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Effect of Syrian Crisis on Potato Planting in Tartous Governorate Using Mathematical Simulation

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Abstract

Potato is the third most important food crop at the human consumption level after rice and wheat. It is consumed by more than one billion people. The total world potato crop exceeds 300 million metric tons. There are more than 4,000 varieties of potato, most of which are found in the Andes. Potato can be grown up to 4,700 meters above sea level. Also, one hectare of potato can give two, three, or four times than cereal crops. This research deals with potato cultivation in Tartous during the period 1990-2018 and the most important production process components related to this important cultivation. The most important results of this study are: (1) No statistically significant differences in potato-cultivated areas before and after the crisis; (2) Statistically significant differences in potato production before and after the crisis; (3) No statistically substantial differences in potato yield before and after the crisis; and (4) Statistically significant differences in potato production cost before and after the crisis.

Keywords: *Potato Production, Yield, Cultivated Area, Syria***.**

I. INTRODUCTION

Agriculture is a very important economic sector in Syria due to its large population that depends on agriculture and its related economic activities. The rural population constitutes about 51% of the total population. The contribution of the agricultural sector to the Gross Domestic Product (GDP) is about 30%, while the labor force to agriculture is about 30% of the total workforce (National Center for Agricultural Policy, 2016, Mohammed et al. 2020). Potato accounts for one of the important crops in Syria, as it represents a high percentage among the main food ingredients for consumers. It is considered an important alternative to cereals as it is characterized by relative abundance in yield per hectare and is grown in more than one season per year: spring, summer, and autumn. In addition, the varying weather and soil conditions that are suitable for cultivation enable the expansion of area planted with potato under different local conditions. Potato is a very adaptive plant that even provides good production under unfavorable conditions of cultivation and soil, but at the same time, it is vulnerable to infection with many pests and diseases. Therefore the farmers avoid cultivation on the same land from year to year.

In Syria, few studies were carried out related to agr-products. For instance, Al-Ahmad (2003) showed that vegetable-grown areas experienced sharp fluctuations over the last ten years (1991-2000) due to the frequent marketing bottlenecks that affected products' prices, adversely affecting the agro-product, which depends on replacing vegetable crops with other better income-generating ones. The vegetable-grown area amounted to 137.6 thousand hectares in 1991 and rose to about 165.5 thousand hectares in 1992, and then it began to rise and fall, reaching 116 thousand hectares in 2000. The case is the same with production which amounted to about 1041 thousand tons in 1991, rose to about 2381 thousand tons in 1995, then it went up and down to reach about 1965 thousand tons in 2000. The study results also showed that vegetable production costs include costs of agronomic practices, the value of production inputs, and other costs (land rent, capital interest, and miscellaneous expenses). The study found that the costs of agronomic practices per dunum of potato amounted to 3543 SP, accounting for 29% of the total costs versus 4205 SP for tomato, accounting for 39% of the total costs, and about 4767 SP for onion, accounting for 43% of the total costs.

Similarly, Al-Tarawneh (2005) aimed to find an economic platform to increase trade exchange between the three countries (Syria, Lebanon, and Jordan) by identifying the size of inter-agricultural trade of fresh vegetables and fruit between the three countries, the most important commodities that are the subject of trade exchange, and estimating the comparative advantage of crops chosen through the policy analysis matrix. As for potato, the study showed that the exported quantities of Syrian potato amounted to about 16.5 thousand tons as an average for the period 2000-2002, of which 30% goes to the European markets, 20% to the United Arab Emirates, 12% to each of Saudi Arabia and Kuwait, 6% to Oman, 4% to each of Qatar and Bahrain, 2% to Eastern Europe and 10% to the rest of the world. The study showed that the amount of

Syrian exports of potatoes is increasingly falling. The results of the policy analysis matrix showed that the Syrian potato crop achieves a comparative advantage, and the criterion for the cost of local resources was less than integer one for the Syrian potato, i.e., there is use efficiency of local resources, and therefore there is a comparative advantage for potato production in Syria. The criterion for the Nominal Protection Coefficient (NPC) of the outputs was less than integer one, indicating that potato price is not subsidized. There is a tax charged on the product because the local prices are lower than the international ones. As for the NPC criterion for inputs, it was less than integer one, i.e., there is a decrease in the costs that the producer pays due to subsidization policy, as the prices of domestic inputs are lower than international ones. Al-Mekdad (2005) try to study the productive and economic efficiency of studied crops, including potato, by studying the differences between the productivity of different capacities as a measure of production efficiency, in addition to calculating some economic criteria such as average costs, average revenue, and average net yield per unit area. The results indicated higher potato productivity per unit area from the small- to the large-scale category, i.e., increased productivity with increasing farm capacity, and this may be due to the availability of financial possibility for the large-scale holder and increased utilization of production inputs in line with the capacity savings that led to an increase in productivity. The average production of autumn potato per dunum for the small-scale category reached about 1954 kg versus 2015 kg for the large-scale category. The use of variation analysis proved a significant difference between the average productions of the different landholding categories of autumn potato. It has been proved, via the Tukey test, that the average productivity of the medium-scale category differs significantly over the average for the productivity of the small-scale category, as well as the average productivity of the large-scale category for the smaller category. However, the significance of the difference between the average productivity of medium-scale category and large-scale one was not proven. The study also showed no significant difference between average net return in various holdings, and the same is for the average dunum costs

