Food Security of Tunisia: Comprehensive Analysis of a Composite Index

Marwa Ben Abdallah[1], Maria Fekete Farkas[2], László Vasa[3,*], Zoltán Lakner[4]

[1] Doctoral School of Economic and Regional Sciences, Hungarian University of Agriculture and Life Sciences (MATE), Páter Károly utca 1, H-2100 Gödöllő, Hungary, marwa.ben.abdallah@phd.uni-mate.hu

[2] Institute of Agricultural and Food Economics, Hungarian University of Agriculture and Life Sciences (MATE), Páter Károly utca 1, H-2100 Gödöllő, Hungary, farkasne.fekete.maria@uni-mate.hu

[3,*] Budapest Metropolitan University, Nagy Lajos király útja 1-9, H-1148 Budapest, Hungary, laszlo.vasa@ifat.hu; corresponding author

[4] Institute of Agricultural and Food Economics,, Hungarian University of Agriculture and Life Sciences (MATE), Páter Károly utca 1, H-2100 Gödöllő, Hungary, lakner.zoltan.karoly@uni-mate.hu

Abstract: For decades, food security has been the main concern of a large number of researchers. With the emerging of the COVID-19 pandemic, growing research that try to measure the food security status. Different studies have attempted various measurement methods aiming to quantify the level of food insecurity for some countries. Seventeen indicators have been selected to build a unique food security index. Principal Component Analysis (PCA) method has been employed to determine a comprehensive evaluation of index. 2 factors have been resulted to comprehend the food security index movement based on yearly indicators. Furthermore, the econometric model, Vector Error Correction Model (VECM) has been employed to detect the relationship between the built food security index and macroeconomic indicators. a long run causality relationship has been identified between the food security index, exchange rate, GDP, and global food price index. The resulted food security index is positively affected by the food price and there is an adjustment of 42.7% annually of the food security disequilibrium.

Keywords: Food import; Food price; Food security Index; Tunisia; VECM

1 Introduction

Food security has been always a challenge for the humankind. Therefore, understanding the main drivers of food security is the key to identify the most important factors leading to mitigate the insecurity level and to forecast which country is more sensitive to food insecurity. FAO defined the food security concept as the state "*when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food in order to respond to their needs for an active and healthy life*" [1]. Four pillars have been identified for food insecurity: availability, access, utilization and stability [1].

The United Nations (UN) has identified a group of goals to end hunger by 2030 [1]. Roser and Ritchie in the framework of their research affirmed that the current situation is far from reaching this goal. They found that 820 million people, equivalent to 11% of the world population, are undernourished. About 1.8 billion people, which equals to a quarter of the world population are moderately or severely facing food insecurity [2]. At the end of 2019, the spread of the new Coronavirus epidemic (COVID-19) interrupted a considerable part of socio-economic processes in the world life. It aggravated the situation of people who already had been suffering from food insecurity and malnutrition. The COVID-19 made a pressure for policymakers to take quick decisions to mitigate the effect of the pandemic, e.g., in West Africa, which is dependent on rice import. The governments have established new policies trying to reduce the impact of the pandemic on the rice trade [3]. The lockdown resulted from COVID-19 has endangered the food security of vulnerable and low-income households which are highly linked on labour income [4]. The world food program forecasts a number of 130 million of hunger people resulted from the COVID-19 [5]. The fast transmission of COVID-19 harmed different sectors leading to various concerns. The highest concern during this critical situation was that people find their food needs. The COVID-19 endangered as well the food security in some developed countries, but mostly the developing countries had been proven the most vulnerable [6]. A bibliometric study between the food security and their price shows the importance link between the food price and the nutrient intakes especially in developing countries [7].

The world population growth leads to the increase of the food demand, which is accompanied by an income growth and urbanization. The problem is that how to feed and to respond the needs of a global population that is predicted to attain near 10 billion by mid-century (2050). The main concern is that the ability of achieving the required production increases under the pressure of various, demographic, climatic and political factors, just a name a few [8]. Urbanization is defined by the growing share of people who are settling in urban areas and aftermath; the share of people who are living in rural areas is reducing [9].

