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MODELING AND FORECASTING FOOD GAP IN SYRIA: A BOX-JENKINS ARIMA APPROACH

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ABSTRACT

This research aims to analyze the Syrian food gap, to determine its characteristics, development, and vulnerability, and then to create the appropriate predictive model, depending on the time series data of the commodity balance and of the food Gap between (1986-2019). ARIMA's models were used to formulate the best model for prediction, compared to other traditional models. During the study period, the value of the Food Gap was very changeful, as the coefficient of variation has risen to 344, 2%. And most of the studied period years showed a positive value of the gap (food deficit), its maximum was 3044 million in 1987, while the gap decreased , reaching negative values (food surplus)during six years, its maximum (-3738) million dollars in 2006. For the prediction process, there was no general , statistically clear trend of the time series of the Syrian food Gap by using traditional models like "Ordinary least square" method , while the efficiency of "ARIMA" models was visible , where the best model for prediction was " ARIMA (0,1,1)" , which provided expectations of the continuous increasing of the Syrian Food Gap's value during 2020-2025 , which indicates the necessity of taking urgent measures by focusing on the agricultural sector, especially by increasing investments and reclaiming more land.

Keywords: *Syrian Food Gap, Self-sufficiency index, Box-Jenkins models , time series, food security.*

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1. INTRODUCTION

The food demand is at the forefront issues of global concern, it continuously increases because of many factors related to the food production and the demand on it. The environmental change and the security crisis are considered as the most important factors which increase the risk of food Insecurity (Justino, 2009). Syria is a developing country and its national demand on food is increasing permanently. Therefore, it always suffers from a lack of meeting its citizens' nutritional needs, especially with its growing population, estimated at about 254% (Central Bureau of statistics,2014). UN reports confirmed that Syria is one of the countries the most exposed to the food security risks because of the conflict that has begun since 2011. Two years after the beginning of the Syrian Crisis, Syria declined seven places, of the Global food Security Index, to rank 79/107. In the case of sub-indicators, it declined further and got the place 75/107 of the cost affordability Index, 96/107 of food availability index, 73/107 of food quality and safety index (Economic Information Unit,2013).

Food security crisis in addition to the climate change effects have lately created an increase in the food shortage. The Syrian food production has decreased dramatically, and it has transformed from an exporting to an importing country especially in terms of some agricultural products like the staple crops. This contributed to deepen the food gap, increasing the inability of local production in for covering the required consumption and as a result this led to a huge increase of malnutrition effects (FAO & WFP, 2015).

International reports have indicated that the most important negative effects of the Syrian crisis are the deprivation of people from Food Security. The defect of Syrian food Security's components has been reflected as an increase in families' numbers exposed to Food Insecurity, where part of them have entered the circle of extreme poverty. The Food Security Survey Data, in 2015, indicates that nearly the third of Syrian population are food insecure. And a little more than half of them (51,6%) are at risk of food insecurity. This means only 15,6 % of the Syrian population have food security (International Agency for food Policy Research,2012).

2. RESEARCH METHODOLOGY

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The development of the Syrian food gap takes an unstable and fluctuating trend, which leads to the difficulty of forming mathematical models. Thus, alternative models that can isolate the abnormal changes and consider the correlations between years, as, to predict the food gap's value in Syria, are required. To the best of the authors knowledge, ARIMA model has never been used to predict food gap in Syria. Thus, this research adopted ARIMA model which consider more accurate results than traditional models especially that the future prediction of the gap's path and direction will enable us to realize the volume of nutritional imports to meet the need of total demand. In this sense, the main goals are to:

1-Calculating the components of the food gap in Syria.

2-Estimating the effect of the Syrian Crisis on the food Gap.

3-Formulating a model of the food gap , appreciating its features and predicting its future path.

4-Prediction effectiveness by comparing between regression method and ARIMA.

4- Research Methodology:

The research depended on time data of production (Agricultural Statistical Groups 2004 , 2018) to calculate the index of the self-sufficiency ratio. This index is often used to indicate how capable the state is to meet the consumption's needs of its local production, with reducing the dependence on importing. When the local production incapacitates of covering this consumption, importing or aids are resorted to , where a gap in self-sufficiency occurs, which is called the food Gap.. The self-sufficiency ratio of a commodity is calculated by dividing the total of its local production by its available total and multiplying the result by 100 (ALRAWI, 2003), and thus, the food gaps expresses a reduction of self-sufficiency ratio which is estimated by less than 100. For the gap value, it was calculated through the difference between the value of food imports and exports during a specific period , and its data was obtained through the database of the International Food and Agricultural Organization (FAO) during 1986-2019.

This research is based on using the standard Prediction models, called Box-Jenkins , and applied by George Box and Gwilyn Jenkins on time series (1970) , and these models are based on extracting the expected changes of the observed data, basing on the fragmentation of the time series into several components which are " Stationary Component" , " Autoregressive Component" and " Moving Average Component". These components process the time series to obtain, ultimately, data that cannot be processed and contain only random changes " Random Noise".

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3. RESULTS AND DISCUSSIONS

Classification of crops and agricultural food products in Syria:

Plant agricultural production is divided into groups of crops, vegetables, and fruit trees. These products are grown as winter and summer crops in irrigated and rainfed lands, while the animal production is mainly based on poultry production for meat and eggs, on raising cows, sheep and goats for milk and dairy products, in addition to meat production.