Tartous is considered one of the relatively distinct governorates in the cultivation and production of potatoes, but the current Syrian crisis, accompanied by the economic blockade and economic and social changes, affected the return and production of this crop. Potato production faced many obstacles, the most important of which is the high cost of production inputs, crop exposure to fungal diseases, scarcity, and lack of optimal agricultural resources. This necessitated a study of this crop's economic and productive efficiency, how efficiently they use agricultural resources related to crop production, and the extent of its deviation from optimal use.

The importance of this research is due to the fact that it deals with a crop of high economic importance, a source of income for many farm households in Tartous countryside, and its contribution to determining the most important items of cost and return, and thus studying various aspects related to the economic and productive conditions of the potato crop, to identify the use efficiency of available resources in crop production, developing proposals that help to reduce the production cost to the lowest possible level, achieving economic and productive efficiency, improving production and increasing export capacity, especially during the current situation, in light of the change in the exchange rate of the Syrian pound and its value falls against the US dollar. Thus, this research aims to:

1. Study the reality of the development of potato cultivation and production in Tartous in light of the current crisis.

2. Study the costs and returns of potato, and estimate the productive and economic efficiency.

3. Estimate the production functions of potatoes in the study area.

II. MATERIALS AND METHODS

To study the problematic subject of the research and analyze its dimensions, aspects, and results, and to answer research questions and validate the hypotheses, a descriptive approach will be used to familiarize with theoretical frameworks related to the subject in addition to a set of statistical tools to collect and correct data and use specialized statistical software (SPSS) and (e-views) for the statistical and standard study of research data. This research will discuss the following hypotheses:

1. No statistically substantial differences in potato cultivated areas before and after the crisis;

2. No statistically substantial differences in potato production amount before and after the crisis;

3. No statistically substantial differences in potato yield before and after the crisis; and

4. No statistically significant differences in potato production cost before and after the crisis.

A. THEORETICAL FRAMEWORK

Potato is an important vegetable crop in the Syrian Arab country, where it occupies the second rank after tomato in terms of production, as potato cultivation is prevailing in most Syrian governorates, and its cultivation is concentrated in the northern, coastal, central and southern regions. Potato is planted in three consecutive seasons: spring, summer, and autumn according to the climatic conditions of each region, and this distribution in growing gives potato an advantage that provides fresh produce for domestic markets most of the year, providing an opportunity to export to other countries (Ali *et al.*, 2016).

According to MAAR's statistics, the reality of potato cultivation in Syria in the last ten years (2008-2017) has been as shown in Table (1):

Table (1). Status of potato cultivation in Syria during the period 2008-2017

Area (000 ha) Production (000 ton) Productivity: ton/ha	Development of area, production, and productivity of potato in Syria		
Year	Area	Production	Yield
2008	36	721	20
2009	35	706	20
2010	35	673	20
2011	35	713	20
2012	34	698	21
2013	22	442	20
2014	30	537	18
2015	23	505	22
2016	22	507	23
2017	24	562	23

Table (1) show that the area planted with potato is steadily decreasing over time. Production has been characterized by fluctuation and instability more than the area, reaching its highest in 2008 at about 721 thousand tons and lowest in 2013 of about 442 thousand tons to increase later in 2014 of 537 thousand tons and then decreases significantly in 2015 at a rate close to that of area decrease between these two years. This indicates that low production may be directly due to the low cultivated area as a result of introducing potato-cultivation areas to war conflicts and terrorist operations, in addition to the adverse impact of the crisis on the availability of many production inputs such as diesel, fertilizers, irrigation water, etc., which also adversely affected productivity in some years, leading to varying productivity from year to year.

Focusing on the crisis years in relation to potato crop, we notice that it decreased from 35,000 ha in 2010 to less than 30,000 ha in 2014 and its production from 673,000 tons to 540000 tons. However, the natural scenario (no crisis) assumes that the cultivated areas increase to more than 40,000 ha with production increase to over 790,000 tons.