On the other hand, the agriculture is facing a huge task to realize a secure food for all the population. In addition to the rapid urbanization, people and governments will be confronting further enormous challenges [10]. At the beginning, food security research concentrated on economic policy and global issues and later on the literature has been enlarged to include other subjects such livelihoods, health, and the environment [11]. This paper suggests a simple and relatively comprehensive method to analyse the food security, based on Tunisian case. Tunisia is the northernmost African county, neighbour of Algeria and Libya.

Tunisian households are facing a decrease of their real incomes, as a consequence of the increasing of food prices, caused by climate change [12]. In last decades the governments of Tunisia could increase the self-sufficiency in case of many products [13], [14], [15], but despite of the partial successes, Tunisia is highly dependent on cereal imports regardless the quantity produced. 3.7 million tons of cereal are forecasted had to be imported during 2021-2022. Tunisia is mainly producing cereals, olives, fruits. It suffers from the lack of water availability (450 m^3/capita/year) and in next decades a growing water scarcity is expected [16] Many united factors may affect the quality and the productivity of the different agricultural commodities. Most of the people who are deprived from food constitute the poor segment of the population. Based on the food security index, in 2018, Tunisia has occupied the rank 51 from 113 countries [17]. In current situation a comprehensive food security strategy is needed [18], [19], importance of which is highlighted the fact that Tunisia will suffer significantly from the war between Russia and Ukraine, which could affect the imported quantity of cereals. Ukraine and Russia are the main sources of cereal from where Tunisia import cereals [20].

2 Theoretical Frameworks

Food security is jeopardised by a wide range of factors, e.g., the disruption of the food supply chains or income losses, just to name a few [21, 22, 23]. Price fluctuations could disturb the consumer diet, forcing them to change their preferred food [24]. Food security always presents the hub of research, especially in case of extreme situations, e.g., pandemic or war. The uncertain spread of the pandemic COVID-19 aggravated the situation, its evolution around the world menaced food security by reducing food production [25]. Vulnerable households such as small-scale farmers were highly affected by the COVID-19, threatening the food availability and accessibility [26]. The pandemic weakened the food production, modified the demand and food access [27], [28], [29], [30]. As a summary it can be stated that COVID-19 presented critical situation for the global food security [31], as opposed to the former local crises. To evaluate the food security situation in developing countries, two criteria should be taken into account. The first criterion is about food availability, which means the food that is

physically available by production and import. The second criterion is the access economically to food which means that food is well distributed to the population and people have enough income to buy it [32]. In 2019, Popp et al., elaborated a study which is considered the first one that focuses on the food supply systems in Africa in order to figure out the most important stages responsible to boost the food security [33]. In order to reach the sustainability of food security, a long-range strategy should be elaborated, which aim is to respond the health requirements of contemporary people, without endangering the needs of future generations. For these reasons, various studies have been published trying to estimate food security using different indicators which may cover some of its dimensions [34], [35], [36]. Two levels are considered to assess the food security: the national level and the household level. To investigate the household level, survey method is needed while secondary data could be used to assess the national level. Blekking et al, in 2020, analysed the household level urban food security situtation on base of a panel of 718 households, using survey method. Two measures have been used for that; the food consumption score and the coping strategy index [37]. A comparative study has been established by Omidvar et al, in 2019 to assess food security between different countries within MENA region. They used the food insecurity experience scale applying different statistical methods (e.g., descriptive statistics and binary logistic regression, etc.) to identify three groups of countries from severe to moderate food insecurity [38]. In developed countries, food insecurity could be affected by socio-economic and demographic indicators. It has been revealed that people who live alone and don't have social life are more food insecure [39]. The level of education, number of children and the home location present a significant effect on food insecurity [40] and also on the ecological footprint and after all on the climate change process [41]. In 2017, Akinboade and Adeyefa collected primary data to investigate the household food security of low income, poor urban households. ANOVA method has been applied to detect the existence or the absence of difference between different analysed groups. A food insecurity index has been developed as a potential indicator [42]. It has been built with the probability of covariate shock happening, the experience of food insecurity accumulation and household's endurance [43]. After the introduction of food security index by the Economic Intelligence Unit in 2012, many research papers have been published to assess the global food security [44], employing the Data Envelopment Analysis (DEA) and Principal Component Analysis (PCA) methods, showing, how the global food security is sensitive the selected indicators such as food consumption as a share of household expenditure. Caccavale and Giuffrida in 2020 built a new composite index by selection variables, weighting, normalization and aggregation and they tested it using Monte Carlo procedure [45]. To measure the food security index, many researchers have classified drivers into groups. Two main groups of factors are introduced by Smith in 1990, which influence the food security status. The first group involves the supply determinants. It includes the following factors: weather circumstance, imported products, policy inducement, stocks, and

