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Nonlinear Relationship Between Food Price Uncertainty and Food Security in Iranian Households: Evidence from GAS Modelling

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Abstract

The main purpose of this study is to investigate the effect of food price uncertainty on food security in Iranian households during the period 1981-2018 in a nonlinear model. To estimate uncertainty, the Generalized Autoregressive Score Model, and to estimate the effect of food price uncertainty on food security, the Smooth Transition Autoregressive model has been used. The results show that food price uncertainty in the first regime (low level of investment in agriculture) has a negative and significant effect and in the second regime (high level of investment in agriculture) has a negative and non-significant effect on food security. In the first regime, where the level of investment in the agricultural sector is below the threshold, as food price fluctuations increase, market uncertainty increases and signals with less transparency to producers and consumers. Under these circumstances, consumers will face the problem of reduced purchasing power and insecurity in access to food, which has a negative impact on food security. While, in the second regime and increasing the level of investment in the agricultural sector, the negative effects of uncertainty on food security can be partially offset. According to the results of the present study, officials should take effective steps on one hand, by prioritizing the financing of investment in the agricultural sector and facilitating the conditions of activity of the private and cooperatives sector in this field like moving from traditional to industrial agriculture. On the other hand, to reduce the price gap, regulate the market demand of agricultural products, and create conditions for food price stability, create a kind of protection against short-term fluctuations and shocks.

Keywords: Food Price Uncertainty, Food Security, Generalized Autoregressive Score Model, Smooth Transition Autoregressive Model.

JEL Classification: C51, D80, Q11, Q18.

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1. Introduction

Food security is a key factor in the physical, mental, cognitive and mental health of individuals (Gubert et al., 2017). Nearly 800 million people worldwide suffer from hunger, many of whom live in developing countries (UN Report, 2015). The importance of these figures is further highlighted by the fact that they run counter to the United Nations Sustainable Development Goals to eradicate hunger and achieve food security.

According to the FAO (2015), despite declining global hunger and malnutrition, food insecurity is a major challenge. While most food security concerns focus on poor areas, hunger in rich countries is a surprise. In rich countries, despite concerns about agricultural productivity and food supply, little attention is paid to the consumption and food security aspects of households. Extensive research on the evidence of food poverty and its effects confirms that food insecurity is a significant public health issue in high-income countries (Kneafsey et al., 2013) like the United State. For example, the United Department of Agriculture (USDA) stated 14.3 million of U.S. households – 11.1 percent- were food insecure during 2018.

Due to the importance of food security and the need for comprehensive attention, it has a special place in the policies of the Islamic Republic of Iran. Policies like the 20-Year Perspective Document, the law of the five-year economic, social and cultural development plans, and the national document on nutrition and food security of the Islamic Republic of Iran (2012-2013). In these policies, special attention has been paid to food security and health, such as personal and social health and well-being, food security, social security, equal opportunities for access to healthy food, proper income distribution and the institution of the family away from poverty.

Despite Iran's attention to food security, according to studies such as Karimi Takanloo et al. (2018), the level of food security is increasing over time, however, it has decreased in some years. One of the factors that may be effective in reducing the level of food security is the uncertainty of the food price index. Uncertainty is a state in which the knowledge of an individual is limited and it is not possible to fully explain the state or the result that is being achieved (Hubbard, 2007). Accordingly, economic uncertainty can be interpreted as the inability of economic agents to accurately predict the outcome of their decisions. Friedman (1977) argues that as the uncertainty is greater, the more difficult is to detect relative than absolute price changes because economic agents set their prices in different ways (due to incomplete forecasting future inflation). Thus, relative prices are affected, economic efficiency is reduced, and there is less production than in a state of stabilization. Barrett (2002) identified three groups of people whose food security is vulnerable to price fluctuations: the traditional vulnerable population, wage earners, and retail farmers. The traditional vulnerable population includes very young and old people who rely on the savings and support of society and the family. The food security of wage earners depends heavily on how food prices rise relative to their wages.

Agricultural households' consumption fluctuations, however, are affected by price volatility through two channels: (i) price volatility affects consumption for a given income and (ii) price volatility makes income from selling agricultural products volatile, too. So, the interplay of these two channels makes the assessment of the benefits from price stabilization more complex (and stabilization might be not desirable for specific combinations of income and price elasticities) (Kalkuhl et al., 2013).

As food price fluctuations increase, market uncertainty increases and signals with less transparency to producers and consumers. Under these circumstances, on the one hand, consumers will face the problem of reduced purchasing power and insecurity in access to food, which has a negative impact on poverty and food security. On the other hand, manufacturers are turning to low-productivity technologies. As a result, production costs increase and producer's motivation destroy to do production work, thereby harming food security (Kalkuhl et al., 2013).