Table (2). Changes of area, production, and productivity of potato in the study area (Tartous)

Area (000 ha) Production (000 ton) Productivity: ton/ha	Changes of area, production, and productivity of potato in the study area (Tartous)		
Year	Area	Production	Yield
2008	820	20196	24632
2009	1240	32168	25942
2010	1187	30452	25733
2011	1479	38510	26038
2012	1776	29574	16650
2013	2070	58592	28303
2014	2235	56015	25063
2015	2248	63735	28352
2016	2539	50909	20051
2017	2536	55597	21923

Table (2) shows changes in the area, production, and productivity of potato in the study area (Tartous) for the last ten years. We notice a steady increase in the area planted with potato in all their seasons over time, reaching a minimum of 820 ha and production of about 20196 tons, while productivity reached 24,632 ton/hectare versus the highest level in 2016, 2539 hectares. Though the area decreased in 2017 by only three hectares, production witnessed a remarkable improvement estimated at 55597 tons and high productivity at 21,923 tons/ha.

Table (3). Changes of area, production, and productivity of spring potato in the study area

Area (000 ha) Production (000 ton) Productivity: ton/ha	Changes of area, production, and productivity of spring potato in the study area		
Year	Area	Production	Yield
2008	814	20147	24751
2009	1224	32007	26150
2010	1181	30391	25655
2011	1441	38123	26456
2012	1757	29121	16574
2013	2034	57937	28484
2014	2211	55727	25204
2015	2237	63656	28456
2016	2508	50499	20135
2017	2524	55448	21968

Source: MAAR, Annual Agricultural Statistical Abstract, various series

Table (3) shows changes in the area, production, and spring potato productivity in the study area for the last ten years. A steady increase was found in the area planted with spring potato over time, with a minimum of 814 ha and production of about 20147 tons, while productivity reached 24751 ton/ha with the highest level in 2017 of about 2524 ha, production of about 55448 tons and productivity of 21968 ton/ha.

Table (4). The relative importance of spring potato in terms of area and productivity

Area (000 ha) Production (000 ton) Productivity: ton/ha	The relative importance of spring potato in terms of area and productivity					
Year	Area of spring potato	The total area of potato	%	Spring potato production	Total potato production	%
2008	814	820	99.28%	20147	20196	99.76%
2009	1224	1240	98.71%	32007	32168	99.50%
2010	1181	1187	99.49%	30391	30452	99.80%
2011	1441	1479	97.43%	38123	38510	99.00%
2012	1757	1776	98.93%	29121	29574	98.47%
2013	2034	2070	98.26%	57937	58592	98.88%
2014	2211	2235	98.93%	55727	56015	99.49%
2015	2237	2248	99.51%	63656	63735	99.88%
2016	2508	2539	98.78%	50499	50909	99.19%
2017	2524	2536	99.53%	55448	55597	99.73%

Table (4) shows the relative importance of spring potato in terms of area and productivity in the study sample for the last ten years. We notice that the proportion of area planted with spring potato constitutes the vast majority of the total area planted with potato, and the area planted with summer and autumn potatoes is almost zero. The percentage of spring potato reached 99% in the last ten years, and the same is true for spring production, which also reached 99% of the total potato production in all seasons. This prompted the researcher to focus on studying spring potato in Tartous.

III. RESULT and DISCUSSION

In the following, we will study the most important indicators of potato (cultivated area, production, productivity, and costs per kg) during the period 1990-2018 to determine the production developments of this vital crop in the agricultural economy and explain the impact of the Syrian crisis on this very important crop:

A. In terms of area:

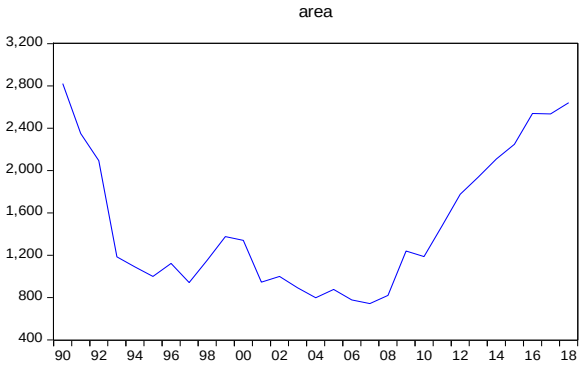

Figure (1). Development of potato cultivation in Tartous

The above figure shows the development of the potato-grown area in Tartous during the period 1990-2016, where the area tends to decrease during 1990-1994, and then the cultivated area settled for a relatively long period from 1994 to 2008 to rise again after 2008 until 2018. It is worth noting that the cultivated area has continued to increase even after the Syrian crisis.

