser and Spitz-Oener, 2000; Alsakka and ap Gwilym, 2009; Greene, 2012)

$$y_{it}^{*} = x_{it}\beta + v_i + \varepsilon \quad 1 \qquad (1)$$

where y_{it}^{*} is a latent variable (food supply status) ranging from $-\infty$ to ∞; i is the observation (countries); $\mathbf{x}$ is a vector of economic, socio-demographic, and regional dummies determining food supply levels; $\boldsymbol{\beta}$ is a vector of unknown parameters to be estimated; v is the time-invariant country-specific random variable with unobservable country heterogeneity and assumed to be unrelated to any independent variable in the random-effects; and the ε_{it} are errors assumed to be independent of v_i (independent among time and countries) and distributed as standard normal with mean zero and variance one.

The measurement modelfor ordered outcomes can be obtained by expanding the measurement model for binary outcomes by dividing the latent variable into J ordinal categories:

$$y_{it} = m_i \text{ if } m_{i-1} < y_{it}^{*} < \tau_m \; 2 \quad \text{for } m = 1 \text{ to } J. \qquad (2)$$

Therefore, the latent variable could be measured as:

$$y_{it} = \begin{cases} 1 \Rightarrow \text{very low calorie } (y_{it} < 2050) & \text{if } \tau_0 = -\infty \le y_{it}^{*} \le \tau_1 \\ 2 \Rightarrow \text{Low calorie } (2050 \le y_{it} < 2500) & \text{if } \tau_1 = \tau_1 \le y_{it}^{*} \le \tau_2 \\ 3 \Rightarrow \text{Medium calorie } (y_{it} \ge 2500) & \text{if } \tau_2 = \tau_2 \le y_{it}^{*} \le \tau_3 = \infty. \end{cases} \qquad (3)$$

The cutpoints (or the threshold parameters) τ_1 through τ_{J-1} can be estimated. Thus, when the latent y^{*} crosses a cutpoint, the observed category of food supply level changes. The outcome will be in the second ordered category (low calorie supply) or higher if $\tau_1 = \tau_1 \le y_{it}^{*} \le \tau_2$. The outcome will be in the third ordered category (medium) or higher (not the first or second) if $\tau_2 = \tau_2 \le y_{it}^{*} \le \tau_3$.

3. Results and Discussion

3.1. Description of Variables

The economic, socio-demographic and regional factors hypothesized to influence food supply levels are described in Table 1. The mean values of these variables are reported by food supply level of countries in SSA. There are important differences in the mean values of the basic structural features of food supply situation in SSA countries across the three levels of food supply. Unlike the countries with relatively better food supply, countries with *very low* food supply are characterized by lower agricultural production and industrial GDP, high military expenditure (as a proxy for political instability and civil strife), high (or two-digit) inflation of consumer prices, high proportion of rural population, high age dependency ratio, and high HIV prevalence rate.

Table 1. Variables affecting food supply per capita levels in SSA.

Variable	Mean values by levels of food supply			
	Very low	*Low*	*Medium*	All (SSA)
Agriculture production index (2004-2006 = 100)	80.64	93.70	99.16	91.51
Industry, value added (% of GDP)	24.21	25.41	29.47	25.91
Military expenditure (% of GDP)	6.16	2.07	1.39	2.96
Annual inflation (%)	51.85	14.49	4.65	21.90
Annual inflation level [1 if high (>10%), 0 otherwise]	0.64	0.31	0.15	0.36
HIV prevalence rate (population aged 15-24 years)	7.25	6.64	4.08	6.29
Rural population (% of total population)	73.53	66.58	52.32	65.51
Age dependency ratio (% of working-age population)	91.05	87.93	75.69	86.30
Southern Africa	0.02	0.16	0.12	0.12
Eastern Africa	0.67	0.30	0.12	0.36
Middle Africa	0.24	0.12	0.09	0.14
Western Africa	0.07	0.42	0.67	0.38

Agricultural production, as proxied by agricultural production index (based on 2004-2006 years), consistently varies from nearly 81 percent in countries with*very low* supply to 99 percent in countries with*medium* supply, a difference of 19 percentage points increasing monotonically with food supply level of the countries. This large and systematic difference across food supply levels markedly explains agricultural production as the major source of variation in food supply levels. This signifies that agricultural production remains the central feature of food availability in SSA.