Conversely, if the market is transparent and the signals are transmitted correctly, price increases lead to increased production and reduced consumption, which is a pressure to reduce prices. Also, sometimes the lack of investment in the agricultural sector and insufficient attention to the issue of food security and nutrition is the reason for the increase in food prices. In this case, by applying appropriate and infrastructural policies, increasing food prices leads to increasing farmers' wages and incomes, reducing unemployment, increasing agricultural production and rural economic growth, stimulating for long-term economic growth, increasing physical access to materials food and improving food security (Gustafson, 2013; Boratynska and Huseynov, 2017).

Therefore, this study investigates the uncertainty of food price index on food security in Iranian households using the Smooth Transition Autoregressive (STAR) Models during 1981-2018. It should be noted that the estimation of uncertainty by the Generalized Autoregressive Score model (GAS) and investigation of the uncertainty of food price index on food security in all papers of these topics are innovations of this study. While in most papers like Kontonikas (2004) and Rahman and Serletis (2012) use the GARCH model and in some papers like Chen and Xu (2019) use the GAS model to calculating uncertainty. Papers like Gustafson (2013) and Applanaidu et al. (2014) investigate the effect of inflation on food security not uncertainty. Also, Rudolf (2019) and Eslami and Baghestany (2020) respectively confirm the negative and positive effect of inflation uncertainty on food security.

2. Methodology

2-1. Food Security index

According to theoretical foundations, food security is a hidden variable that cannot be directly calculated (Vaitla et al., 2017). Estimating and calculating this complex situation with multiple dimensions requires an index that includes several sub-indicators that each of these sub-indicators cover specific dimensions. In this context, these multiple dimensions are distinct, but not necessarily independent (Vaitla et al., 2017).

In various studies, several indicators have been used to estimate food security and this large number leads to ambiguity of decision makers in choosing the correct food security index in a particular situation. In this study, following the studies of Chen et al. (2015) and Karimi Takanloo et al. (2018), the Global Food Security Index (GFSI) was used. The GFSI index is designed by the Economist Intelligence Unit (EIU) and is a model capable of calculating food security in developing and developing countries. The index analyses food security across three internationally designated dimensions: affordability, availability and utilization (or quality and safety). The EIU built the GFSI according to the following definition of food security adapted from a formulation established at the World Food Summit in 1996: “When people at all times have physical, social and economic access to sufficient and nutritious food that meets their dietary needs for a healthy and active life.” Experts on food security and agricultural policy all over the world were gathered by EIU to establish the methodology and weighting for all indicators. In addition to the quantized data. there are also some qualitative items, such as agricultural infrastructure, nutrition plan, and strategy (Chen et al, 2015).

2-2. Research model

The theoretical and conceptual model of the effect of food price index uncertainty on food security is based on the modified model of Applanaidu et al.

(2014) and taken from the study of Thomson and Metz (1998), which is expressed in the model (1):

$$FS_t = f(I_t\ , GDP_t\ , Open_t\ , UCpi_t\ , Pop_t\ , Dummy\quad , u_t) \tag{1}$$

FS: Food Security indexed by Global Food Security Index; UCpi: Uncertainty of the consumer price index of food and beverages (2011=100). This index is one of the best criteria for measuring fluctuations in the purchasing power of a country's domestic currency. To index this variable, the GAS model is used, which is described in Section (2-3).

Pop: Population; GDP: Gross domestic product at base price (2011=100); Open: The degree of economic openness in the exchange of agricultural products that can be calculated from Equation (2):

$$Open_t = \frac{(XA_t + MA_t)}{GDP_t} \tag{2}$$

XA_t: Indicates the export of the country's agricultural products in time t, MA_t: Indicates the import of the country's agricultural products in time t and GDP: Gross domestic product at the market price at time t. The higher the value of this criterion, the higher the volume of trade in agricultural products and the higher the degree of economic freedom.

I: Net government investment in agriculture. For this index, changes in the net capital stock of the agricultural sector (2011=100) have been used. Tangible fixed capital or assets produced is a set of tangible physical capital goods of the country such as "buildings and facilities" and "machinery and equipment" that can be measured in the process of producing goods and services and generating income such as agriculture, animal husbandry and hunting, forestry, fishing and agricultural services are involved. According to the definition of the national accounting system, net capital stock at any given time is the value of capital goods produced minus the consumption of cumulative fixed capital up to that time. According to the figures of gross fixed capital formation, consumption of fixed capital and useful life of various assets in each group of economic activities, capital stock is calculated (Central Bank, 2014).

Dummy: A virtual variable to take into account the effects of the Iraq-Iran war.

u: Except for disturbances or other variables affecting food security. In the above model, the t-index represents the year. To estimate Equation (1), the STAR model itself is used, which is described in Section (2-4). To collect statistics and information, the data of the libraries of the Central Bank of the Islamic Republic of Iran, the Statistics Center of Iran, the World Bank and Karimi Takanloo et al. (2018) have been used.