Studying the general trend of cultivated area in Tartous:

- Self-correlation and partial self-correlation function:

Table (5). Self-correlation and partial self-correlation function

Date: 12/23/19 Time: 20:32
Sample: 1990 2018
Included observations: 29

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.788	0.788	19.962	0.000
		2	0.588	-0.08...	31.476	0.000
		3	0.354	-0.21...	35.812	0.000
		4	0.229	0.125	37.697	0.000
		5	0.094	-0.12...	38.028	0.000
		6	0.002	-0.05...	38.028	0.000
		7	-0.08...	-0.02...	38.312	0.000
		8	-0.12...	-0.01...	38.973	0.000
		9	-0.16...	-0.04...	40.120	0.000
		1...	-0.23...	-0.21...	42.750	0.000
		1...	-0.28...	-0.01...	46.872	0.000
		1...	-0.28...	0.060	51.297	0.000

From the above table, we notice that the coefficients of self-correlation function (AC) were outside the confidence range during the first period. The coefficients of partial correlation function (PAC) remain outside the confidence range until the third period. Thus, there is a kind of instability in the area planted with potato during the study period. To validate this result, we tested the unit root to determine whether the planted area was stable or not.

- Series stability test by unit root:

For decision making, we will consider the series stable if the value of the Augmented Dickey-Fuller Test Equation test is less than 0.05, giving an indication of the time series stability as shown in the following table:

Table (6). The results of the unit root test for area variable

Null Hypothesis: AREA has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.665353	0.4198
Test critical values:	1% level	-2.650145	
	5% level	-1.953381	
	10% level	-1.609798	

*MacKinnon (1996) one-sided p-values.

The above table shows the results of the unit root test for the area variable, where the probability value is 0.419, which is greater than the significance level 0.05, and thus we accept the null hypothesis stating time series instability during the study period.

It is expected that the reason for the instability during the last period of the series is the Syrian crisis, and therefore we will analyze the differences between the time series values before and after 2011. We will also use two statistical methods: The first is the T-Student for independent samples, and the second is the Augmented test Dickey-Fuller Test Equation with a breakpoint, which is the most powerful test for studying time series as follows:

a. T-Student Test for independent samples:

Table (7). Changes of the cultivated area due to the crisis

	Crisis	N	Mean	Std. Deviation	Std. Error Mean
Area	Before crisis	22	1237.9545	533.45705	113.73343
	After crisis	7	2255.8571	331.52749	125.30561

Source: The researcher, depending on the questionnaire and SPSS 25 software

From the above table, we find that the average cultivated area before 2011 was 1237.95 with a standard deviation of 533.45 ha, and this average rose to 2255.8571 ha with a standard deviation of 331.52 ha. To show whether these differences are statistically significant, we consider the results of the Independent Samples Test shown below:

Table (8). Independent Samples T-Test

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Area	Equal variances assumed	.417	.524	-4.732-	27	.000	-1017.90260-	215.12744	-1459.30764-	-576.49756-
	Equal variances not assumed			-6.015-	16.717	.000	-1017.90260-	169.22408	-1375.39597-	-660.40923-

From the above table, we find that the significance value corresponding to Levene's test is greater than 0.05. Therefore we assume that the variations are not equal.

From the above table, we also find that the significance value corresponding to the assumption of unequal variations in the t-test for Equality of Means equals 0.00, which is less than the significance level of 0.05. The differences between areas planted with a potato before the crisis are fundamentally different from those planted with a potato after the crisis. We will consider this result as the first indication of the differences, but for reasons related to the presence of unreal differences which the previous test cannot reveal, we tested the Augmented Dickey-Fuller Test Equation with a breakpoint shown below.

- Augmented Dickey-Fuller Test Equation with a break point

This test is one of the most important tests used in time series to determine the existence of real differences between the data before and after a specific time point, as shown in the following table:

Table (9). Augmented Dickey-Fuller Test Equation with a breakpoint

Null Hypothesis: D(AREA) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2011
Break Selection: User-specified break
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.160114	< 0.01
Test critical values:	1% level	-4.030000	
	5% level	-3.485000	
	10% level	-2.440000	

*Perron (1989, 1993) asymptotic one-sided p-values (lambda=0.75).
**Warning: the reported intercept-trend model critical values may not be

From the above table, we find that the Augmented Dickey-Fuller test statistic's absolute value is greater than the absolute value corresponding to 1%, 5%, and 10%. The probability value is less than 0.05. Therefore the differences between the values of cultivated areas before and after the crisis are statistically significant, and accordingly, we can say:

We reject the first hypothesis stating that "There are no statistically significant differences between the areas planted with a potato before and after the crisis," We accept the alternative hypothesis stating that "There are statistically significant differences between the areas planted with a potato before and after the crisis."