Since 1990s, and until the beginning of the Syrian crisis, the Syrian Agricultural Production has known a remarkable and continuous development, because of increasing the cultivated areas, especially the irrigated ones, and providing the production requirements. And this was accompanied with agricultural politics which encourage the production according to general directions of the state, and these led to achieve faster steps towards developing the reality of the agricultural production and improving the farmers' lifestyle. However, the performance of the agricultural sector has been negatively affected by the crisis which has begun since 2011, as the most important challenges, that faced the plant production sector during the crisis, were the production regression and the exit of extensive areas from agricultural land production cycle .Also, the sharp rise in production costs, and the damages to farms, poultry farms and the infrastructure, as a result of burning and vandalism, which led to increase the costs of transporting and marketing the product between governorates , simultaneously with drought conditions and the instability of weather factors in general (World Bank , 2017).

The total value of damages and losses, in the agricultural sector during 2011-2016, is estimated at about 16 billion dollars, at least. This means the third of the Syrian Local Production in 2016. AlHasakah, Al-Raqqa, Rural Damascus , Deir Ezzor, Daraa and Idlib were damaged the most , where the value of damages and losses in each one reached more than billion dollars (FAO, 2017).

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To determine the effect of the Syrian crisis on the Food Crops Production, the major agricultural food crops in Syria were classified into eight main groups, as shown in table 1.

Table 1: The classification of Agricultural food crops according to the main nutritional composition standard

Group	Composition
Grains	Wheat
Legumes	Lentils, chickpeas, green peas, kidney beans, kidney beans
Vegetables	Beans, kidney beans, green peas, cabbage and cauliflower, garlic and dry onions, green beans, cucumber, pumpkin, zucchini, red watermelon, yellow watermelon, potatoes, tomatoes, eggplant.
Oil/olives	Crops of sesame, sunflower, soybean, oilseed rape and cottonseed oil, in addition to olive oil.
Fruits	Fresh grapes and figs, apricots, apples, pears and quince, peach and ginkgo, pomegranate, cherry, peach, pistachio, citruses.
Eggs	Table eggs from poultry and birds of all kinds
Meat	Meat of bovine, sheep, goat, poultry and fish
Milk	Cow, goat and sheep milk

It is important to say that Syria imports all its needs of rice, and two thirds of its need of sugar, and this is what was considered to calculate the Food Gap using the monetary value scale.

- **The development of agricultural food products in Syria during the crisis compared to the previous period:**

Food self-sufficiency is one of the most important determinants of food security, especially in conditions of political and economic pressures of some developing countries. The more a country can achieve self-sufficiency of basic food commodities, the less it becomes dependent on the economy of other countries. Since the 1980s , Syria has followed a national policy based on the achievement of self-sufficiency of most agricultural crops, and for this it employed all the material and technical capabilities, and was significantly able to improve the agricultural products, so it transformed from wheat importer to its exporter, and this applies to many other food commodities which have achieved high levels of production , but the impact of Syrian

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Crisis and the destruction of the agricultural infrastructure led to a significant decline of production despite of all the previous efforts and this is shown in table 2.

Table 2: The development of the local production of agricultural food products in Syria by comparing between the two study periods

Unit: 1000 tons for all crops and products except eggs (million eggs)

Year	Wheat	Pulses	Vegetables	Oil/olive	Fruits	Milk	Eggs	Meat
2004	4537	212.9	3177	1054	1751	2129	4002	405
2005	4669	261.1	3063	642	1759	2358	3104	423
2006	4932	275.6	3017	1240	2080	2535	3781	447
2007	4041	190.9	3291	545	1995	2680	3428	472
2008	2139	105.8	3053	881	1324	2425	3028	452
2009	3702	205.7	3414	921	2280	2409	3249	459
2010	3083	163.1	3190	990	2178	2242	3266	432
Avg	**3872**	**202**	**3172**	**896**	**1910**	**2397**	**3408**	**441**
2011	3858	208.4	3353	1116	2239	2558	3457	445
2012	3609	226.5	2524	1070	2089	2452	2967	401
2013	3182	221.2	1683	868	2233	2364	2466	361
2014	2024	139.4	1990	418	2056	2311	2242	346
2015	2862	185.7	2120	936	2158	1987	2037	309
2016	1726	174.9	2169	694	2249	1989	2138	320
2017	1851	216.2	2505	871	2112	1874	2077	322
2018	1223	193.4	2518	876	2257	1967	2176	376
2019	3085	217.5	2528	895	2238	1971	2389	391
2020	2848.5	187.4	2175	769	2091	1883	2169	328
Avg	**2626.9**	**197.1**	**2356.5**	**851.3**	**2172.2**	**2134.7**	**2411.8**	**359.9**
Total Avg change %	**-32.2 %**	**-2.4%**	**-25.7%**	**-5%**	**13.7%**	**-10.9 %**	**29.2 %**	**18.4 %**

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Annual growth rate during (2004-2020)	**-2.7%**	**-0.7%**	**-2.2%**	**-1.8%**	**1%**	**-0.7 %**	**-3.5 %**	**-1.2 %**

Source: Annual Agricultural Statistical Data (2004-2018).

Through the table, on average, there is a decrease of production for all food crops, during the crisis, especially for wheat production which decreased from about 3.9 million tons, as an average for the previous period, to only 2.7 million tons as an average for the crisis period, registering a negative annual growth rate during the total period (2004-2017). Also, the vegetable production declined significantly by -26.4 % compared to pre-crisis period, while the production of fruit trees increased during this period by 252 million tons, that means an increase of 13 % compared to pre-crisis period.

While for animal products, they mostly declined during the two study periods, especially with egg production which declined by -27% as a result of the destruction of a large part of poultry farms, especially in the countryside of Damascus, which ranked the first place of the number of poultry farms in Syria, in general.

- **The development of the available food products for consumption in Syria, during the crisis, compared to the previous period:**

The availability for consumption expresses better the food state in a region, measures generally the food availability; and the total food availability/consumption was calculated according to the following relationship:

"Total availability = local production + imports – exports – non-food uses -+ change in inventory".