2-3. Generalized Autoregressive Score Model (GAS)

In classical models, the GARCH model (Bollerslev, 1986), which is rooted in the ARCH model introduced by Engel (1982), is used to estimate uncertainty and fluctuations. One of the weaknesses of the ARCH model is its sensitivity to out-of-range data (Müler and Yohai, 2008). Fluctuations in food price are sometimes caused by sudden changes and instability in national and foreign policy, such as inflation, oil prices, and sanctions. Therefore, due to the weakness of the ARCH model, in this study, the new generalized autoregressive score (GAS) model introduced by Creal et al. (2013) has been used.

The GAS model is in the group of observation-based models, which includes well-known models such as the GARCH model, in which the conditional distribution of the ARCH and GARCH models is used. To introduce the GAS model (1,1), assume that r_t is a random k-dimension vector at time t with conditional distribution:

$$r_t|F_{t-1} \approx p(r_t; \Psi; \theta_t) \quad (3)$$

Ft-1 represents the sigma algebra generated by the time series up to time t, θ_t the vector of the time series parameters with the density function p (.) which is dependent F_{t-1} and a set of static parameters Ψ . The time series parameters of θ_t are created by the scalable score function of the conditional distribution, and its prime function is as follows:

$$\theta_{t+1} = \kappa + As_t + B\theta_t \quad (4)$$

Thus, A, B, κ are the matrix of coefficients and the Scaling Score Function s_t is as follows:

$$s_t = S_t \nabla_t \quad (5)$$

$$\nabla_t = \frac{\partial \ln p(r_t; \theta_t)}{\partial \theta_t} \quad (6)$$

$$S_t = \eta_t(\theta_t)^{-\gamma} \quad (7)$$

$$\eta_t(\theta_t) = E_{t-1}[\nabla_t \nabla_t^T] = -E_{t-1}[\frac{\partial^2 \ln p(r_t; \theta_t)}{\partial \theta_t \partial \theta_t^T}] \quad (8)$$

In the above equations, ϒ is a number from the set {0, 1.2, and 1}. The value of s_t changes the time series parameters from θ_t to θ_{t+1}, which is similar to the well-known Newton-Raphson algorithm (Chen and Zhu, 2019).

2-4. Smooth Transition Autoregressive (STAR) Model

The Smooth Transition Autoregressive model is extended form of Threshold Regression (TR) proposed by Hansen (1999). In these models, the relationship between the two variables changes over time, which is said the change of regime is happen and the point of change of regime is specified as the threshold level. In the threshold regression model, there are observations that are very close to the threshold values, which are in two different groups in terms of slight differences, and their effect is subject to a sharp jump. To solve this problem, the Smooth Transition Autoregressive (STAR) Model was developed by Terasvirta and Anderson (1992) to make a smooth transition between the two regimes. This model is introduced in Equation (9):

$$y_t = \pi' z_t + \theta' z_t F(s_t; \gamma; c) + u_t) \quad (9)$$

Equation (9) assumes that the model residues are evenly and independently distributed with a mean of zero and a constant variance. Zt is equal to $z_t = (W'_t, X'_t)$, where $W_t = (1, y_{t-1}, ..., y_{t-p})$, p is the optimal self-regression interval of the dependent variable and T is the sample size. $X_t = (x_{1t}, x_{2t}, ..., x_{kt})$ Contains k independent variables. The vector parameters π and θ include the model parameters for estimation. S_t is a transfer variable that can be selected based on studies from explanatory variables or any other variable outside the model that is theoretically related to the model under study and is the cause of nonlinear relationship. γ is a Slope Parameter that indicates the rate of transfer between regimes, and c is the value of the Threshold Variable of the transfer variable in the transfer of different regimes.

$F(s_t, \gamma, c)$ is a continuous, derivative and finite transfer function. This function typically has one or two thresholds (j = 1, j = 2). Assuming j = 1, there will be a transfer function called LSTR1 with two linear regimes. Assuming j = 2, if the slope parameter is inclined to infinity, we will encounter a three-mode transfer function called LSTR2. The modified form of LSTR2 model is a nonlinear regression model of smooth transition with Exponential function (ESTR).

If the slope parameter tends to zero with the intermediate transition speed to zero, the STR model will become a linear regression model. The null hypothesis of the test is that the model is linear: H0 = β1 = β2 = β3 = 0, which uses the F statistic for the test. If hypothesis H0 is rejected, to determine the type of nonlinear pattern, the following tests are performed on the model according to the relevant test statistics:

F_2. H_{04}:β_3=0

F_3. H_{03}:β_2=0 | β3=0 (10)

F_4. H_{02}:β_1=0 | β_2=β3=0

To confirm the LSTR1 model, hypotheses H04 and H02 must be rejected, and in case of hypothesis H03, the LSTR2 or ESTR model is selected (Alimi et al., 2017).