Industrial GDP, as a proxy for structural transformation in SSA, is consistent with the implications of agricultural production. The mean difference between countries with *very low* and *low* food supply level is quite small but significantly large when compared with countries with *medium* food supply. Industrial growth creates job opportunities and enables to withdraw idle labor force from primary activities (agriculture and related enterprises) to secondary and tertiary activities ((Dabla-Norris, 2013; Duarte, 2010).. This opportunity secures economic access to food by creating other sources of food. .

The mean military expenditure, as a percentage of GDP, in SSA is about 3 percent. This figure considerably varies from 1.4 percent in countries with *medium* food supply to 6.2 percent in those with *very low*food supply. As evidenced by Maxwell and Slater (2003), Benson, (2004), and Kidane *et al.* (2006), this pattern of military expenditure in the study period could be explained by the incidences of war and civil strife experienced in Eastern Africa including Rwanda, Uganda, Ethiopia, Eritrea, andthe Sudan and Middle African (Angola, Chad, and Democratic Republicof Congo). Occurrence of drought is the other factor negatively affecting food supply in these regions. Compared to Western Africa, food availability in Eastern, Middle and Southern Africa is generally worse-off in the study period.

Inflation of consumer prices is becoming an increasingly important policy imperative of all economies. The mean annual inflation in SSA has been proportionally increasing with decreasing food supply levels, which is suggestive of the negative association between inflation and food availability. The annual inflation of consumer prices is about 52 percent in countries with *very low* food supply level, but it drastically and monotonically decreases in countries with *low* and *medium* food supply levels. However, there are consistent but less observed differences in the prevalence of HIV across food supply levels, the SSA mean being 6.3 percent.

Percentage of rural population, as a proxy for urbanization usually accompanying structural transformation, is assumed to influence food supply levels negatively. The mean value is about 74 percent in countries of *very low* calorie supply level and consistently decreases to 67 percent and 52 percent, respectively, in countries with *low* and *medium* calorie supply. Age dependency ratio is high in SSA (86%), considerably varying from 76 percent in countries with *medium* food supply to 91 percent in those with *very low* food supply. This aggravates the mismatch between the supply of and the demand for food in SSA.

The effects of regional heterogeneities in SSA countries on their food supply levels are captured by

regional dummies. About 67 percent and 24 percent of the SSA countries facing incidence of *very low* food supply situation are found in Eastern Africa and Middle Africa, respectively. Western African countries are better-off in their food supply situation since 67 percent of SSA countries experiencing *medium* food supply are in this region, with only 7 percent facing incidence of *very low* food supply. But nearly 42 percent of SSA countries with *low* food supply situation are in Western Africa, 30 percent in Eastern Africa and 16 percent in Southern Africa.

3.2. Trends of Food Supply and Undernourishment

Figure 2 traces the regional and inter-temporal mean values of daily calorie per capita supply and prevalence of undernourishment compared with the SSA mean over the years. The regional mean values of daily calorie supply per capita, compared to the SSA mean (2245 kcal) indicated by the horizontal broken line, are markedly different. Eastern and Middle SSA countries have relatively depressed calorie supply which is far below the SSA mean. However, as depicted by the consistent inter-temporal growth of daily calorie per capita over the period (1994-2009), food supply in Southern and Western SSA is far above this mean, which is suggestive of the substantial food supply difference between the two groups of regions. The mean SSA calorie per capita supply in 1994 (2142 kcal) was monotonically increased to 2354 kcal in 2009. Both spatial and inter-temporal variations in calorie supply have resulted in an aggregate mean food supply of 2245 kcal in SSA.