In view of the absence of accurate information about loss, waste and change in inventory, and the absence of an accurate balance about the commodity and its uses, the total availability of food commodities will include the quantities prepared for food consumption and the quantities prepared for other consumptions such as feed, seeds, loss, waste, and industrial uses. The

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commodity balance data, issued by the Ministry of Agriculture and Agricultural Statistics, is the only official source for calculating the available food index in Syria (National Center for Agricultural Policy ,2010).

Like production, the quantities of crops, which are available for consumption in Syria, had undergone remarkable changes during the Syrian Crisis, as shown in table 3.

Table 3: The development of the agricultural food crops in Syria , which are available for consumption , by comparing between the two study periods.

Unit: 1000 tons for all crops and products except eggs (million eggs).

Year	Wheat	Pulses	Vegetables	Oil/olive	Fruits	Milk	Eggs	Meat
2004	3980	127	2962	1104	1681	2129	3954	380
2005	4104	166	2793	697	1608	2358	3084	384
2006	4995	180	2763	1289	1786	2829	3751	466
2007	3084	-37	2660	608	1759	2680	3429	492
2008	2283	68	2514	918	1100	2425	2054	387
2009	5362	211	2536	995	1766	2409	2865	498
2010	4193	140	2061	1056	1705	2242	3267	445
Avg	**4000.1**	**122.14**	**2612.7**	**952.43**	**1627.3**	**2396**	**3200.6**	**436**
2011	4343	221	2458	1184	1770	2558	3457	443
2012	4165	226	1991	1130	1795	2452	2948	422
2013	4574	216	1213	891	1867	2364	2325	371
2014	2901	210	1433	448	1819	2311	2208	362
2015	3476	171	1472	966	1978	1978	2039	319
2016	2602	155	1318	725	2065	1989	2132	322
2017	2072	196	1338	899	1995	1874	2078	326
2018	2597.7	177.6	1220	816	1984	1829	2116	328
2019	3516	201.8	1417	865	1975	1874	2082	337
2020	3279.5	118.8	1827	769	2018	1814	2158	319
Avg	**3352.6**	**189.3**	**1568.7**	**869.3**	**1926.6**	**2104.3**	**2354.3**	**354.9**
Total Avg	**-16.2 %**	**55%**	**-40%**	**-8.7%**	**18.2%**	**12.2 %**	**26.4 %**	**18.6 %**

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change %								
Annual growth rate during (2004-2020) %	**-1.1%**	**-0.4%**	**-2.8%**	**-2.1%**	**1.1**	**-0.9 %**	**-3.5 %**	**-1%**

Source: Annual Agricultural Statistical Data (2004-2018).

As shown in the table, some products have achieved a positive development during the Syrian Crisis, while other products have declined. In general , the cereals are the crops that achieved the most positive growth , as its availability increased on average by 60,6% , and this due to that a huge part of these crops , especially lentils , chickpeas and beans, was exported before the crisis, while their exports have extremely declined during the crisis until they were almost not-existent , which led to transforming the quantities dedicated for export in favor of the local consumption in the internal market. This also applies to fruit trees, whose average availability increased during the crisis by 17.6% compared to the previous period. The most important crops or products, which declined in quantities dedicating for consumption, were vegetables, as their available quantities in the internal market decreased by -43,3 %, this is mainly due to the decrease in their production, as mentioned previously. The same thing for eggs, whose availability decreased by -27,8 % on average, and the meat's availability decrease, on average, by -18,5 %. We observe also the decrease of wheat's availability as a result of the Syrian Crisis, as its quantities decreased from 4,3 million tons , as an average of pre-crisis period , to 3,4 million tons as an average of the crisis period , that means a decline of -17% on average , and this will be reflected , in turn , on the decline of per capita share of this crop , as well.

Despite of the decrease of available milk by -9,5 % on average, during the Syrian Crisis, it achieved a positive development during (2004,2017), with an average growth rate of -0,3 % a year , this also applies to fruit tree.

- **Measuring the food gap using the self-sufficiency criteria:**

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Self-sufficiency of commodities expresses the percentage of the local production which can cover the local consumption, and when this production can't cover the consumption, imports or aids are resorted to, as a self-sufficiency gap occurs, expressed as " The Food Gap". The development of this gap, for the main food crops, has been studied by comparing between the crisis period and pre-crisis period according to self-sufficiency measure, as shown in the following table 4.

Table 4: The development of self-sufficiency rates (SSR) of Agricultural Food Products in Syria , comparing between(2004-2010) and (2011-2017).

Year	Wheat	Pulses	Vegetables	Oil/olive	Fruits	Milk	Eggs	Meat
2004	114	168	107.2	95.5	104.2	100	101.2	106.7
2005	113.8	157	109.7	92.1	109.4	100	100.7	110.1
2006	98.7	152	109.2	96.2	116.5	100.2	100.8	95.9
2007	131	-521.6	123.7	89.7	113.4	100	100	95.8
2008	93.7	155.4	148.6	93.6	107.1	100	103.4	116.4
2009	69	97.4	134.6	92.6	129.1	100	113.4	92.3
2010	73.5	116.6	154.8	93.8	127.7	100	100	97.2
Avg	**99.1**	**46.6**	**126.8**	**93.4**	**115.3**	**100**	**102.8**	**102.1**
2011	88.8	94.2	136.4	94.2	126.5	100	100	100.5
2012	86.7	100.4	126.8	94.7	116.4	100	100.7	95.1
2013	69.6	102.3	138.8	97.4	119.6	100	106.1	97.2
2014	69.8	66.3	138.9	93.4	113	100	101.	95.6
2015	82.3	108.5	144.1	96.9	109.1	100	99.9	96.9
2016	66.3	112.5	164.6	95.7	108.9	100	100.3	99.3
2017	89.3	110.5	187.2	96.9	105.9	100	100	98.7
2018	47.1	108.9	206.4	107.4	113.8	107.5	102.8	114.6
2019	87.7	107.8	178.4	103.5	113.3	105.2	114.7	116
2020	86.9	157.7	119	100	103.6	103.8	100.5	102.8
Avg	**77.5**	**106.9**	**154.1**	**98**	**113**	**1017**	**102.7**	**101.7**
Total Avg change	**-23.8 %**	**129.4 %**	**21.5%**	**4.9%**	**-2%**	**1.7 %**	**-0.1 %**	**-0.4 %**