A. In terms of production

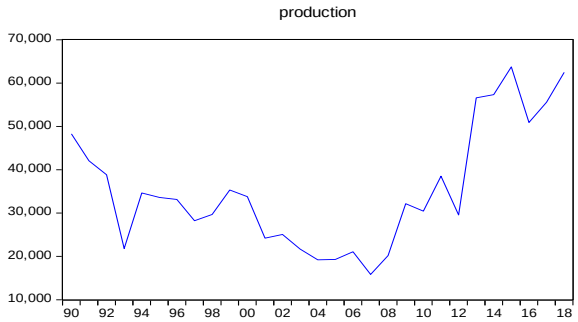

Figure (2). Development of potato production in Tartous during 2007-2018

The above figure shows the development of potato production in Tartous during the period 1990-2006 with a general decreasing trend, and this curve changed to an upward trend during the next period 2007-2018. Study of the general trend of potato production in Tartous:

- Self-correlation and partial self-correlation function:

Date: 12/23/19 Time: 22:59
Sample: 1990 2018
Included observations: 29

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.731	0.731	17.175	0.000
		2	0.615	0.173	29.785	0.000
		3	0.459	-0.08...	37.077	0.000
		4	0.379	0.042	42.236	0.000
		5	0.175	-0.27...	43.378	0.000
		6	-0.06...	-0.35...	43.520	0.000
		7	-0.13...	0.113	44.271	0.000
		8	-0.21...	0.004	46.192	0.000
		9	-0.24...	0.027	48.838	0.000
		10	-0.32...	-0.02...	53.729	0.000
		11	-0.33...	-0.12...	59.339	0.000
		12	-0.32...	-0.09...	64.748	0.000

From the above table, we notice that the coefficients of the self-correlation function (AC) were outside the confidence range during the first period. The partial correlation function (PAC) coefficients remain outside the confidence range until the fourth period. Thus, there is some instability in potato production during the study period. To validate this result, we tested the unit root to determine whether the planted area was stable or not.

This test is one of the most important tests used in time series to determine the real differences between the data before and after a specific time point, as shown in the following table:

- Series stability test by unit root:

For decision making, we will consider the series stable if the value of the Augmented Dickey-Fuller Test Equation test is less than 0.05, indicating time series stability as shown in the following table:

Table (11). Series stability test by unit root

Null Hypothesis: PRODUCTION has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.214210	0.6538
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

*MacKinnon (1996) one-sided p-values.

The above table shows the results of the unit root test for the area variable, where the probability value is 0.85, which is greater than the significance level 0.05, and thus, we accept the null hypothesis stating unstable time series during the study period. It is expected that the reason for the instability during the last period of the series is the Syrian crisis. Therefore we will analyze the differences between the time series values before and after 2011. We will use two statistical methods: The first is T-Student for independent samples, and the second is the Augmented test Dickey-Fuller Test Equation with a breakpoint, which is the strongest test for studying time series as follows:

Table (10). Self-correlation and partial self-correlation function

a) Student's Independent Sample Test:

Table (12). Change of production before and after the crisis

	Crisis	N	Mean	Std. Deviation	Std. Error Mean
Production	Before Crisis	22	28551.1364	9533.67973	2032.58735
	After Crisis	7	53745.7143	11494.96887	4344.68985

From the previous table, we see that the average costs before 2011 were 8.35 with a standard deviation of 2.62, and this average rose to 60.96 tons with a standard deviation of 34.04 tons. To show whether these differences are statistically significant, we consider the Independent Samples Test results shown below.

We find that the average production amount before 2011 was 28551.13 with a standard deviation of 9533.67 tons from the table. This average rose to 53745.7143 tons with a standard deviation of 11494.96 tons. To show whether these differences are statistically significant, we consider the Independent Samples Test shown below:

Table (13). T-student for production changes due to the crisis

Independent Samples Test										
		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Production	Equal variances assumed	.012	.913	-5.804	27	.000	-25194.57792	4340.70908	-34100.97728	-16288.17856
	Equal variances not assumed			-5.253	8.793	.001	-25194.57792	4796.63853	-36084.30016	-14304.85569

From the above table, we find that the significance value corresponding to Levene's test is less than 0.05. We consider the assumption of equal variations. We also find that the significance value corresponding to the assumption of equal variations in the T-test for Equality of Means equals 0,000, which is less than significance level 0.05. The differences between potato-grown areas pre-crisis are fundamentally different from those of post-crisis. We will consider this result as the first indication of the differences, but for reasons related to unreal differences which the previous test cannot reveal, we tested the Augmented Dickey-Fuller Test Equation with a breakpoint shown below.

- Augmented Dickey-Fuller Test Equation with a breakpoint

This test is one of the most important tests used in time series to determine the real differences between data before and after a specific time point, and it is shown in the following table:

Table (14). Augmented Dickey-Fuller Test

Null Hypothesis: PRODUCTION has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2012
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.547846	0.0380
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

From the previous table, we notice that the Augmented Dickey-Fuller test statistic's absolute value is less than the absolute value corresponding to 1%, 5%, and 10%. Also, the probability value is greater than 0.05, and thus the difference between production values before and after the crisis is not statistically significant, and accordingly, we can say:

We reject the fourth hypothesis stating, "There are no statistically significant differences between potato production amounts before and after the crisis," and we accept the alternative hypothesis stating, "There are statistically significant differences between potato production amounts before and after the crisis."