3. Results

3-1. GAS model results

First, the food price uncertainty is modeled by the GAS model. Table (1) shows the results of the initial study of the food price index variable.

Table 1: Descriptive statistics of variable food price

Variable	Mean	Standard Deviation	Normality Test			ARCH Test	Stationary Test		Auto-Correlation Test
			Skewness	Kurtosis	Jarque-Bera Test		ADF Test	ZA Test	Hurst-Mandelbort R/S test
Cpi	46/15	79/332	2.02 (0.000)	2.85 (0.000)	44.87 (0.000)	1093.8 (0.000)	4.471 (0.999)	2.021 (0.270)	2.328

Source: Research Findings

Normality tests show that the data and residual statements of the variable distribution of the food price index are abnormal. Therefore, since the GAS model as a model based on Score-Driven is used in models based on abnormal distributions such as the t Student distribution (Creal et al., 2013), the GAS model can be used to model fluctuations.

The results of the stationary test of the food price index variable using the generalized Dickey-Fuller test indicate that this variable is non-stationary. But it is possible that the non-stationary of the variable is due to the possibility of structural break of this variable. Hence, its structural break was studied using the Zivot-Andrews test. The results show that the variable still maintains its non-stationary. As a result, according to the GAS model, in case of instability of the variable, it is possible to estimate uncertainty and its fluctuations (Makatjane et al., 2017).

The Hurst-Mandelbort R/S test introduced by Hurst (1951) and Mandelburt (1972) was used to examine the autocorrelation. The results show that at the

95% significance level, there is no reason to accept the null hypothesis that there is no autocorrelation. All preliminary tests indicate the possibility of using the GAS model to estimate the uncertainty of the food price index. The result of estimating food price uncertainty by Oxmetrics software can be seen in Figure (1).

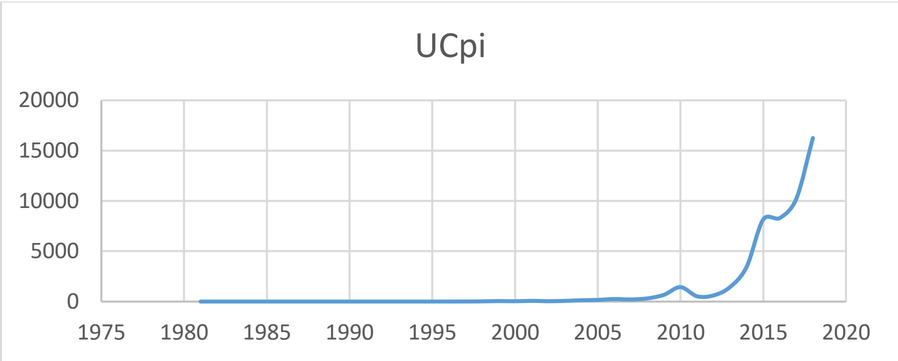

Figure 1: Uncertainty in food price index 1981-2018

Source: Research Findings

Figure (1) shows the uncertainty of the food price index during the years 1981 to 2018, which is a turning point in 2010. So before 2010, fluctuations do not have a significant jump compared to subsequent years. The separation of this part of the diagram can be seen in Figure (2). After 2010, severe leaps have begun. One of the reasons for the beginning of these leaps can be attributed to the Iranian subsidy reform plan in 2010. Intensification of leaps are ongoing because of jumping in the exchange rate due to the intensification of unfair US sanctions against Iran in 2011 and decreasing in the country's oil production from 3481.2 to 3063 thousand barrels per day in 2013 (Central Bank, 2018).

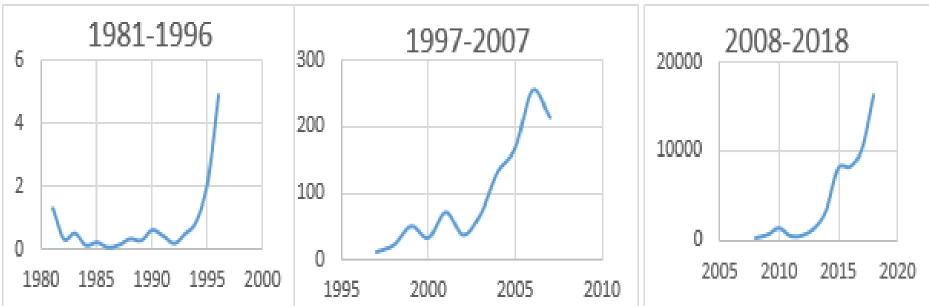

Fig. 2: Uncertainty in the food price index separately

Source: Research Findings

For a clearer analysis, in Figure (2) the fluctuations of the food price index before 2010 were studied separately. The results show that during the years of the imposed war of Iraq against Iran (1981-1989), the food price index, despite ups and downs, has not experienced a sudden jump. This trend continued until the early 1991s and the beginning of the construction period. Until in 1994-96 with currency jump, fluctuations also increased. This upward trend continued despite ups and downs with a gentle slope until 2001. Until a sudden increase has started since 2001. This period coincides with the fluctuations of crude oil prices in world markets after the September 11 incident in the United States (Central Bank, 2001).