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%								
Annual growth rate during (2004-2020) %	**-1.6%**	**-0.4%**	**0.6%**	**0.3%**	**0**	**0.2%**	**0**	**-0.2 %**

Data (2004-2018). **Source:** Annual Agricultural Statistical

Based on previous the table, it is possible to calculate the value of the food gap(100- available for consumption) whose value, of some agricultural food products, raised during the Syrian crisis , especially the wheat crop by 21% , then oil crops by 4,4 % and meat by 2,4 %.

In general, the most important impact of the Syrian crisis was on the wheat crop, as the self-sufficiency ratio for this crop decreased from 99,1 %, on average, during the first period, to 79% on average, during the second period. In addition, the self-sufficiency of meat knew a significant decrease, from 102,1 % during the first period to 97,6 % during the second one. While the self-sufficiency of fruit trees and eggs recorded a slight decrease between the two periods, by only 1% for each of these two crops, respectively.

The self-sufficiency, of pulses and vegetables, increase remarkably during the Syrian crisis, comparing to the first period. This is an important and unexpected result, unless we take into account that the self-sufficiency factor doesn't show the individual's adequacy of necessary food energy , as we notice that the rise of self-sufficiency percentage of eggs , milk and meat was accompanied with a decrease of the production and the availability of each one , this means also a lower per capita share , and this applies generally to the rest of the crops that didn't know any important increase of production except fruit trees which achieved an increase of production with relatively slight decrease of exporting.

Thus, in general, it can be said that the rise or the stability of self-sufficiency ratios, of many food commodities, despite the Syrian crisis, doesn't necessarily mean an improvement of food security indicators because the stability may sometimes be accompanied with a decrease of production. The failure of covering this decrease is by import, which makes the availability equal

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to the production, and that makes the self-sufficiency ratio in this case misleading and doesn't reflect the individual's adequacy of these commodities.

- **Calculating the food gap value and its development in Syria during (1994-2018):**

Official Data, about Syria's total imports of food, is considered insufficient to calculate the food deficit's value, it lacks classification and organization, and difficult to be obtained, especially 1990s' data. Therefore, the data of the International Trade Center (ITC) and the International Food and Agricultural Organization" (FAO), is used. The availability of this data was limited to the period between (1986-2019). It includes information about the quantity of each commodity Syria imported and the value of this deal by "dollars": As the difference between the value of imports and exports , was calculated ; which expresses the food gap's value , as shown in table 5.

Table 5: The evolution of the food gap (DDF) , in Syria , during (2001-2019)

Unit: 1 million dollars $

Year	Import value	Export value	Gap value	Year	Import value	Export value	Gap value
1986	2710	411.5	2298	**2003**	14	8.1	6
1987	3064	19.4	3044	**2004**	250	446.0	-196
1988	462	44.1	418	**2005**	77	34.2	43
1989	332	205.5	126	**2006**	1082	4820.8	-3738
1990	8	0.0	8	**2007**	705	1253.9	-549
1991	1	0.0	1	**2008**	778	602.0	176
1992	1411	363.9	1047	**2009**	1350	1334.2	15
1993	111	0.0	111	**2010**	1357	555.3	801
1994	143	0.0	143	**2011**	25	0.6	24
1995	633	0.0	633	**2012**	26	1.2	25
1996	7	0.0	7	**2013**	4	0.0	4
1997	4	0.1	4	**2014**	1874	312.3	1562
1998	298	20.5	278	**2015**	2836	505.3	2331
1999	369	557.5	-189	**2016**	2240	3686.1	-1446
2000	20	0.2	20	**2017**	3248	932.4	2316
2001	203	826.0	-623	**2018**	1959	1425.9	533
2002	686	281.8	404	**2019**	3203	799.4	2404

Source: Database of (FAO) , (International Trade Center "ITC").

The table's data indicates that the Syrian food Gap ranged between -3738 million dollars in 2006, and 3044 million dollars in 1987, with an average of 354 million dollars, and a standard deviation of about 1219,1 million $, and the coefficient of variation of this gap reached about

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344,2 5during the studied period, which indicates a very large fluctuation of the food gap's values in Syria. It's clear that the food gap's value was positive (Food Deficit) during most years of the studied period, except six years, during them the value of exports exceeded the import's ones, achieving a trade balance surplus. And it's important to indicate that the decrease of food gap's value , during some years of the Syrian crisis, doesn't generally reflect an improvement of food security's measure , because this decline is mainly due to the decrease of importing because of economic sanctions , in addition to the decline of local production in the same time (as mentioned earlier), this leads to a decrease in available food and thus a decrease in food consumption at the individual level , which leads to negative effects on food security indicators, in general.

- **Checking the stability of time series "Stationary Test" of the Food Gap:**

The time series may be unstable in variation, and in the average as well, as the "unstable variation" problem arises because of the association between the random term (U_i) and the explanatory variable (X_i), and this problem leads to make the model parameters less efficient, and thus, the predictions are less reliable.

While "instable average" problem arises from the existence of self-association (Pirece, 1971). In decline models, this "self- association" problem indicates to the existence of a correlation between the successive values of the random bound, and for time series, the self-association indicates to the correlation between the successive values of the random bound across successive periods (Nuno,1996).