B. In terms of yield

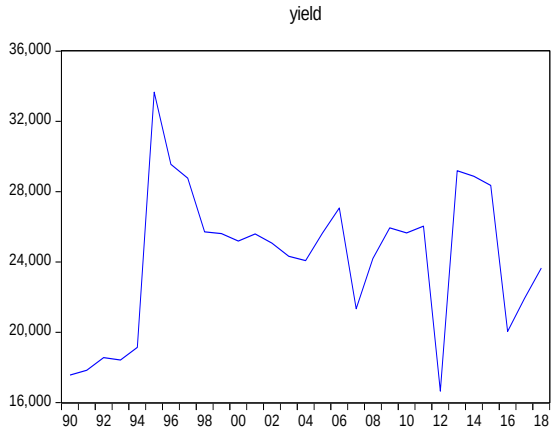

Figure (3). Development of potato yield in Tartous during 1990-2018

The above figure shows yield development of potato production in Tartous during 1990-2018, where we notice a significant fluctuation in yield during the study period, indicating great instability in this series.

Studying the general trend of potato yield in Tartous:

- Self-correlation and partial self-correlation function:

Table (15). Self-correlation and partial self-correlation

Date: 12/23/19 Time: 23:19
Sample: 1990 2018
Included observations: 27

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.60...	-0.60...	11.026	0.001
		2	0.189	-0.28...	12.139	0.002
		3	-0.23...	-0.44...	13.937	0.003
		4	0.161	-0.42...	14.816	0.005
		5	0.093	-0.11...	15.122	0.010
		6	-0.14...	-0.15...	15.863	0.015
		7	0.037	-0.16...	15.916	0.026
		8	-0.04...	-0.13...	15.995	0.042
		9	0.091	-0.111	16.356	0.060
		1...	-0.05...	-0.15...	16.511	0.086
		1...	0.073	0.035	16.772	0.115
		1...	-0.13...	-0.03...	17.662	0.126

From the above table, we notice that the coefficients of the self-correlation function (AC) were outside the confidence range during the first period, and the coefficients of the partial correlation function (PAC) were also outside the confidence range during the first period. Thus, there is some instability in potato yield during the study period. To verify this result, we tested the unit root to determine whether the planted area was stable or not.

- Series stability test by single root:

For decision making, we will consider the series stable if the value of the Augmented Dickey-Fuller Test Equation test is less than 0.05, which is a test that indicates time series stability as shown in the following table:

Table (16). The results of the unit root test for yield variable

Null Hypothesis: YIELD has a unit root
Exogenous: None
Lag Length: 3 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.226490	0.7437
Test critical values:	1% level	-2.660720	
	5% level	-1.955020	
	10% level	-1.609070	

*MacKinnon (1996) one-sided p-values.

The above table shows the unit root test results for the yield variable, where the probability value is 0.7437, which is greater than the significance level of 0.05. Thus we accept the null hypothesis that the time series is unstable during the study period.

It is expected that the reason for instability during the last period of the series is the Syrian crisis. Therefore we will analyze the differences between the time series values in the period before and after, and we will use two statistical methods: The first is the T-Student for independent samples. The second is the Augmented test Dickey-Fuller Test Equation with the breakpoint, which is the most powerful test for studying time series as follows:

a) Student's Independent Sample Test:

Table (17). Changes in yield due to the crisis

	Crisis	N	Mean	Std. Deviation	Std. Error Mean
Yield	Before Crisis	22	23533.7273	6214.52174	1324.94049
	After Crisis	7	24099.4286	4893.44343	1849.54777

From the previous table, we notice that the average yield before 2011 was 23533.72 with a standard deviation of 6214.52, and rose to 24099.42 tons with a standard deviation of 4893.44 tons. To show whether these differences are statistically significant, we look at the results of the Independent Samples Test shown below:

Table (18). Homogeneity test of variance

Independent Samples Test										
		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Yield	Equal variances assumed	.004	.952	-.219	27	.828	-565.70130	2580.41976	-5860.28531	4728.88271
	Equal variances not assumed			-.249	12.777	.808	-565.70130	2275.14708	-5489.60151	4358.19891

From the above table, we notice that the significance value corresponding to Levene's test is greater than 0.05. We assume that the variations are not equal.

From the previous table, we also find that the value of signatures corresponding to the assumption of unequal variations in the T-test for Equality of Means is 0.808, which is greater than the significance level of 0.05. However, the differences between potato-grown areas before the crisis are fundamentally different from those after the crisis. We will consider this result as the first indication of the absence of differences, but for reasons related to unreal differences and the previous test cannot detect, we tested the Augmented Dickey-Fuller Test Equation with a breakpoint as shown below.