3-2. STAR model results

To estimate model (2), the STAR model is used. The estimation of this model has the following steps.

3-2-1. Stationary results of variables

Before estimating the pattern, it is necessary to evaluate the significance of the variables to prevent false regression. The results of the generalized Dickey-Fuller and Phillips-Peron tests jointly show that the variables of food security index, GDP, investment in agriculture, degree of openness of the economy and uncertainty of food price index are not stationary. The results of the Phillips-Peron test show that the population variable is stationary, while the results of the Dickey-Fuller test show the opposite. While some variables are nonstationary, based on Kadilli and Markov (2012), it is necessary to ensure that all residuals are stationary at the end of the estimation[1].

3-2-2. Linearity test results and optimal model selection

After the stationarity test, the intervals of the pattern variables in estimating the STAR model should be determined. The optimal interval was selected 2 based on the significance of the coefficients, compliance with economic theories and the Akaike information criterion for all variables. The final model is specified as follows:

$$FS_t = \alpha_1 + \alpha_2 UCpi_t + \alpha_3 GDP_t + \alpha_4 Pop_t + \alpha_5 Open_t + \alpha_6 Dummy + u_t \quad (12)$$

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1 . To avoid increasing the volume of the article, we don't write the results of variable stationary test. So, if the readers need the results, they can contact the corresponding author to email them.

In the next step, it is necessary to test the nonlinear relationship between the variables, which if there is a nonlinear relationship, the use of STAR model is unobstructed. The results of the linearity test and the determination of the transfer variable are presented in Table (2). Accordingly, column F shows the confidence level in rejecting the linearity hypothesis and F2, F3 and F4 show the confidence level in rejecting the H02, H03 and H04 hypotheses, respectively.

Table 2: Results of the linearity test and determination of the transfer variable

transfer variable	F	F4	F3	F2	Suggested Model
GDP(t)	0.854	0.759	0.931	0.762	Linear
I(t)*	0.035	0.005	0.783	0.779	LSTR1
Pop(t)	0.889	0.651	0.755	0.778	Linear
UCpi(t)	0.503	0.280	0.446	0.830	Linear
I(t-1)	0.633	0.768	0.224	0.605	Linear
UCpi(t-1)	0.044	0.262	0.048	0.082	LSTR2

Source: Research Findings from jmulti Software

The values shown in the table indicate the value of the uncertainty level of the F (Probe F) statistic.

Based on the results of Table (2), the appropriate transfer variable is marked with *. The results of the first column showed that the null hypothesis based on the linearity of the model are rejected at 95% confidence level by considering the variable of investment in agriculture (I(t)) and food price uncertainty with one interval (UCpi(t-1)) as the transfer variable. Therefore, the existence of a nonlinear relationship for them was confirmed. The appropriate transfer variable must be chosen that according to Terasvirta and Anderson (1992), rejects the null hypothesis of the F-test strongly. Among the variables, the investment variable was identified as the proposed transfer variable. Now the appropriate functional form proposed for the transfer variable is the logistic type (LSTR1), which represents a model with a threshold point in which the H04 hypothesis is more strongly rejected.

The variable of investment in the agricultural sector is a suitable variable to study regime change. Investment is one of the most important components of aggregate demand, which plays a very decisive role in the economic fluctuations of any country; Therefore, understanding the behavior of economics towards investment has been in the focus of economists and economic policy makers.

3-2-3. Initial values in estimating c and γ

The parameters of the STR model are estimated by Newton-Raphson algorithm. Therefore, it is necessary to select a suitable initial value to start the algorithm. Based on the results, the transfer threshold variable c = 52.24187 and the transition speed between regimes were selected as γ = 7.33 as the starting point of the algorithm.

3-2-4. Model estimation by LSTR1 model

Considering that all the necessary tests have been performed to determine the pattern, it is possible to estimate the final model (12). The results of Jmulti software are as follows.