Accordingly, the time series stability will be examined using the "Sequence Plot" or "scatter Curve", this means the graph of actual data of the phenomenon studied over the time. This is useful to identify the characteristics of the time series in terms of the presence or the absence of a "Trend", the instability of variation, missing or irregular values "Outliers" within the series, or other practical problems. This means that the series graph leads to discover the causes of instability. Generally, if this series wanted to be stable, this curve must be concentrated on a constant average (Dicky &Fuller 1979).

The sample's historical data, from 1986 to 2019, were represented as shown in figure 1, as the horizontal axis represents the specific year, while the vertical axis represents the number associated to the food gap (million dollars).

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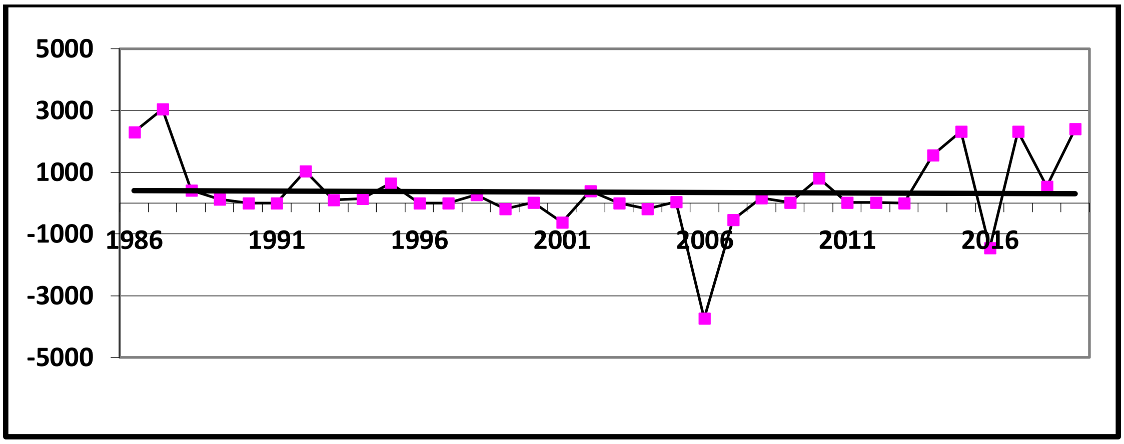

Figure 1 : Traceability Curve of the original data of the Syrian food Gap during (1961-2018).

It is evident from the graph that this time series is not static in contrast, as it is characterized by the presence of an unstable random trend, especially during the periods (2005-2007) and (2014-2019), where the first period witnessed an economic openness that was reflected in positive changes at the level of foreign trade. Especially with the European Union, in parallel with the increase in the productivity of the agricultural sector, which led to a decrease in the size of the food gap during this period. As for the second period, it is the period extending during the Syrian crisis, which negatively affected the productivity of agriculture and led to disruption of agricultural production and its subjection to random and irregular fluctuations more than in previous years. Accordingly, this chain is not apparently static, which required a single difference (d = 1) in order to get rid of the unstable random changes in it, to get a new, more stable series, as in Figure (2).

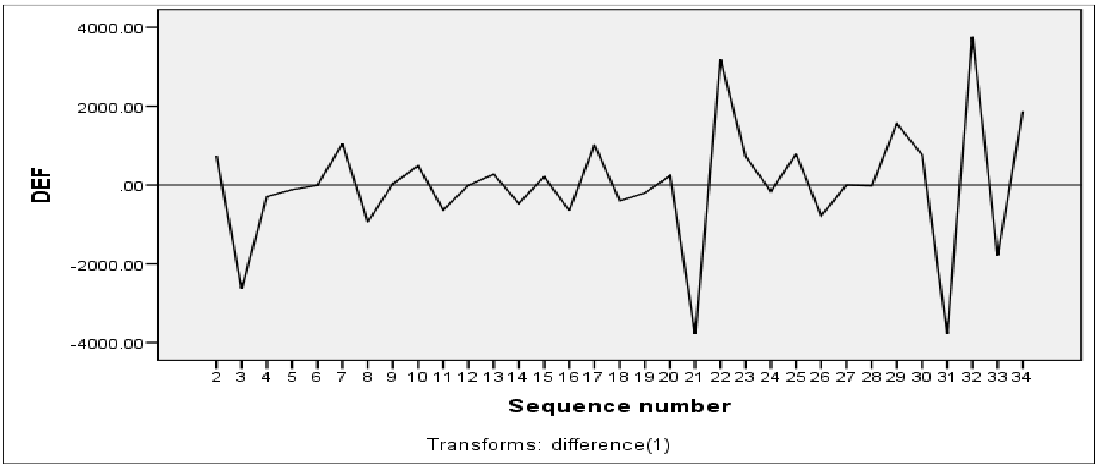

Figure 2): Sequence plot using the first-order difference determinant of the food gap in Syria during the period (1986-2019).

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It is clear from the figure that the time series has become more stable after the first difference, and here it should be noted that it is not possible to use logarithmic transformation or square roots due to the presence of negative values during some years of this series.

Determine the rank of the model: ARIMA (p,d,q)

The stage of defining the random context generating the time series is one of the critical stages, as we search in the ARIMA family of models for the appropriate model for our time series. It was proposed (Box & Jenkins, 1976) to determine the appropriate model rank based on the shape of the modified chain autocorrelation function (ACF) curve, and the shape of the partial self-correlation function (PACF), as shown in Figure (3).

