Estimating the agricultural production function in the State of Mila in the period of (1990-2020)

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Abstract:
The study aims to estimate and analyze the agricultural production function in the Wilaya of Mila over the period from 1990 to 2020 using the autoregressive distributed lag (ARDL) model to estimate and test the relationship between variables. The dependent variable is agricultural production, while the explanatory variables are employment, equipment, annual precipitation, and cultivated area. The results indicate a positive relationship in both the long run and short run between agricultural production and the explanatory variables of employment, equipment, and annual precipitation. However, the relationship with cultivated area is negative in the short run, contrasting with the positive association found in the long run. Overall, the study finds agricultural production is positively influenced by labor, capital in the form of equipment, and favorable climatic conditions as measured by precipitation, while the impact of land area devoted to cultivation differs in the short and long term.
Keywords: Agricultural production function, agricultural labor, agricultural equipment, precipitation, agricultural area.
(JEL) Classification : Q15 ‹Q18‹ J43‹ O13‹ Q13.

1. Introduction:

The Wilaya of Mila possesses significant agricultural potential that can substantially contribute to developing the agricultural sector at the state level. In 2017, the total land area used for agriculture was estimated to be 237,955 hectares. Additionally, Mila has abundant water resources from precipitation and dams. These favorable natural endowments represent a major driver for increasing and growing agricultural output in Mila through their full and efficient utilization, given available human capital, agricultural equipment, and appropriate financing.

To attain productive efficiency and optimal combination of the aforementioned agricultural production factors, estimating the agricultural production function in Mila State and formulating it mathematically provides clearer insight into the most impactful production components and their influence on raising agricultural productivity. This understanding further identifies underutilized resources to improve efficiency in harnessing production inputs of labor, land, capital, and management. Moreover, it assists farmers in maximizing production and minimizing costs

1.1. Research Problematic:

Through the current study, we present the distinctive nature of the agricultural production function that maximizes production and productivity and reduces costs, with the following main question:

What is the nature and determinants of the agricultural production function in Mila State from 1990-2020?

1.2. Research Objectives:

In addition to estimating the agricultural production function in Mila, the study has the following specific objectives:

- Identify the key determinants of the agricultural production function in Mila State. This will delineate the most influential inputs impacting agricultural output.

- Determine the nature of the relationship between agricultural production and critical agricultural production factors including land, labor, capital, and management. This will reveal whether the correlates have a positive or negative effect on productivity.
- Help select the optimal combination of production factors to increase agricultural output in Mila. The results will provide guidance on how to efficiently allocate scarce resources to maximize production.

1.3. Research Importance:

The importance of the study stems from the expected additions on the scientific and practical levels by estimating the determinants of the agricultural production function in the State of Mila and identifying the most effective production elements for improving agricultural production and productivity.

1.4. Study Hypotheses:

The study tests the following hypotheses:

H1: Statistical analysis will indicate that increased agricultural labor has a significant positive effect on agricultural production.

H2: Statistical analysis will indicate that increased agricultural equipment has a significant positive effect on agricultural production.

H3: Statistical analysis will show that higher rainfall has a significant positive effect on agricultural production.

H4: Statistical analysis will demonstrate that an increase in cultivated area has a significant positive effect on agricultural production.

The first three hypotheses posit that greater inputs of labor, capital in the form of equipment, and favorable climatic conditions as measured by rainfall will increase agricultural outputs. The fourth hypothesis states that expanding land area under cultivation will raise production. Statistical testing will determine the direction, magnitude, and significance of these relationships. Confirmation of these hypotheses will provide evidence that allocating more resources to agricultural inputs can improve productivity in the Wilaya of Mila.

1.5. Study methodology:

This study utilizes the standard method for estimating the agricultural production function in Mila State by developing a model based on the Cobb-Douglas production function form augmented with additional relevant production factors. The model incorporates the typical inputs of labor, land, capital as well as management capabilities.