Table 3: Model estimation results

Variable	Coefficient	t value (Prob)	Variable	Coefficient	t value (Prob)
Linear Part			Non- Linear Part		
CONST	-10.06	-0.52 (0.603)	CONST	-0.23	-2.90* (0.008)
GDP(t)	-0.001	-0.64 (0.526)	GDP(t)	0.001	3.34* (0.003)
UCpi(t)	-0.001	-3.99* (0.000)	UCpi(t)	-0.001	-0.32 (0.746)
Pop(t)	0.001	0.56 (0.576)	Pop(t)	0.001	4.12* (0.000)
Open(t)	11995.5	0.26 (0.793)	Open(t)	1863.5	3.67* (0.001)
dummy	-0.05	-2.61* (0.016)	dummy	13345.4	0.007 (0.994)
R^2=0.98			γ	166.16	2.38* (0.027)
			c	40438.6	46.51* (0.000)

Source: Research Results
Shows significance levels at 1%

Based on the results of Table (3), the slope parameter (γ) was estimated to be equal to 166.16, which indicates the average transmission speed between two regimes. The value of the transfer threshold (c) was estimated to be 40438.6, if the investment variable in the agricultural sector (I (t)) is less (more) than this value, the model behaves according to the linear pattern and the first regime (nonlinear pattern and the second regime). According to the logistic function related to the regime change in Figure (3), the moment of regime change can be considered for the estimated model.

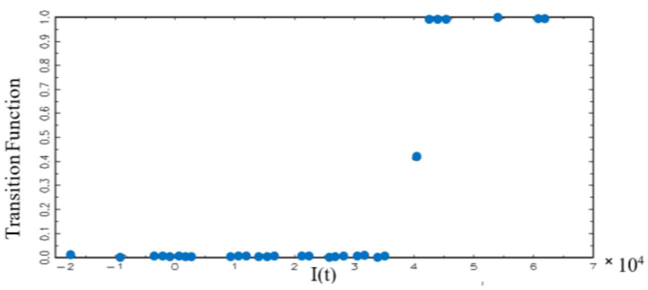

Fig. 3: Logistic function diagram related to regime change

Source: Research Results

Since the coefficients of the variables change according to the value of the transfer variable and the slope parameter and are not the same over time, the numerical value of the coefficients presented in table (3) cannot be interpreted directly and merely analyzed signal. Examining the sign of the coefficients of the variables shows that the uncertainty variable of the food price index has a symmetrical effect on food security. So, in the first regime has a negative and significant effect and in the second regime has a negative and non-significant effect on food security. Iran's economy is supported by the government. As food price fluctuations increase, according to the Logue and Sweeney (1981) hypothesis, the supply of agricultural products should increase with government support to ensure food security in society. But in the first regime, where the level of investment in the agricultural sector is low, on the one hand, there are no conditions for increasing the real production of agricultural products. On the other hand, people prefer to reduce their savings and increase their liquidity. Because Iran is classified as a low-income country, in the face of price fluctuations, people are more inclined to consume essential goods than luxury goods. Hence, the demand for agricultural products increases (Islami and Baghestani, 2020). As a result, the country is unable to meet the demand and supply so food security is reduced.

Also, when the level of investment in the agricultural sector is low, people will face the problem of reduced purchasing power and insecurity in access to food, which has a negative impact on poverty and food security. So, in first regime food price uncertainty does not lead to increase real agricultural production and food security. The results are consistent with the study of Torless et al. (2003) and Block et al. (2004) and are not consistent with the study of Islam and Baghistani (2020). The reason for the inconsistency of the results can be attributed to ignoring the low level of investment in the agricultural sector.

In the second regime and the increase in the level of investment in the agricultural sector, with increasing fluctuations in food prices, producers tend to low-productivity technologies. As a result, production costs increase and producers' motivation decrease and cannot have a significant impact on food security (Kalkuhl et al., 2013). These results are consistent with the study by Arndt et al. (2012).

The effect of population on food security in the first regime is positive and non-significant and in the second regime is positive and significant. Food security is a condition in which food supply and demand can effectively meet the food needs of growing population. So, there is needing to increase per capita food production through policies of increasing investment in agriculture sector or the food trade (Sen, 1999). We can analyze the balance and imbalance between population and food according to the food availability approach, which was the oldest and most profitable approach studied in the field of food security and was famous by Thomas Malthus (1789). To maintain balance, the growth rate of food availability should not be less than the growth rate of the population. When investment in agriculture in the second regime exceeds the threshold, production of agricultural products and available foodstuffs increase. Since the population growth rate in Iran has remained somewhat stable, the growth rate of agricultural production has been higher than the population growth rate. As a result, population growth has a positive effect on food security. While in the first and low level of investment regime, there is no evidence of such relationships. The results of this section are consistent with the study by Applanaidu et al. (2014). While with the study of Karimi Takanloo et al (2018), based on the negative impact of population on food security is inconsistent due to ignoring of investment in the agricultural sector.