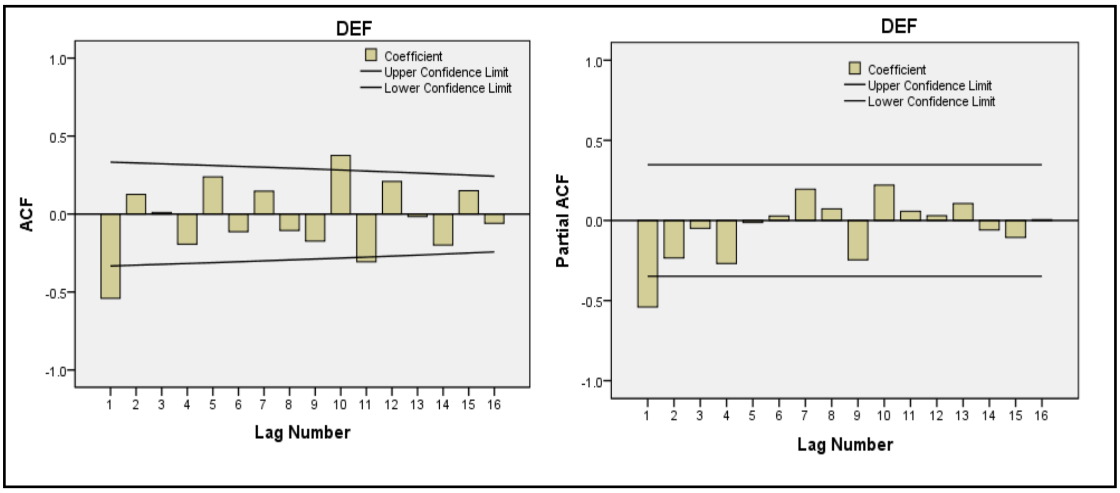

Figure (3): Self-correlation and partial autocorrelation curves for the time series of the food gap in Syria.

It is observed that the curve of the ACF is gradually decreasing with increasing lag periods (K), so that it follows the behavior of the gradually decreasing sine function which leads to the model proposal AR (p). It was found that this behaviour is also evident in the partial autocorrelation function (PACF), as it leads to the proposition of MA (q) Given that the number of non-significant correlations in the autocorrelation functions and the partial correlation can suggest AR (1) and MA (1), and since the original function was stabilized by making a single difference, the proposed model is the ARIMA (1,1,1) model, and the ARIMA model can also be proposed (1,1,0) and ARIMA (0,1,1). Accordingly, a comparison was made between these three models through a set of tests shown in Table No. (6).

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Table (6): Metrics that tests the predictive accuracy of the model

(Model Fit Statistics)

Measures	ARIMA(1,1,1)	ARIMA(1,1,0)	ARIMA(0,1,1)
RMSE	1147.865	1291.471	1099.714
MAPE	2942.978	2074.414	2911.218
MaxAPE	28542.311	39255.548	61461.328
MAE	812.533	817.546	716.363
MaxAE	3315.971	3725.331	3592.957
Normalized BIC	14.515	14.645	14.323

The best model is the model that meets the minimum values for each of the criteria shown in the table (Armstrong et. Al. 1992). Accordingly, we note that the ARIMA model (0,1,1) achieved the lowest values for most of these criteria, and thus it is considered better than the other two models. To express the time series of the food gap in Syria. Thus, the general form of the estimated equation of the model can be written, taking into account placing a negative sign in front of the parameters ɵ , given that most computer programs do not observe this rule, but estimates of these parameters are written assuming the resulting signal in the estimated equation (Al-Taie, 2003). Thus, the general form of the estimated equation of the model is

$$Y_t = u_t - \theta_1 u_{t-1}$$

$$|\theta| < 1$$

Moving averages parameter, which is smaller than the absolute one to achieve the condition of stillness and reflection.

ut: the random error of the type white noise, that is, with a normal distribution and constant contrast, (Brockwell & Davis, 1991). As for the assumption behind the moving average model, it states that the behavior of the time series Yt is often determined in terms of the current random change and the random change in Previous year also t-1.

- **Estimation of ARIMA(0,1,1) model parameters for nutritional gap prediction:**

After determining the general model diagnosed for the chain, the parameters of this model will be estimated at this stage by using the SPSS program and by the function of the greatest possibility (Pirece, 1971). Where possible to express the results as in Table No. (6)

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Table (6)- ARIMA (0,1,1) model estimates of the food gap in Syria

		Estimate	SE	t	sig
No Transformation	Constant	-6.324	67.911	-.093	.926
Difference		1			
MA	Lag_1	.715	.151	4.731	.000

From the table, we notice that the estimated parameter $\theta 1$ is significant, and it is not equal to zero, and: | θ | <1 as it fulfils the static and reflection condition of the moving average parameters.

On the other hand, the self-correlation problem was examined using the Ljung-Box test, where the model statistics also indicate the independence of the sample vocabulary, as shown in Table (7).

Table 7: Model Statistics

ARIMA(0,1,1) Model Statistics

Model	Number of predictors	Model Fit	Ljung-Box Q(18)		
		Stationary	Statistics	DF	Sig.
DEF	0	.358	12.822	17	.748

The depreciation of the Ljung-Box Q statistic indicates acceptance of the hypothesis that there is no subjective correlation between the sample values:

$$H_o : \rho_1 = \rho_2 = ... = \rho_K = 0$$

This means that the sample values are independent, and the correlation between them is equal to zero, and this leads to the stability of the predictions of the time series ((Ljung & Box, 1978). Thus, the prediction equation corresponding to the ARIMA model (0,1,1) can be written as follows:

$$Y_t = -6.324 + u_t - 0.715u_{t-1}$$

- **ARIMA (0,1,1) accuracy test result:**

In order for the model to fit, the model errors must be random variations with a mean of zero and a constant variance. The analysis of model errors depends on the estimates of these errors, that is, it depends on the remainder of the model, as the residuals or prediction errors are the real values minus the estimated values from the model and are also called the white noise series. To use the

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boundary confidence test, which states that the values of the residual autocorrelation coefficients fall between this specified range with probability of 95% according to the following formula:

$$p_r\left\{-1.96\left[\frac{1}{\sqrt{n}}\right] \leq p_k(a_t) \leq +1.96\left[\frac{1}{\sqrt{n}}\right]\right\} = 0.95$$

Upon achieving the above formula, this proves that the residues are randomly distributed, that the model used adequately represents the data, and can be used in prediction, and that the autocorrelations of the remainder are normally distributed with an arithmetic mean of zero and variance (1 / n) (Al-Jabouri, 2010) This is what we notice, drawing the two functions of self-correlation and partial self-correlation, shown in Figure (4).