production. The second group covers demand determinants and it contains population progress, income development and distribution, and export income [46]. Ulezko and Pashina, suggested three groups of indicators; macroeconomic, trade and subjective one. The macroeconomic group contains macroeconomic variables such as GDP and the agricultural production. The trade group has data about the volume of agricultural raw materials import and export. The subjective group involves market determinants, commodity suppliers and consumers [47]. A recent study was elaborated to analyse food security index in China, in 2021 by Lv et al., [48] using agricultural, climatic, and socioeconomic factors. An analysis was carried out, using stepwise regression, to identify the spatiotemporal prevailing factors leading to food security. There are different methods to assess the food situation. Based on the amount of production and purchases of agricultural commodities, the food market potential in developing economies could be evaluated. Another method of assessment employs demand and supply, the level and nature of the prices, market infrastructure, and market adjustment [49]. The usability of these methods much depends on data availability and complexity. In 2021, Sam et al., estimated the food security index in India based on group of factors using PCA method as a weighing method to generate a unique indicator [50].

Based on the advantages and limitations of this measurement methodology the current study is established to construct a non-subjective weighted index which allows providing a quantitative analysis and objective evaluation of Tunisia's food security. Tunisia experiences a specific case because of two overlapping concerns: from one side the overweight and obesity and the deficiency of micronutrients (i.e. anaemia) from the other side. The percentage of children under 5 years who have anaemia is 28 in 2017. Despite the low-level of hunger, Tunisia suffers from regional disparities which hamper the vulnerability of certain region more vulnerable for food security. These regions face an access problem to healthy and nutritious meals caused low purchasing power. For this reason, the World Food Program (WFP) with the collaboration of the government, in 2017, served schools with meals to facilitate the access to nutritious food for children [51].

3 Methodology and Data Collection

In accordance with to the implication of food security, the factor measurably and data availability, 17 indicators have been selected in this paper, covering Food exports (% of merchandise exports), agricultural raw materials exports (% of merchandise exports), food imports (% of merchandise imports), mortality rate, under-5 (per 1,000 live births), food supply kcal, cereal yield (kg per hectare), Life expectancy at birth total (years), agriculture, forestry, and fishing, value added (% of GDP), food production index (2014-2016 = 100%), livestock production index

(2014-2016 = 100%), fixed telephone subscriptions (per 100 people), rural population growth (annual %), agricultural land (% of land area), population growth (annual %), daily protein supply per capita (g/capita/day), arable land (hectare per person) and agricultural raw materials imports (% of merchandise imports). The selected indicators could be classified into four groups. The first one includes the trade indicators which provide an image about the Tunisian ability to rely on local resources (food, agricultural raw materials). To take into consideration the trade balance, it can be analysed the country's dependence on import. It includes agricultural raw materials imports, agricultural raw materials exports, food exports (% of merchandise exports), and food imports. The second group forms the quality of life, including mortality rate under five rate (mortality per 1,000 live births) and life expectancy at birth (years). The third group constitutes the economic and development component. It has population growth (annual %), rural population growth and value added in agriculture, forestry, and fishing (% of GDP), arable land per person, agricultural land and fixed telephone subscriptions (per 100 people). The fourth group forms the supply feature. It involves food supply, daily protein supply per capita, livestock production index, food production index and cereal yield. Livestock production has been involved as an indicator of diet quality [52].