The index of economic openness in the first and second regimes has a positive effect on food security. So that this effect is non-significant in the first regime and significant in the second regime. With increasing of investment expenditures in the agricultural sector more than the threshold, the productivity of the agricultural sector will increase and the possibility of increasing exports and foreign trade will be provided. Exchange of agricultural products are done in terms of imports with the aim of eliminating food shortages based on Ricardo's theory. With the growth of agriculture production trade, the employment rate, income and wages of villagers and other sections of society improve, their ability and purchasing power increase, access to food improves and food security improves (Diaz-Bonilla and Ron, 2010; Bagherzadeh Azar, 2017). In fact, with increasing investment in the agricultural sector, the greater possibility of foreign trade in agricultural products and the greater provision of food security conditions. These results are consistent with the study of Diaz-Bonilla and Ron (2010) and Chen et al. (2015). However, when the level of investment is below the threshold, it is not possible to produce products for foreign exchange. So, the degree of openness of the economy has no significant effect on food security.

GDP variable is a measure of the country's relative wealth and the average ability of citizens to consume food, in the first regime has a negative and non-significant effect and in the second regime has a positive and significant effect on food security, which shows the asymmetric effect of this index. By increasing investment in the agricultural sector and exceeding the threshold, the level of GDP, household income and wage, purchasing power and accessing to food and food security improves. This is in the context that people with food insecurity are involved in the process of economic growth and its benefits such as agricultural growth. These results are consistent with the study of Heady (2013). In the first regime, due to low levels of investment in the agricultural sector, economic growth was mainly due to service sector growth and sometimes the increasing of informal and low-productivity jobs, and the performance of the agricultural sector was not very significant. So, economic growth does not have a significant effect on food security. These results are consistent with the study by Breisinger et al. (2012).

The virtual variable of Iraq-Iran war in the first (second) regime has a significant and negative (non-significant) effect on food security. When the level of investment in the agricultural sector is low, as expected from the conditions of the war, it has had a negative impact on food security, while in the second regime and more investment has not been able to neutralize the destructive effects of the war. The two limit states studied above are part of the limit regimes, and in fact the behavior of the variables is between these two limit states.

3-2-5. Model diagnostic tests

After estimating the results, the model is evaluated by diagnostic tests. The first test is to check for non-autocorrelation. The null hypothesis of this test is the non-autocorrelation that should not be rejected. Considering the probability value of this test for the first to third intervals (0.173, 0.416, 0.317), the null hypothesis was not rejected in any of the intervals, so there is no autocorrelation. The second test is the stability test of parameters in different regimes. Since the probability value of the F function of this test is reported (0.005), so it can be concluded that at the 99% probability level, the coefficients of linear and nonlinear part are not the same. The third test is the test of linear relationship in the model residues. Given the estimated value of the estimated F test statistic (0.16), the null hypothesis that there is no additional nonlinear relationship is confirmed. As a result, the nonlinear relationship between the variables is correctly specified by the model. For variance heterogeneity test based on ARCH-LM test, the probability values of F and $\chi 2$ statistics were estimated to be

0.621 and 0.751. As a result, the null hypothesis of this test that there is no heterogeneity-conditioned variance at an acceptable significance level cannot be rejected. Also, the normality test of residuals by Jarque-Bera test reported the probability value of $\chi2$ equal to 0.120, which resulted that the residuals have a normal distribution. The stationary test for model residuals also shows a long-run relationship between model variables and our regression is not false. In summary, according to the model evaluation tests, the estimated nonlinear model is evaluated as acceptable in terms of quality.

4. Conclusion

Food insecurity continues to be a major development problem across the globe, undermining people's health, productivity, and often their very survival. Efforts to overcome the development challenges posed by food insecurity necessarily begin with accurate analysis of factors effect on it like uncertainty of the food price index. Uncertainty is a state in which the knowledge of an individual is limited and it is not possible to fully explain the result that is achieved or is being achieved. So, the purpose of this study is to study the effect of food price uncertainty on food security in terms of investment in the agricultural sector as a variable of regime change. Therefore, the first step is to estimate the uncertainty of the food price index by the GAS model, which can model the fluctuations with high accuracy. The next step is to estimate the impact of uncertainty on food security by the STAR model during the period 1981-2018.

The results show that in the first (second) regime where the level of investment in the agricultural sector is below (higher) the threshold, food price uncertainty has a negative and significant effect (negative and non-significant) on food security, which confirms based on theory. As food price fluctuations increase, market uncertainty increases and signals less transparency to producers and consumers. Under these circumstances, consumers will face the problem of reduced purchasing power and insecurity in access to food, which has a negative impact on food security. By increasing investment in the agricultural sector, the negative effects of uncertainty on food security can be partially offset. Based on theory that state sometimes the reason for the increase in fluctuations is the lack of investment in the agricultural sector. In this case, steps can be taken to improve food security by compensating for this shortage.