The distribution of national food supply across populations could be revealed by estimating the percentage of population facing food insecurity and hunger. The dynamics of this alternative measure, prevalence of undernourishment, in SSA is depicted in the second panel of Figure 2. As depicted in the figure, there is a declining trend in the prevalence of undernourishment over the years. However, Eastern African countries exceptionally faced a high level of undernourishment far above the SSA mean value (31.8%). As revealed in the lower panel of the figure, the lowest prevalence rate of undernourishment is observed in Southern Africa, which is consistent with the results of the dynamics of food supply situations in the regions.

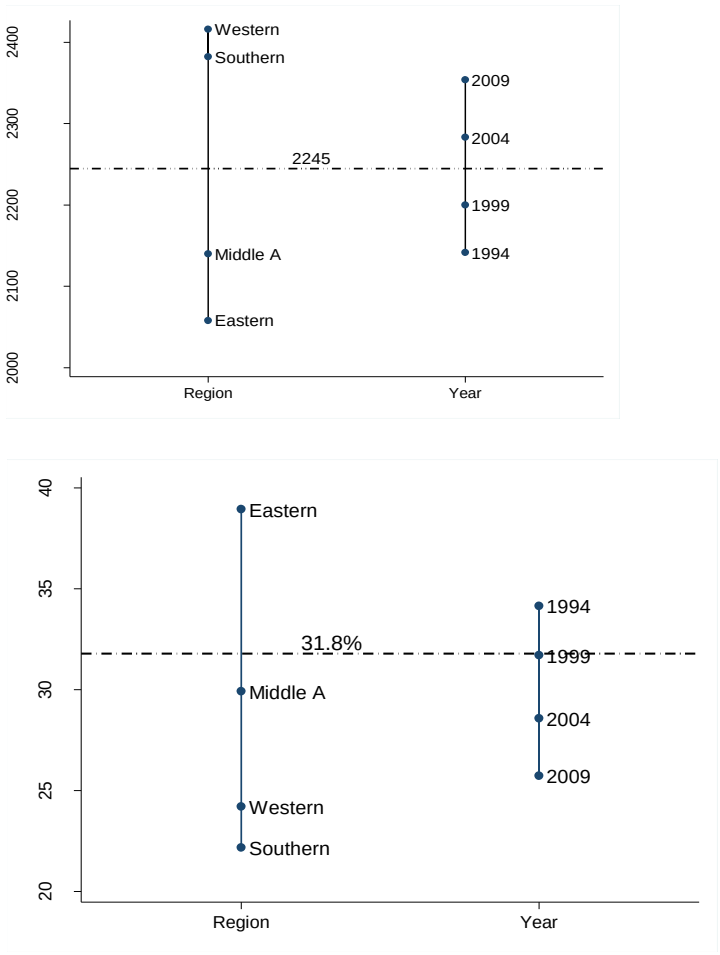

Figure 2. Regional and inter-temporal dynamics of calorie supply and undernourishment in SSA.

The transition probabilities[1] of countries in SSA from one food supply status to the other every year are reported in Table 2. The results point out that, each year, some 54 percent of the countries with *very low* food supply status remained in the same food insecurity situation for five years while the remaining 46 percent had a chance of achieving *low* food supply status. About 15 percent of the countries with *low* food supply shifted up to *medium* food supply situation while some 81 percent with *low* food supply situation remained in the same food supply status and the rest 5 percent rather faced a downturn in their food supply situation.

[1] In a panel data, the probability that $y_{i,t+1} = v_2$ given that $y_{it} = v_1$ can be estimated by countingtransitions, where v_1 and v_2 are ordinal outcomes. Notes: In interpreting the transition probabilities, the rows reflect the initial values, and the columns reflect the final values.

Table 2. Transition probabilities between food supply status in SSA.

Level of daily calorie per capita	*Very low*	*Low*	*Medium*
Very low	53.85	46.15	0.00
Low	4.48	80.60	14.93
Medium	0.00	5.00	95.00
Overall (SSA)	19.05	57.94	23.02

3.3. Dynamics of Food Supply Levels

The dynamic forces behind differing food supply levels and prevalence of undernourishment in SSA were broadly mirrored in the non-parameter measures and descriptions of variables. However, results of the previous preliminary exploration using non-parametric measures might appear to be less clear-cut. The magnitude and extent of the association between the dynamic forces and food supply levels could not be revealed and the process could be less robust in suggesting an unbiased picture. Here, a non-linear parametric measure is used in a way that permits to verify, with acceptable robustness, the statistical significance of estimates compared to empirical and a priori expectations. In order to provide the gauge of future food security prospects based on past experiences, the panel data estimators allow a better exposition of the topic and enable to identify the link between food supply and the underpinning proximate determinants.