3.1 Data Sources

This data has been collected from FAO statistics and World Bank databases, where 17 yearly measured variables have been obtained from 1967 to 2017. Ind1, Ind2, Ind5, Ind6, Ind7, Ind10, Ind11, Ind12, Ind13, Ind14, Ind15, Ind 16 and Ind17 are positive indicators. Ind3, Ind4, Ind8 and Ind9 are reverse indices. The indexes are presented in Table 1.

Table 1
List of indicators used in food security index estimation

Variables	Dimension	Code
Food exports	% of merchandise exports	Ind1
Agricultural raw materials exports	% of merchandise exports	Ind2
Food imports	% of merchandise imports	Ind3
Mortality rate, under-5	number, per 1000 live births	Ind4
Food supply	kcal/capita	Ind5
Life expectancy at birth, total	years	Ind6
Daily protein supply per capita	g/capita/day	Ind7
Arable land	hectares per person	Ind8
Agricultural raw materials imports	% of merchandise imports	Ind9
Population growth	annual change, %	Ind10
Agricultural land	% of land area	Ind11
Rural population growth		Ind12

Fixed telephone subscriptions	% per 100 people	Ind13
Livestock production index	% 2014-2016 = 100	Ind14
Food production index	%, 2014-2016 = 100	Ind15
Cereal yield	kg/ha	Ind16
Agriculture, forestry, and fishing, value added	% of GDP)	Ind17

The min-max standardization, 0-1 scaling, has been adopted to normalize the chosen indicators.

3.2 Principal Component Analysis (PCA)

PCA is a statistical multivariate method that has been used to study large sets of data. It is chosen to be utilized to combine different data in a constricted way. PCA is not a subjective methodology; it produces a unique aggregated value built under an objective approach. The weight of each indicator presents a critical component for the final assessment results of food security in Tunisia. To avoid biased results which could be caused by the correlation between the variables and objectively demonstrate the food security situation in Tunisia, this paper uses factor analysis by the principal component analysis. Factor analysis allows deriving a relatively small number of independent variables from many dependent variables. Two tests have been considered to check the validity of the use of the PCA method; the Bartlett test of sphericity and the Kruskal-Meyer-Olkin (KMO) test [53]. These tests justify the use of factor analysis.

4 Empirical Results and Analysis

4.1 Factor Choosing and Identification

Two factors have been deducted from 17 variables. Each factor has an eigenvalue greater than 1 and their cumulative variance explanation is 89%. In other words, the resulted two factors present nearly 90% of the variance of 17 indicators.

The food security score has been obtained by the multiplication of each factor by its variance and divided by the cumulative variance (89%). It is the sum of weighted factor1 and factor2. A comprehensive food security index of Tunisia's has been found from 1967 to 2017. The weight of each factor is presented by their variance explanation. The equation is the following:

$$FSI_t = a\,Factor1 + b\,Factor2 \quad (1)$$

In the equation 1, FSI means food security index, *t* means year (t = 1967 -2017), "*a*" and "*b*" are two coefficients which present the weight of each factor. The food security index resulted from the weighted factors (factor1 and factor2) are presented in Table 2.

The value of the KMO test is equal to 0,861, which is greater than 0.5 and closer to 1. Bartlett's test has a significant *p*-value. It indicates that there is a strong correlation between variables. Both tests justify the suitability of the use of PCA and its application on our database.

Table 2

Principal component analysis results: Percentage of variance contribution of factors

Comp.	Initial Eigenvalues			Rotation Sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	13.9	78	78	7.7	45	45
2	1.7	10	89	7.4	43	89

Source: SPSS output

PCA method results have been highlighted in Table 3. using Varimax rotation. Factor explained 45.388% of total variance and factor explained 43% of the total variance. The cumulative variance is equal to 89%. The weighted sum of these two factors and the normalized value of the resulted index. Food and agricultural raw material export have the highest variance percentage contribution to build factor 1. Having high export value leads to surplus of food trade balance. Arable land per person is a decreasing index which plays a disadvantageous determinant for small farmers engendering the reduction of their income and increasing their cost of production. Hence, it handicaps their access to health services. Factor 2 encompasses demographic development and production indicators. Population growth, agricultural land and rural population growth have the highest variance percentage contribution. The population growth is the highest explained variable by factor 1. This could be explained by the dietary change of people, they become protein consumers more than pulses. The government should take in consideration this change in order to offer the need of population food.

