Regime Switching in Food Security: An Assessment on Five Regions in the World

A.N. KODITHUWAKKU and J.C. EDIRISINGHE

Department of Agribusiness Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka

ABSTRACT

Food insecurity is a recurring problem rather than reducing over time. This research was conducted to study the state transition behaviors in the dimensions of global food security (availability, access, utilization and stability) by constructing two state (crisis and success) Markov-switching model. Markov-switching model is a method applied to investigate structural changes of nonlinear time series. In this study Markov switching autoregressive model was used because the data used were lower frequency data. Secondary data were obtained for five main regions in the world (Africa, America, Asia, Europe, and Oceania) and one sub region (South Asia). Results highlighted that growth rate of food availability was high in developing regions like Asian and African than developed regions like America. America, Asia, and South Asian regions showed longest time period in crisis state in accessibility to food. Utilization of food in South Asian region was in a crisis state and success state in European region. Asian region showed the highest stability in other three dimensions of food security. African region has to face a chronic food insecurity in the aspect of all four dimensions. American, Asian, European and South Asian regions have to face food insecurity not critically in terms of food availability, but in the case of accessibility of food, utilization of food and stability of other dimensions. Therefore, this study emphasis that to eradicate food insecurity all four dimensions should be considered and appropriate policies and investments should be made.

INTRODUCTION

Food security is an essential element of overall well-being and it exists when all people, at all times have physical, social and economic access to sufficient, safe, nutritious and affordable food to provide the foundation for active and healthy lives (World Food Summit, 1996). Food security is a multi-dimensional phenomenon. First dimension is physical availability of food and it emphasis the supply side of food and is determined by the level of food production and net trade. Second one is economic and physical access to food and it concerns about the ability to produce one's own food or buy it. Third one is food utilization and it is understood as assurance of safe and nutritious food which meets their dietary needs. Fourth one is stability and it must be present at all time in terms of availability, accessibility and utilization, for food security to exist (world Food Summit, 1996).

Food insecurity can be transitory, seasonal, or chronic. Transitory food insecurity is temporary and occur when there is a sudden drop in the ability to produce or access to enough food to maintain good healthy lives. Chronic (or permanent) food insecurity occur when people are unable to meet their minimum food requirements over a sustained period of time. The concept of seasonal food security falls between chronic and transitory food insecurity (FAO, 2015a). There are many complex reasons which prevent achieving global food security.

These obstacles include extreme poverty, issues in food distribution and food supply, food waste, population growth, climate change, water scarcity, government policies that inhibit trade and price volatility. Food security is more prominent in the policy agenda today than it has been in the past. Policy makers should give equal prominence to both transitory and chronic food insecurity because if transitory food insecurity is neglected it can convert to a chronic food insecurity.

Regional Overview of Food Security in World

Africa has made some progress towards halving the proportion of its population suffering from hunger (Millennium development goal 1.C target). Overall, the prevalence of hunger in the region declined by 31 percent by 2015 (FAO, 2015b). Though Asia and pacific region has achieved the largest reduction in the number of undernourished people this was not sufficient to meet the target set by the World Food Summit (WFS) of halving the number of undernourished people by 2015 (FAO, 2015c).

In America though most of the households have a stable access to enough food, minority of American households face food insecurity (Jensen *et al.*, 2014). European region has been experiencing reduction in the prevalence of undernourishment since 2000 (FAO, 2015d).

During the past year, food security has improved in almost every region of the world.

But, food security is still a major concern around the world. Millions of money and lot of time are spent annually on food aid programs intended to minimize food insecurity. For these programs to work effectively there is an urgent need to identify current and future states (crisis state or growing state) and the movement of all four food security dimensions (availability, access, utilization and stability) with time. Because food insecurity occur with the lack of all these four dimensions. So the objective of this study is to identify these, so that the appropriate food aid programs can be directed to where it needs most.

METHODOLOGY
Theoretical Framework
Markov Chain

If we have a set of states, S = {s_1, s_2... s_t}. The process starts in one of these states and moves successively from one state to another. Each move is called a step.

Transition Probability Matrix

The transition probabilities of a stationary Markov chain can be represented by a matrix Pij, called the transition probability matrix.

$$\begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}$$

Where:

$p_{11} + p_{12} = 1$
$p_{21} + p_{22} = 1$

p_{11} is estimated probability of staying in state one in next period given that the process is in the current period. And p_{22} denotes the probability of staying in state 2.

Markov Switching Autoregressive Model

This study used the simplest form of the model, where the transition was driven by a two state Markov chain. A time series (Y_t) follows a Markov Switching Autoregressive (MSA) model (with two regimes) was used because these models are often applied to lower frequency data (quarterly, yearly, *etc.*). The

function derived for Markov switching autoregressive model was expressed as,

$$Y_t = C_1 + \varphi_i : s_t Y_{t-1} + \varepsilon_t$$

Where,

Y_t - average value of variable related to food security given in Table 1

C_1 - State-dependent intercept which denotes growth rates as the data series is in the differenced form

$\varphi i; s_t$ - i^{th} AR term in state s_t

t - 1, 2... T

ε_t - Error

Variable Selection

Food security is measured with four main dimensions such as food availability, accessibility to food, utilization of food and stability of these three. These dimensions were measured with several indicators (Table 1).