Irrational price fluctuations and increases are neither in the interest of the producer nor the consumer, but only those who benefit from price fluctuations are intermediaries, who themselves are a factor in increasing instability (Diaz-

Bonilla and Ron, 2010). Therefore, the necessary mechanisms should be done to increase investment in the agricultural sector and reduce price fluctuations in agricultural products. This situation becomes more prominent because of the importance of food and its price in people's livelihoods. Governments have always tried to prevent food prices from rising in line with inflation in other sectors of the economy. Therefore, due to the lack of increase in the price of agricultural products, the incentive to invest in the agricultural sector decreases. Also, the existence of inflation uncertainty due to lack of confidence in the economic future and disrupting the exchange relationship between the agricultural sector and other economic can have a detrimental effect on investment in this sector. Especially in Iran, the issue of capital and investment has always been associated with many problems due to its strong dependence on oil revenues and its price instability and high risk.

According to the results of the present study, officials should take effective steps on one hand, by prioritizing the financing of investment in the agricultural sector and facilitating the conditions of activity of the private and cooperatives sector in this field. So, more investments must be made, particularly in research and development and infrastructure that promote irrigation as well as drought-resilient crops and their hybrids, increasing the efficiency of agricultural land, avoiding wasting and facilitating the export of agricultural products and moving from traditional to industrial agriculture. On the other hand, to reduce the price gap, regulate the market demand of agricultural products and create conditions for food price stability, create a kind of protection against short-term fluctuations and shocks. Approaches like improving market transparency, maintaining adequate emergency food stocks, or strategic reserves, governing commodity exchanges must also be reviewed to reduce speculative behavior and thus limit volatility. Over-regulation must be avoided, however, as it could limit the market’s ability to discover prices and provide liquidity.

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رابطهٔ غیرخطی نااطمینانی شاخص قیمت موادغذایی و امنیت غذایی در خانوارهای ایرانی: شواهدی از مدل GAS

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چکیده

هدف اصلی پژوهش حاضر بررسی تأثیر نااطمینانی قیمت موادغذایی بر امنیت غـذایی در خانوارهـای ایرانی طی دورهٔ ۱۳۹۶-۱۳۵۹ در چارچوب یک مـدل غیرخطی است. جهـت بـرآورد نااطمینـانی از مـدل امتیاز خودرگرسیونی تعمیم یافته و برای برآورد تأثیر نااطمینانی قیمت موادغذایی بر امنیت غـذایی از مـدل خـود رگرسیونی انتقال ملایم استفاده شده است. نتایج نشان می‌دهد که نااطمینانی قیمت مواد غذایی در رژیم اول (سطح پایین سرمایه‌گذاری در بخش کشاورزی) تأثیر منفی و معنادار و در رژیم دوم (سطح بالا سرمایه‌گذاری در بخش کشاورزی) تأثیر منفی و غیرمعنادار بر امنیت غذایی دارد. در رژیم اول که سـطح سـرمایه‌گذاری در بخش کشاورزی از حد آستانه کمتر است، با افزایش نوسانات قیمت مواد غذایی، نااطمینانی در بازار افزایش و علائم با شفافیت کمتری به تولیدکننده و مصرف‌کننده سیگنال می‌دهد. در این شـرایط مصـرف‌کنندگان بـا مشکل کاهش قدرت خرید مردم و نااطمینانی در دسترسی به مواد غذایی مواجه خواهند شد، که تأثیر منفی بر امنیت غذایی دارد. درحالی‌که رژیم دوم و افزایش سطح سرمایه‌گذاری در بخش کشاورزی توانسته است تا حدودی تأثیرات منفی نااطمینانی بر امنیت غذایی را خنثی نمود. با توجه به نتایج مطالعهٔ حاضـر، مسـئولان بایستی از یک‌سو، با اولویت‌دهی به تأمین منابع مالی سرمایه‌گذاری در بخـش کشـاورزی و تسـهیل شـرایط فعالیت بخش خصوصی و تعاونی‌ها در این زمینه و حمایت از کشـاورزان گام‌هـای مؤثری بردارنـد؛ ازسـویی دیگر، برای کاهش فاصلهٔ قیمت‌ها، تنظیم تقاضای بازار محصولات کشـاورزی و ایجـاد شـرایط ثبـات قیمـت موادغذایی نوعی مصونیت در مقابل نوسانات و شوک‌های کوتاه‌مدت ایجاد نمایند.

کلید واژه‌ها: نااطمینانی قیمت موادغذایی، امنیت غذایی، مدل امتیاز خودرگرسیونی تعمیم یافتـه، مـدل خودرگرسیونی انتقال ملایم.

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