Table 3

Rotated Component Matrix: The rotation method is Varimax with Kaiser Normalization

Indicators	Factors	
	1	2
Food exports	-0.942	-0.145
Agricultural raw materials exports	-0.941	-0.176
Food imports	0.867	0.352
Mortality rate. under-5	0.850	0.514
Food supply	0.816	0.535

Life expectancy at birth. total	0.808	0.576
Daily protein supply per capita	0.787	0.575
Arable land	-0.751	-0.617
Agricultural raw materials imports	0.638	0.595
Population growth	0.189	0.957
Agricultural land	0.352	0.863
Rural population growth	-0.148	-0.854
Fixed telephone subscriptions	0.457	0.851
Livestock production index	0.527	0.824
Food production index	0.541	0.771
Cereal yield	0.476	0.705
Agriculture. forestry. and fishing. value added	-0.611	-0.644

Source: SPSS output

Table 4 presents the descriptive statistics of FSI.

Table 4
Factor analysis results of Food Security Index

	Factor 1	Factor 2	Total	Normalised
min	-130106	-242367	-182217	0.00
1st quarter	-0.64	0.14	-0.78	0.35
median	-0.14	0.37	0.31	0.60
mean	1902	-25546	-13206	0.60
3rd quarter	0.71	0.48	0.70	0.91
max	140792	100807	138749	1.00

Source: Own calculation

Figure 1 shows the two factors' scores and the resulted food security index. The two factors are moving oppositely. Two intersections have been registered: the first one was in 1974 and the second intersection was 2000. In 1982 the trade and life quality factor has registered its highest value, meanwhile demand and development factor had the lowed score. The up-warding movement of trade factor is explained by the trade policy adopted by Tunisia, to encourage exports by giving fiscal benefits to companies. The production and development factor has witnessed an increase which could be justified by the introduction of new technologies in agricultural activities and mechanization of the agriculture field. After 2000, the production and development factor surpassed the trade and life quality factor. This downward could be explained by the deficit of food trade balance and the deterioration of the food quality and health services.

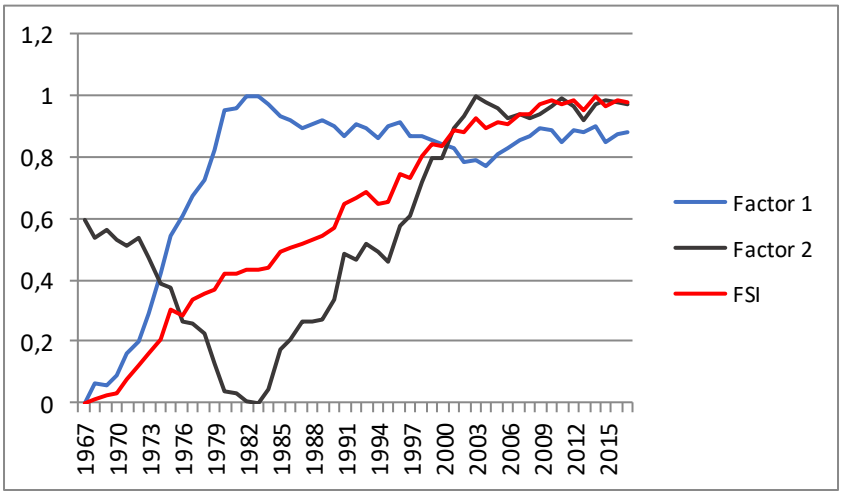

Figure 1
The fluctuation of food security based on factor score

4.2 Assessment of the Estimated Food Security Index: VEC Model

Comparing the resulted index and existed indicators of food security on FAO website. A correlation coefficient test has been done to show the strength of the relationship. Food security data was used by different proxies. Mainly the number of calories that people consume and food production index. Average energy supply is a strong indicator because of its strong inversely relationship in determining the undernourishment prevalence Furthermore, of its, availability. it contributes to ameliorate the nutritional status [54].