Data Collection

All the data in this study was obtained from the database available in the suite of food security indicators of Food and Agriculture Organization (fao.org) and from United Statistics division-National Accounts Main Aggregates Database (unstats.un.org) covering the period of 1960 to 2014 for four dimensions except for Utilization of food (1990-2014) for five main regions (Africa, America, Asia, Europe, Oceania) and one sub region of Asian region (South Asia). And data were made stationary by first differencing.

Data Analysis

A nonlinear time series model known as Markov switching autoregressive Model proposed by Hamilton (1989) and available in STATA (version 14) was used in modeling the movement of states (crisis or growing) in dimensions of food security, transition probabilities between two states and the expected duration that one state last for each and every region.

Table 1. Variables used in the study

Dimension of Food Security	Indicator	Description
Food availability	Average value of food supply	The total value of annual food production expressed in international dollars per caput.
Accessibility to food	Gross Domestic Product per capita($)	Average income per person in a region.
Utilization of food	Access to improved water sources (%)	Percentage of the population with access to an adequate amount of water from improved water source
Stability of other dimensions	Percentage of arable land equipped for irrigation (%)	Share of land irrigated over total land area

The Markov switching model uses the idea of the Markov process. This model can be used for time series that transition over a set of finite states. States are unobserved and the process can switch among states throughout the sample. The time of transition between states and the duration in a particular state are both random (Hamilton, 2008).

RESULTS AND DISCUSSION
Outcome of Markov Switching Autoregressive Model

Estimated means of two state Markov Switching Autoregressive model are given in Table 2. The lower p-value reported in the test implied that two states (state one-crisis state, state two-success state) were significant for all the regions except the state two in Europe region. All the regions showed low mean for state one than the mean of state two (Table 2).

Food Availability

The average growth rate of crisis state in food availability was negative and that of the success state is positive for all regions (Table 2). The lowest average growth rate of crisis state of food availability was shown by Asian region and the highest growth rate was shown by American region. It implied that growth rate of food availability was high in developing regions like Asian and African than developed regions like America.

African and Oceania regions showed high probability of being in the crisis state in the next period of food availability (Table 3) and the estimated duration of crisis period was 22 and two years respectively (Table 3). Meanwhile one year was the estimated duration of success state.

For American, Asian, and South Asian regions showed high probability of being in the success state in the next period and the estimated duration of growing period was 15, 2.7, and 1.2 years respectively. For Europe region the probability of being in both crisis and success state in next period were high, so both states were persistent. The estimated duration was two years. Therefore when compared with the other regions, African region showed longest period in crisis state in food availability.

Table 2. Means of two states obtained from Markov switching auto regressive model

Region	Food availability Mean		Accessibility to food Mean		Utilization of food Mean		Stability of other dimensions Mean	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Africa	-0.54*	0.24*	-16.9*	163.1*	0.65*	1.10*	0.01*	0.06*
America	-0.52*	0.42*	405.6*	394.6*	0.45*	0.53*	0.02*	0.102*
Asia	-1.19*	0.38*	57.2*	2299*	0.26 *	0.55*	-1.50*	0.112*
Europe	-0.54*	0.49*	269.3*	5509.5*	0.07 *	0.01*	-0.04*	0.105
Oceania	-0.55*	1.03*	349.7*	211.64*	0.15*	1.92*	0.006*	0.06*
South Asia	-0.01 *	0.01 *	23.19*	211.69*	0.79 *	0.90*	0.38*	0.02*

*Significant at 5% Note: S_1- State 1, S2-State 2

Table 3. Transition probabilities and expected duration

Region	Food availability		Accessibility to food		Utilization of food		Stability of other dimensions	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Africa								
Probability	0.95	10^{-8}	0.88	0.75	0.95	10^{-8}	0.98	0.005
Duration	1.2	1	8	4	20	1	48	1
America								
Probability	10^{-8}	0.93	0.95	0.64	10^{-8}	0.49	0.96	0.83
Duration	1	15	19	2	1	2	23.5	1.5
Asia								
Probability	10^{-8}	0.64	0.95	0.49	0.91	0.47	10^{-8}	0.97
Duration	1	2.7	19	1	11.2	1.9	1	49
Europe								
Probability	0.38	0.34	0.94	0.69	0.82	0.68	0.97	0.97
Duration	2	2	16	3	5.8	3.2	35	36
Oceania								
Probability	0.31	10^{-8}	0.92	0.38	0.90	10^{-8}	0.98	10^{-8}
Duration	2	1	12	1	10	2	11	1
South Asia								
Probability	0.12	0.17	0.95	0.32	0.34	0.28	0.98	10^{-8}
Duration	1.14	1.2	20	1	1.5	1.4	40	1