- Augmented Dickey-Fuller Test Equation with a breakpoint

This test is one of the most important tests used in time series to determine the real differences between data before and after a specific time point, and it is shown in the following table:

Table (19). Augmented Dickey-Fuller test statistic

Null Hypothesis: YIELD has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2012
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.868089	0.2065
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

From the previous table, we notice that the Augmented Dickey-Fuller test statistic's absolute value is less than the absolute value corresponding to 1%, 5%, and 10%. Also, the probability value is greater than 0.05. Thus the differences between production values before and after the crisis are not statistically significant. Accordingly, we can say:

We accept the third hypothesis that "There are no statistically significant differences between potato yield before and after the crisis."

C. In terms of cost:

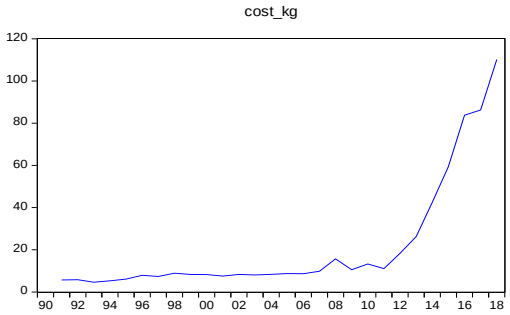

Figure (4). Development of potato production costs in Tartous during 1990-2018

The above figure shows the development of potato production costs in Tartous during 1990-2018, where we observe significant series stability until 2010, so the curve significantly goes upward in the subsequent period.

Studying the general trend of potato yield in Tartous:

- Self-correlation and partial self-correlation function:

Table (20). Self-correlation and partial self-correlation function

Date: 12/23/19 Time: 23:37
Sample: 1990 2018
Included observations: 28

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.767	0.767	18.307	0.000
		2	0.590	0.003	29.544	0.000
		3	0.361	-0.22...	33.930	0.000
		4	0.201	-0.01...	35.346	0.000
		5	0.084	0.010	35.602	0.000
		6	0.027	0.026	35.629	0.000
		7	-0.01...	-0.02...	35.634	0.000
		8	-0.01...	0.018	35.641	0.000
		9	-0.03...	-0.06...	35.701	0.000
		1...	-0.04...	-0.01...	35.795	0.000
		1...	-0.08...	-0.07...	36.134	0.000
		1...	-0.09...	-0.00...	36.630	0.000

From the previous table, we notice that the self-correlation function (AC) coefficients were outside the confidence range during the first period, while those of the partial correlation function (PAC) were outside the confidence range during the first and second periods. Thus, there is

some instability in the costs of potato production during the study period. To validate this result, we tested the unit root to determine whether the planted area was stable or not.

- Stability test by unit root:

For decision making, we will consider the series stable if the value of the Augmented Dickey-Fuller Test Equation test is less than 0.05, which is a test that indicates the stability of the time series as shown in the following table:

Table (21). The results of the unit root test for the yield variable

Null Hypothesis: COST_KG has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.326492	0.8572
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

*MacKinnon (1996) one-sided p-values.

The above table shows the results of the unit root test for the yield variable, where we notice that the probability value is 0.85, which is greater than the significance level 0.05, and thus we accept the null hypothesis that the time series is unstable during the study period.

It is expected that the reason for instability during the last period of the series is the Syrian crisis. Therefore we will analyze the differences between the time series values before and after 2011, and we will use two statistical methods: The first is the Student's t-test for independent samples, and the second is the Augmented test Dickey-Fuller Test Equation with a breakpoint which is the strongest for studying time series as follows:

a. Student's Independent Sample Test:

Table (22). Average costs before and after 2011

	Crisis	N	Mean	Std. Deviation	Std. Error Mean
Cost/kg	Pre-crisis	22	8.3577	2.62874	.56045
	Post-crisis	7	60.9643	34.04541	12.86796

From the above table, we notice that the average costs before 2011 were 8.35 with a standard deviation of 2.62, and this average rose to 60.96 tons with a standard deviation of 34.04 tons. To show whether these differences are statistically significant, we consider the results of the Independent Samples Test shown below:

Table (23) Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Cost/kg	Equal variances assumed	60.409	.000	-7.476	27	.000	-52.60656	7.03680	-67.04489	-38.16823
	Equal variances not assumed			-4.084	6.023	.006	-52.60656	12.88015	-84.09429	-21.11883

From the previous table, we notice that the significance value corresponding to Levene's test is less than 0.05. Thus we consider the assumption of equal variations.

From the previous table, we also find that the significance value corresponding to the assumption of equal variations in the t-test for Equality of Means equals 0,000, which is less than the significance level of 0.05. The differences between the costs of producing one kilogram of potato before the crisis are fundamentally different from those after the crisis. We will consider this result as the first indication of differences, but for reasons related to the presence of unreal differences which the previous test cannot detect, we tested the Augmented Dickey-Fuller Test Equation with a breakpoint shown below.