Table 5 shows the high correlation between the estimated food security index and two indicators (i.e., average energy supply and average protein supply), that researchers use as a proxy for food security index. This result reveals the consistence of the calculated index with food security proxy indices.

Table 5
Correlation coefficient between the calculated food security index and food security proxy indicators

Correlation coefficient	Estimated food security index
Average energy supply (kcal/capita/day)	0.959
Average protein supply	0.966

According to Akaike information criterion (AIC) the selection of lag order was determined. Lag 3 was identified and used in the model estimation. In order to evaluate the causal relationship in short and long run between the estimated food

security index and global food price volatility, we included yearly database retrieved from FAO and World bank. Exchange rate, GDP, global food price was extracted. First, we checked the order of integration of these variables. Using ADF test, we justified that all variables are integrated at order1 which means, they are stationary after applying the first difference. Results of unit root test are displayed in Table 6. To check the existence of co-integration between the variables.

Table 6
Unit root test result

	ADF		Integration order
Variables	Level	First difference	I(1)
Log(food security index) (Lfsi)	-2.172 (0.218)	-8.235***	I(1)
Log (Global food price Index) (Lfpi)	-1.669 (0.440)	-5.564***	I(1)
Log(Gross domestic products) (Lgdp)	1.990 (0.988)	-2.089**	I(1)
Log (Exchange rate) (Lexr)	-0.295	-4.384***	I(1)

Johensen test has been employed. One co-integration equation is confirmed. Results are presented in table 7. After demonstrating that variables are co-integrated. VAR model could not be used. VECM should be estimated.

Table 7
Johansen Cointegration—Eigenvalue test Statistic

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.679840	52.39092	28.58808	0.0000
At most 1	0.357304	20.33584	22.29962	0.0918

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 8
Pairwise Granger causality tests

	GDP-FSI	FPI-FSI	EXR-FSI	FSI-GDP	FSI-FPII	FSI-EXR
F-Statistic	14.357	1.875	25.472	0.14521	2.29721	1.64131
Probability	0.000	0.149	0.000	0.9322	0.092	0.195

Based on Table 8, the value of the error term is significant, negative, and less than 1, which proves the existence of long run causality relationship between the variables. The negative sign indicates the short-term trend stabilization towards long-run equilibrium. The following equation has been formulated to illustrate the causality relationship in short and long run between the resulted food security index, GDP and exchange rate.

$$D(Lfsi) = C(1)*(Lfsi(-1) + 0.501325242278*Lfpi(-1) - 0.529514099681 * Lgdp(-1) + 0.062056361906*Lexr(-1) + 1.48492920419) + C(2) *D(Lfsi(-1)) + C(3)*D(Lfsi(-2)) + C(4)*D(Lfsi(-3)) + C(5)*D(Lfpi(-1)) + C(6)*D(Lfpi(-2)) + C(7)*D(Lfpi(-3)) + C(8)*D(Lgdp(-1)) + C(9)*D(Lgdp(-2)) + C(10)*D(Lgdp(-3)) + C(11)*D(Lexr(-1)) + C(12)*D(Lexr(-2)) + C(13) *D(Lexr(-3)) + C(14) \quad (4)$$

Summary of the Vector Error Coefficient Model is presented in Table 11.

Table 2
Results of VECM model

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.427186	0.086218	-4.954739	0.0000
C(2)	-0.184091	0.114461	-1.608330	0.1176
C(3)	0.092507	0.081873	1.129890	0.2669
C(4)	0.314014	0.074615	4.208433	0.0002
C(5)	0.027005	0.110262	0.244913	0.8081
C(6)	0.215279	0.106710	2.017413	0.0521
C(7)	0.069191	0.109822	0.630025	0.5332
C(8)	0.682086	0.274044	2.488968	0.0182
C(9)	-0.474658	0.204530	-2.320722	0.0268
C(10)	-0.376327	0.301357	-1.248775	0.2208
C(11)	0.745747	0.284219	2.623841	0.0132
C(12)	-0.274466	0.207684	-1.321554	0.1957
C(13)	-0.163985	0.268637	-0.610434	0.5459
C(14)	0.017349	0.011858	1.463048	0.1532
R-squared	0.850216	Mean dependent var		0.024294
Adjusted R-squared	0.789367	S.D. dependent var		0.047187
S.E. of regression	0.021656	Akaike info criterion		-4.581244
Sum squared resid	0.015008	Schwarz criterion		-4.024701
Log likelihood	119.3686	Hannan-Quinn criter.		-4.372760
F-statistic	13.97244	Durbin-Watson stat		2.185853
Prob(F-statistic)	0.000000			