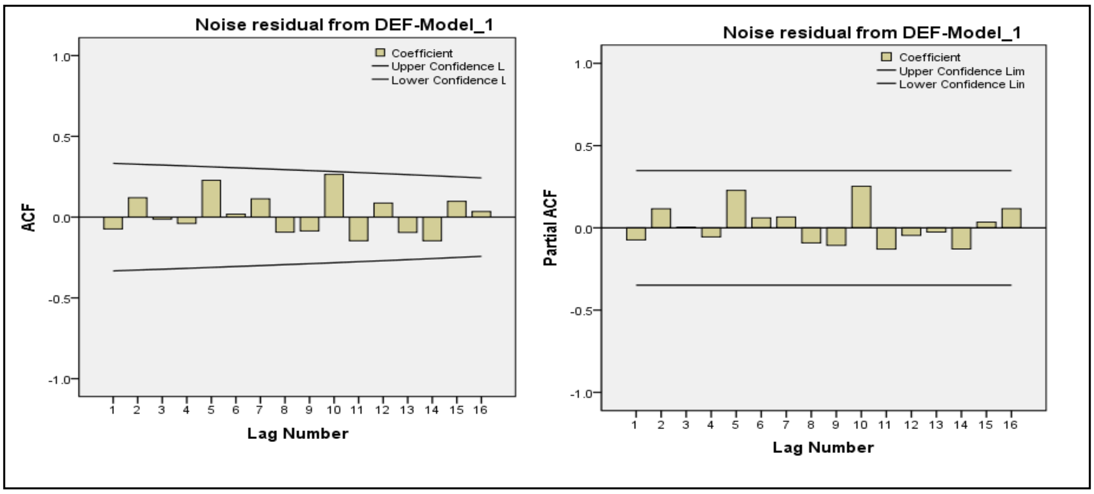

Figure (4): Autocorrelation and partial autocorrelation curves of the remainder of the ARIMA (0,1,1) food gap model.

It is evident that there is no self-correlation ACF or two parts of the PACF between the rest of the model within the confidence limits (25%), thus the residues follow the pattern of the white noise series, that is, it is independent and naturally distributed with an arithmetic mean of (0) and a variance of (σ^2). In order to make sure, tests for the normal distribution of residues were used, as shown in Table (8).

Table (8 Tests of Normality for Residues of the ARIMA Model (0,1,1)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.

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Noise residual from DEF-Model_1	.133	33	.144	.947	33	.107

The decrease in the value of the Gol grove statistic and the Shapiro statistic at a significance level of 1% or 5%, i.e. it is not significant, indicates the rejection of the null hypothesis that says that the residues do not follow the normal distribution, and this is also evident by drawing the histogram of the remainder as shown In Fig.5

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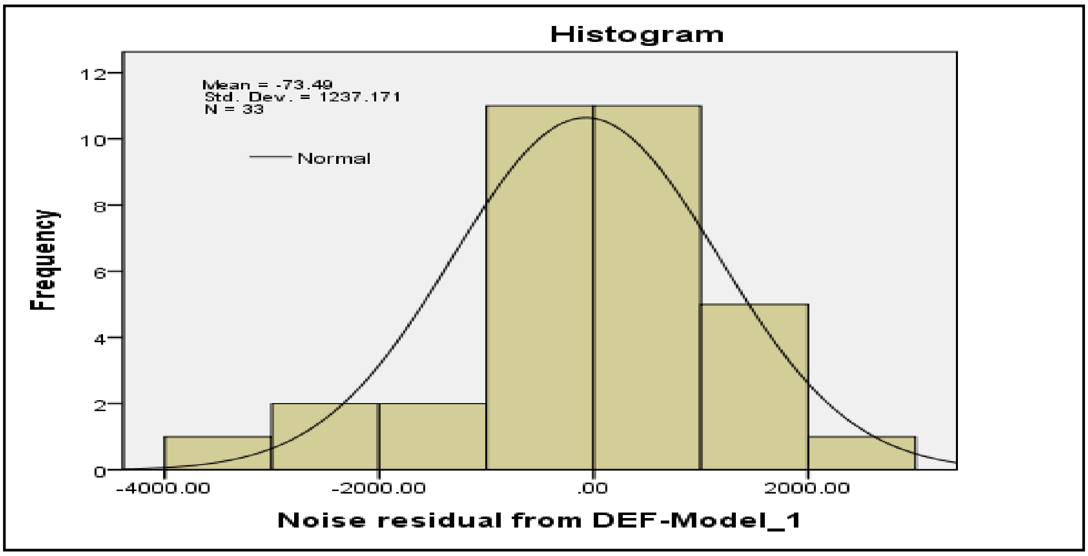

Figure 5: Histogram of rest of the ARIMA model 0,1,1

It turns out that the remainder of the model is distributed naturally, which means that the ARIMA (0,1,1) model according to statistical standards is considered the most accurate and reliable model for predicting the value of the food gap in Syria independently of the anomalous changes.