The random-effects ordered probit model results of the dynamics of food supply levels are reported in Table 3. Out of 10 hypothesized factors of food supply level, nine are found to be statistically significant. After controlling for country and regional factors, the signs of all the parameter estimates are as expected. The estimated variance component is 3.85 with a standard error of 2.27. The likelihood-ratio test shows that there is enough variability between countries in favor of random-effects ordered probit regression over a standard ordered probit regression.

The food supply levels of countries (*very low*, *low*, and *medium*) are significantly and positively associated with agricultural production and industrial GDP. This indicates that the food supply status of SSA countries is enhanced by their crop production, suggesting that own food production is an integral part of food security in the region. Industrial value added, as a proxy for structural transformation of the economies, may have enabled to improve the food security situation of the countries. Agricultural production and productivity and its transformation is a very relevant policy imperative in improving food availability in SSA. Structural transformation is the defining characteristic of the development process itself defined by four interrelated processes: a declining share of agriculture in GDP and employment, the rapid process of urbanization as people migrate from rural to urban areas, the rise of a modern industrial and service economy, and a demographic transition from high to low rates of births and deaths (Duarte, 2010). However, the speed and extent of sectoral shifts from agriculture to industry could be reflected by the willingness and ability of labor and capital to move toward higher-productivity sectors (Dabla-Norris *et al*., 2013).

Food supply status in SSA is adversely affected by military expenditure, inflation level, proportion of rural population, age dependency ratio, and region-specific heterogeneities in Eastern, Middle, and Sothern Africa. Military expenditure has been depleting the resources available for food production (Maxwell and Slater (2003), Benson, (2004, and Kidane *et al.* (2006). SSA countries need to allocate more proportion of their budget to agricultural production and productivity in order to boost national food availability. Countries characterized by two-digit inflation levels of consumer prices have exhibited deteriorating food supply levels.

These countries need to design and implement food price stabilization policies and measures in their effort to improve food security situations. The absence of structural transformation of the economies is partly reflected by more proportion of rural population, as a proxy for urbanization. Countries with more proportion of rural population faced deteriorating food supply levels. Age dependency ratio, which is associated with high births and deaths, is the other indicator of absence of structural transformation aggravating food shortages in SSA. To curb this problem, SSA countries require accelerated family planning interventions and improved and inclusive health care services.

There is also a considerable difference in the daily calorie supply per capita attributable to regional heterogeneities. Due focus should be given to reduce regional shocks and instabilities since these could interfere with food production and budget allocation for food production. The effects of these region-specific heterogeneities, as proxied by the regional dummies, could possibly be explained by various shocks such as instability of social and political environments, war and civil strife, natural resource constraints, natural disasters, and the absence of good governance or weak democratic system (Benson, 2004; Mwaniki, 2005; Kidane *et al*.,2006).

The predictions after random-effects ordered probit indicate that the likelihood of countries in SSA to fall in *very low* food supply category (less than 2050 kcal per day per capita) is 23 percent, while that falling in the *low* food supply category (between 2050 and 2500 kcal) is 61 percent. But the likelihood of SSA countries to obtain *medium* daily calorie supply (2500 kcal and above) is only 16 percent. These results suggest that SSA countries as a whole most likely obtain *low* daily calorie per capita supply. More focus and effort is required to move SSA countries to better food security situation.

Table 3. Random-effects ordered probit model results[2] of food supply status in SSA.