S_1- State 1, S_2-State 2

Accessibility to Food

Both lowest average growth rate of being in crisis state and success state was shown by African region and highest average growth rate of crisis state was shown by American region (Table 2). And highest growth rate of success state was shown by European region. So for African, Asian and South Asian regions though the growth rate of crisis state of GDP was decreased the growth rate of high state was not increased. It implied that these regions have to face fluctuations in accessibility to food. For America, Europe and Oceania regions growth rate of both states was increased. All six regions showed high probability of being in the crisis state in the next period and estimated duration was eight, 19, 19, 16, 12 and 20 years respectively. America, Asia, and South Asian regions showed longest time period in crisis state.

Utilization of Food

The lowest average growth rate of crisis state in utilization of food was shown by European region, and the highest was shown by South Asian region. The highest average growth rate of success state was shown by Oceania region. For American region, average growth rate of both states showed a moderate value. So the utilization in South Asian region was in a low state and high state in European region. Except for American, other regions showed high probability of being in the crisis state in the next period was and the estimated duration of crisis period was 20, 10, 1.5 years respectively.

For American region the probability of being in the success state in the next period was higher and the estimated duration of crisis period was two years. For American region though the estimated probability of being in the crisis state was high, it will not last for a longer time.

Stability of Other Dimensions

Asia and Europe regions showed the lowest (negative) average growth rate of crisis state and that of the state of success was positive for all regions. South Asia showed the highest growth rate of crisis state in stability and Asia showed lowest growth rate.

Because that, the growth rate of success state is higher in Asian region than other regions, it showed the highest stability in other three dimensions of food security. Except for Asian and European, other regions showed high probability in the crisis state in the next period. Africa and Oceania regions showed longest period in crisis state. It implied that Africa and Oceania regions have to face critical problems

in the aspect of stability in dimensions food security.

CONCLUSIONS

Outcome of the Markov switching autoregressive model revealed that there are different regimes in the dimensions of food security (crisis state and success state) as identified by the predicted regimes. Therefore, as believed, food insecurity is a recurring problem rather than reducing over time.

For African region though the availability of food has slightly increased, stability of other dimensions will be in a crisis state for a long time. Therefore, all four dimensions of food security will remain in the crisis state for a longer period when compared with other regions. Therefore, Africa will have to face a critical problem in food security (chronic food insecurity) and food aid and assistance should be prioritized as a concern of all four dimensions.

For American and Oceania regions though food availability is not a big problem but the concern is on other dimensions. So America need much more concern about accessibility to food, utilization of food and stability of other dimensions from policy makers.

For Asian and European regions most critical problem is accessibility to food. So the assistance should be prioritized on increasing economic and physical access to food. South Asian region also face problems in accessibility to food, utilization of food and stability of other dimensions.

To improve food availability, increasing domestic food production and import capacity may be some options. To improve physical access, transport and market structure can be improved. To improve stability of supply and access, price fluctuations and political instability should be minimized.

To improve food utilization, options would be improving food safety, hygiene in manufacturing practices applied and increasing dietary diversity. The options for food insecurity which has long term effects are limit global warming, develop climate- friendly agricultural production systems and land-use policies which helps to mitigate climate change and raise awareness of the pressures of increasing population growth and consumption patterns.

Finally, we can conclude that as food security is a multi-dimensional phenomenon, all four dimensions have to be in a favorable state to eradicate food insecurity. Therefore, all four dimensions should be considered and by understanding, which dimension is critical in

each region, a proper mechanism to eradicate food insecurity can be put in place.

REFERENCES

FAO. (2015). Suite of Food security Indicators. Available from: faostat3.fao.org/download/D/FS/E (Accessed 2 January 2016).

FAO. (2015a). IFAD and WFP. *The State of Food Insecurity in the World 2015.* Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO.

FAO. (2015b). *Regional overview of food insecurity*: African food security prospects brighter than ever. Accra, FAO.

FAO. (2015c). *Regional overview of food insecurity: Asia and the Pacific.* Regional Office for Asia and the Pacific. Bangkok, FAO.

FAO (2015d). *Regional Overview of Food Insecurity Europe and Central Asia.* Focus on healthy and balanced nutrition, FAO.

Hamilton, J.D. (2008). Regime-switching models. *The New Palgrave Dictionary Of Economics,* **2,** 5-16.

Jensen, A.C., Gregory, C. and Singh, A. (2014). *Household Food Security in the United States in 2013,* ERR-173, U.S. Department of Agriculture, Economic Research Service, September 2014.

United Nations Statistics Division, (2015). National Accounts Main Aggregates Database, Available from http://unstats.un.org/unsd/snaama/dnllist.asp, (Accessed 14 January 2016).

World Food Summit. (1996). Food Security. Available from: http//www.who.int/trade/glossary/story 028/en (Accessed 24 April 2016).