- Augmented Dickey-Fuller Test Equation with a break point

This test is one of the most important tests used in time series to determine the real differences between data before and after a specific time point, and it is shown in the following table:

Table (24). Augmented Dickey-Fuller test statistic

Null Hypothesis: D(COST_KG) has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2011
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 4 (Automatic - based on Schwarz information criterion, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.868319	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

From the above table, we find that the Augmented Dickey-Fuller test statistic's absolute value is less than the absolute value corresponding to 1%, 5%, and 10%. The value of the probability is greater than 0.05. Thus the differences between production values before and after the crisis are not statistically significant, and accordingly, we can say:

We reject the fourth hypothesis stating, "There are no statistically significant differences between the cost of potato production before and after the crisis," and we accept the alternative hypothesis that "There are statistically significant differences between the cost of potato production before and after the crisis."

Factors affecting potato production in Tartous:

The following is a study of the most important factors affecting the quantity of potato production in Tartous by means of multiple regression analysis. The results were as follows:

Table (25). The results of the regression analysis between production and cost

Dependent Variable: PRODUCTION
Method: Least Squares
Date: 12/24/19 Time: 01:30
Sample (adjusted): 1991 2018
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
YIELD	1.271224	0.193773	6.560371	0.0000
COST_KG	26.52556	41.83122	0.634109	0.5320
AREA	21.64563	1.986554	10.89607	0.0000
C	-27979.71	5949.384	-4.702959	0.0001

R-squared	0.933160	Mean dependent var	34823.36
Adjusted R-squared	0.924805	S.D. dependent var	13985.10
S.E. of regression	3834.954	Akaike info criterion	19.47327
Sum squared resid	3.53E+08	Schwarz criterion	19.66358
Log likelihood	-268.6257	Hannan-Quinn criter.	19.53145
F-statistic	111.6888	Durbin-Watson stat	2.081918
Prob(F-statistic)	0.000000		

The above table shows the results of regression analysis of the relationship between production as a dependent change and the cost of producing one kilogram of potato, cultivated area, and yield, where we find that the value of the coefficient of determination is 0.933, and therefore the independent variables explain what accounted for 93.3% of the changes in the dependent variable. We also notice that the probability value is 0.00, which is less than the significance level. Therefore the predictive model is statistically significant, and the relationship between independent explanatory variables and the dependent variable is a statistically significant function. The value of Durban Watson statistic is 2.08, i.e., outside the range of suspicion due to self-correlation between the independent variables, which ranges between 0.8-1.2, the model achieved the condition of the existence of a self-correlation between the explanatory variables.

Contrast stability test for the proposed model:

The problem of variance persistence is one of the most important problems facing standard predictive models. This problem means that the explanatory variables have a falsee association with the dependent variable, and it is a problem that increases its probability as the value of the coefficient of determination increases. To test the existence of this problem, we test the Heteroskedasticity Test: ARCH, whose results are shown below:

Table (26). Heteroskedasticity Test: ARCH

Heteroskedasticity Test: ARCH

F-statistic	0.028400	Prob. F(1,25)	0.8675
Obs*R-squared	0.030637	Prob. Chi-Square(1)	0.8611

The above table shows that the probability value corresponding to Obs * R-squared is 0.8611 and is greater than the significance level 0.05, there is no problem of variance persistence, and the correlation is not false.

The equilibrium relationship between potato production and explanatory variables can be expressed according to the following formula:

PRODUCTION = -27979.7067063 + 1.27122443699*YIELD + 26.5255641542*COST_KG + 21.6456344132*AREA

To sum up the above results:

1. There is a kind of instability in the area planted with potato during the study period.
2. There are statistically significant differences between areas planted with a potato before and after the crisis.
3. There is some instability in potato production during the study period.
4. There are statistically significant differences between production quantities of potato before and after the crisis.
5. There are no statistically significant differences between potato yield before and after the crisis.

    1. There is a kind of instability in the costs of potato production during the study period.

    2. There are statistically significant differences between the cost of potato production before and after the crisis.

III. RECOMMENDATIONS

1. Working to achieve stability in the cultivated area and thus the cultivated quantities, due to the stability achieved in providing this very important material for the Syrian people, by increasing the cultivated areas and cultivating good types of potato in terms of productivity and resistance to pests and diseases.

2. Maintaining stability in potato yield and raising it if possible, thereby achieving added value for the farmers and encouraging them to increase production from this vital crop.

3. Mitigating the effects of the crisis on potato production costs by subsidizing farmers and providing seeds at ration prices.

Adopting new methods for potato planting, such as floor cultivation, and providing good types of fertilizers that contribute to increasing production.

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