Six coefficients are significant at 1, 5 and 10%. Lag 3 of food security index has a positive effect on GDP is significant at present with lag value. GDP has negative relation with FPI because, when GDP increase then there is much chance to increase investment in other sectors (e.g., industrial, touristic) rather than agriculture sector [55]. A positive relationship has been registered between the food security index and food price. This registered positive relationship could be explained by the increase of production, which results the price increase. In short run the global food price has a non-significant effect on food security index.

$$D(Lfsi) = C(1)*(Lfsi(-1) + 0.501325242278*Lfpi(-1) - 0.529514099681 * Lgdp(-1) + 0.062056361906*Lexr(-1) + 1.48492920419) + C(2) *D(Lfsi(-1)) + C(3)*D(Lfsi(-2)) + C(4)*D(Lfsi(-3)) + C(5)*D(Lfpi(-1)) + C(6)*D(Lfpi(-2)) + C(7)*D(Lfpi(-3)) + C(8)*D(Lgdp(-1)) + C(9)*D(Lgdp(-2)) + C(10)*D(Lgdp(-3)) + C(11)*D(Lexr(-1)) + C(12)*D(Lexr(-2)) + C(13) *D(Lexr(-3)) + C(14) \quad (5)$$

Figure 2 and 3 prove the adequacy of the econometric model use. CUSUM and CUSUM square curves do not exceed the limited line which means that VECM is a suitable model to determine the causality relationship between the dependent variable (i.e., the resulted food security index) and the independent variables (i.e., exchange rate. GDP and food price index).

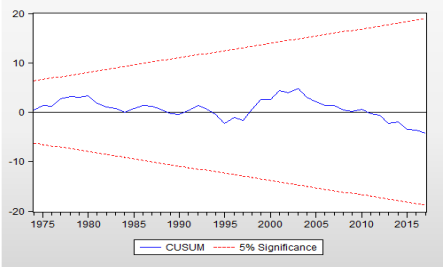

Figure 2
Cumulative sum (CUSUM) of residuals

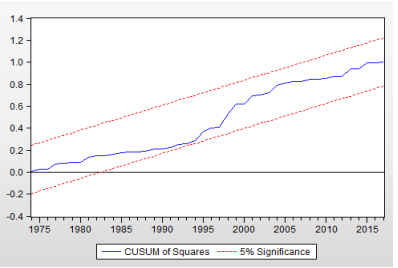

Figure3
CUSUM square of residuals

Conclusions

This paper applied seventeen indicators to build a comprehensive unique index for food security assessment. Findings show that the food security follows an upward trend resulted from two opposing tendencies. This trend could be explained by the improvement of the life quality and the health status. The significant change of dietary consumption system which accompanied the rise of their income, and their demand for food increases. On the other hand, the production level could not meet the level of consumption upward, which leads to the enlarging the gap between the production and consumption, then the food import increased in order to reduce the gap. To tackle the food insecurity risk, Tunisia should focus on the national food production to provide the food and to maintain the sustainability of the alimentary trade balance. This result was admitted by Ouassar et al. in 2021 [6]. Also, this gap could be explained by the rapid growth of population, which is emphasized by a decrease of rural population, migrating to urban areas. In addition, the dietary change became animal protein oriented. A significant long run relationship has been determined between the estimated food security index and the explicative variables (i.e., exchange rate. GDP and food price index).

This study is limited in timeframe; however, it could be extended to more recent times and includes more data. Furthermore, it identifies the weight of each indicator in building a unique index. This study helps future researches by

providing an idea about the movement of the food security index based on selected variables, which cover different aspects.

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