Use the ARIMA (0,1,1) model to predict the nutritional gap for subsequent years:

Forecasting is one of the main objectives of any study dealing with time series analysis, as the ARIMA (0,1,1) model was used to predict the food gap in Syria for the period (2020-2025), as shown in Table (9).

Table (9): Predictive values of the food gap in Syria using the ARIMA model (0,1,1), for the period (2020-2025)

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YEAR	Predictive Nutritional Gap Value
2020	1211.48
2021	1205.15
2022	1198.83
2023	1192.50
2024	1186.18
2025	1179.86

It appears from the forecasts that the food gap improve almost inconceivably during the period (2020-2025), at rates that depend on the amount of random errors in the previous two years, based on the components of the previous prediction equation, However, this improvement is not sufficient to solve the food security problem in Syria and it is highly necessary to take serious actions to solve this problem.

Accordingly, it can be said that this model expresses with statistical accuracy at the confidence level of 1% and 5% for the time series of the food gap in Syria, where the suitability of the model used for the data can be expressed as shown in Figure (6).

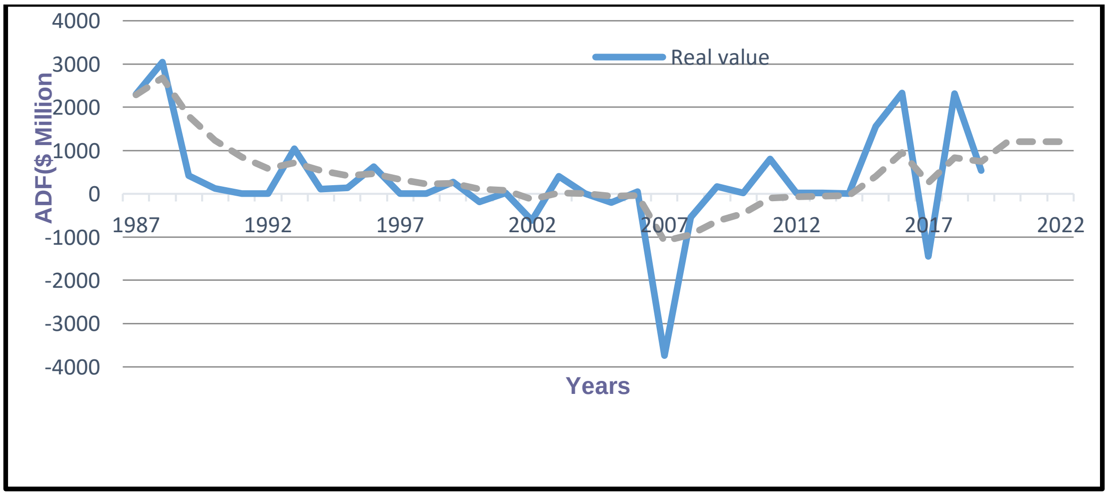

Figure (6): Curve of the observed and predictive values of the food gap in Syria using the ARIMA model (0,1,1).

We notice that the predictive curve takes a general direction that corresponds to the true curve often, except in periods of anomalies resulting from chaos or random changes occurring, and this cannot be observed and visualized using traditional prediction models.

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4. CONCLUSION

The production of most food commodities in Syria has developed significantly in the pre-crisis period, achieving a generally increasing trend, and despite the impact of the Syrian crisis on the agricultural sector, the general trend has returned to an increase, albeit at a slowing rate, which indicates the recovery capacity of the Syrian agricultural sector. The changes in the self-sufficiency rate of food products in Syria during the period are due to two main factors:

The first: random disturbances resulting from climatic factors such as drought, which led to abnormal changes in the production of some of these products, which also reflected on the self-sufficiency ratio, which recorded a marked deviation from the general trend separately from the impact of the Syrian crisis.

The second: the disturbances resulting from the impact of the Syrian crisis, which often took a different direction to the general positive trend - as is the case with fruit trees - or contributed to slowing the rate of increase in the general trend, as is the case with vegetable crops.

3-The significant improvement in the rate of self-sufficiency in some food products such as pulses is a misleading improvement, as it is mainly due to changes in foreign trade that led to a decline in exports, which contributed to covering the domestic consumption of these crops more than before, in light of Production continues to develop according to the general increasing trend.

4-The clear fluctuations of the food gap over a period of 33 years indicate the inability of economic policies to achieve food security in a solid and coherent manner, and it directly reflects the great volatility of agricultural production in Syria as a result of climatic factors and changes in agricultural policies.

The traditional predictive models are poor predictive models of the food gap in Syria compared to the ARIMA model (0,1,1). The traditional models focus on the general trend while failing to reduce the impact of the random changes that characterize the food gap in Syria.

-Predictions showed that the food security problem in Syria will turn into a crisis in the coming years, as the gap continues to widen along the same current pattern. If the high demand for food is accompanied by a scarcity of foreign currencies for import, then it is possible to imagine the food problem that occurs and what it entails for food security. Therefore, matters must be rectified by focusing on the agricultural sector, which is considered a vital sector by changing

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circumstances and giving this sector a leading role In the economy, and accordingly, more investments must be made and more land reclaimed.

5. RECOMMENDATION

Focusing support strategies for crops and agricultural products with a food gap, such as wheat, eggs and meat.

Re-work according to the five-year agricultural plans, and adopt the self-sufficiency strategy as a means to achieve food security due to the spread of chaos and wars in the Middle East region in general, which led to a decrease in the importance of partnership and free trade strategies.

Focusing on the ARIMA (0,1,1) model for predicting the food gap in Syria as an effective model to reduce the effect of random disturbances on the accuracy of predictions. Work to reduce random changes in the food gap and achieve stability between imports and exports when planning to confront the food deficit.

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