Variables	Coefficients	Standard errors
Agriculture production index	0.04***	0.01
Industry valued added	0.08***	0.035
Military expenditure	-0.16***	0.06
HIV prevalence rate	-0.07	0.06
Inflation level	-1.58***	0.57
Rural population	-0.06*	0.04
Age dependency ratio	-0.10***	0.04
Southern Africa	-3.54**	1.86
Eastern Africa	-3.34***	1.29
Middle Africa	-6.15***	1.87
Cut 1	-13.79	4.54
Cut 2	-6.69	3.57
Variance component (σ^2_u)	3.85	2.27
Wald $\chi^2(10)$	20.70	
LR test, $\chi^2(1)$	31.79	
Predicted mean probability:		
Very low supply, Pr (y=1)	0.23	
Low supply, Pr(y=2)	0.61	
Medium supply, Pr(y=3)	0.16	

*Notes: ***, ** and * denote 1%, 5% and 10% significance levels, respectively.*

4. Conclusions

Food insecurity is an overriding problem in SSA where the vast majority of the population suffers from hunger and malnutrition. To address food insecurity problems in SSA, policy interventions require relevant empirical evidence on the national and regional dynamics of food supply. This study examined the dynamics of daily calorie supply per capita of 42 SSA countries in four rounds of five-year intervals (1994 to 2009) by using a panel data constructed from the global database of FAO and the World Bank. The study has demonstrated that there is a positive trend of food availability and a declining trend of prevalence of undernourishment over time and across countries in the region.

The dynamics of food supply status of the countries was significantly and positively associated with agricultural production and industrial value added suggesting that agricultural production and its transformation is the source of well-being in SSA. However, food supply levels were adversely affected by military expenditure, inflation level of consumer prices, proportion of rural population, age dependency ratio, and region-specific heterogeneities. Designing polices and initiating intervention strategies to control such deterrents will improve food security situation in SSA. Accordingly, for sustained and increasing national food supply, SSA countries need to gear their policies and intervention strategies towards enhancing agricultural production and productivity, creation of job opportunities absorbing the cheap and unemployed labor force, structural transformation of their economies through industrialization, and improving health care services. Efforts of countries, regions, and other stakeholders of development need to secure peace and stability by addressing problems of regional shocks and instabilities in order to reduce military expenditures which would otherwise be allocated for food production purposes. Reducing age dependency ratio through family planning is the other policy issues to be accounted for. These underpinning factors of food supply and undernourishment identified in this study could contribute to designing and implementing strategies and policy interventions of food security situation in the region.

This study suggests that countries in SSA are more likely to face incidence of low food supply situation. The most important policy imperative is that countries in SSA need to design policies and strategies of food production and supply which give considerable focus on country-specific idiosyncrasy and regional heterogeneities.

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[2] Notes: Quadrature checks were conducted at different integration points (12, 8, and 16) if changing the number of integration points affects the results. The relative differences among the different models were very low suggesting that the parameters were not sensitive to changing integration points.

Appendix Table 1. Mean daily calorie per capita supply in SSA (1994-2009).

Country/Region	Daily per capita kilocalorie	Country/Region	Daily per capita kilocalorie
Very low calorie supply			
Eritrea	1570	Mozambique	1972
Burundi	1679	Central Africa	1973
Ethiopia	1830		
Angola	1867	Chad	2024
Rwanda	1924	Zimbabwe	2042
Zambia	1928	Eastern Africa	2047
Low supply			
Kenya	2059	Togo	2269
Madagascar	2083	Uganda	2269
Sierra Leone	2087	Senegal	2321
Tanzania	2095	Mali	2329
Congo Rep.	2098	Swaziland	2329
Namibia	2150	Lesotho	2359
Malawi	2152	Guinea-Bissau	2367
Botswana	2163	Gambia	2408
Liberia	2163	Benin	2439
Comoros	2165	Western Africa	2416
Niger	2193	Southern Africa	2382
Sudan	2211	Middle Africa	2140
Cameroon	2233	SSA	2245
Medium supply			
Burkina Faso	2516	Nigeria	2635
Cape Verde	2526	Gabon	2645
Guinea	2533	Mauritania	2716
Ghana	2566	Mauritius	2892
Côte d'Ivoire	2589	South Africa	2911

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