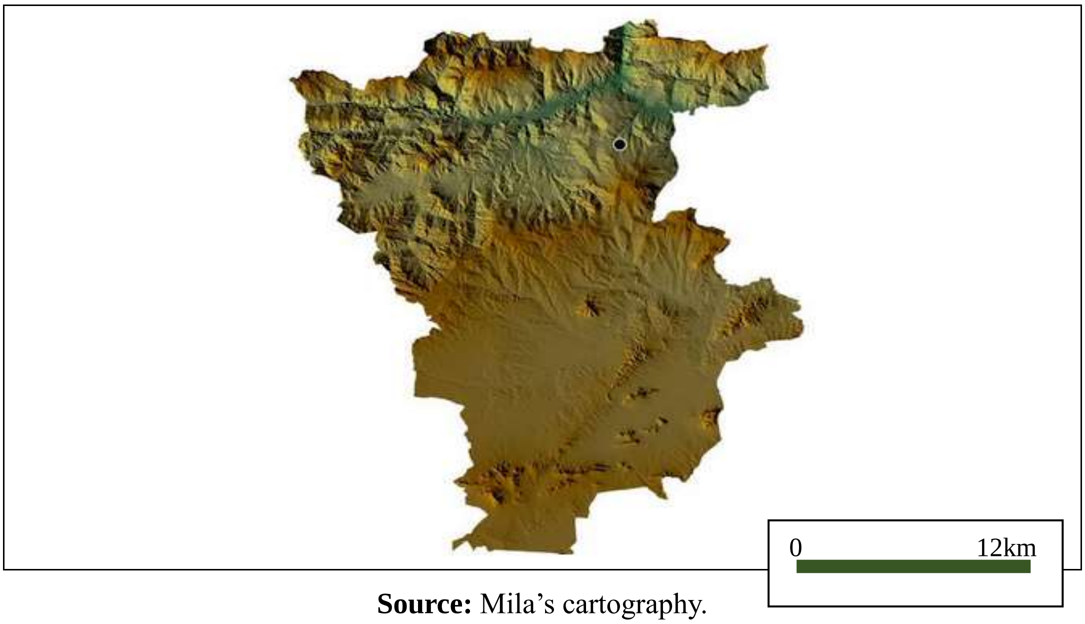
The autoregressive distributed lag (ARDL) approach is employed to construct and analyze the relationship between variables over the long and short term. The ARDL methodology is well-suited for assessing cointegration and the dynamic interactions between variables.

The statistical software Eviews 9 is used to estimate the parameters of the agricultural production function and conduct inference testing. The program enables modeling the time series data spanning 1990-2020 and deriving the optimized combination of inputs to maximize productivity.

2. Factors of agricultural production in the Wilaya of Mila:

Different factors of agricultural production the Wilaya abounds in with its different topography, which combines the high mountainous masses in the northern regions within the mountains of the Atlas chain, on the one hand, and the high plains in the south, which makes it a fertile place to embrace different agricultural activities. The following Figuer depicts the three geographic divisions of the State:

Figure(01): The major natural communities of the State of Mila



Source: Mila’s cartography.

This distinct natural combination of different terrains combines the rugged mountainous environment suitable for growing fruit trees and olive trees with the flat plain environment that has been exploited over the past decades in cultivating grains and various vegetables. The most critical factor in production is the land, in large quantities. In general, the natural capabilities available to the State of Mila can be presented according to their degree of importance as follows:

2.1. Farmland:

Out of its total geographical area, which exceeds 3.48 thousand km^2, the total agricultural area is estimated at 315745 hectares, of which 237557 hectares are arable, or 75.23 percent. Of the total agricultural area, this area represents 90% of the area of the State, which is classified as a peasant state par excellence.

Agricultural land is distributed according to the type and nature of exploitation for each municipality, as the municipalities located in the southern region of the upper plains contain the most significant percentage of agricultural land, in particular (Shalghoum Al-Eid, Oued El-Othmania, Tagnant, Awlad Khalouf, Al-Mouchira, Al-Talaghma, and Oued Saqqan) with a rate of more than 48%. Among the arable lands are the same municipalities that exploit the most irrigated areas. At the same time, we note that the pastoral lands are concentrated in the municipalities of the north and the basins by way of allocation (Minar Zarza, Hamala, Al-Ayadi Barbas, Tassala Lamta'i, Al-Shigara, Tassadan Hadada, Terai Bayan) where The pastoral lands in it constitute between 20 to 46% of the total agricultural lands for each municipality. However, they do not exceed 9% of the total arable lands (report, 2016) .

2.2. Water Resources:

The irrigated area at the state level is estimated at 16030 hectares, or 6.7 percent of the arable area, which is a very weak percentage compared to the area irrigated by precipitation, despite the availability of a large dam that holds more than one billion cubic meters.

The precipitation rate is estimated at 700 mm annually in the northern mountainous regions and 350 mm in the southern regions. In comparison, in the central regions, it ranges between 400 and 600 mm annually, as the level of precipitation varies according to each season and from month to month.

Concerning groundwater, it is estimated at 56 million cubic meters per year. Wells exploits it, and explorations, 36 by 46, are exploited, with a combined flow of 922301 liters/second. As for the unexploited explorations, their number is 15 explorations, of which eight (08) are in the municipality of Shalghoum Al-Eid (Saleh, 2018).

The statistics of the agricultural season for the year 2020/2021 indicate that the annual irrigation yield is estimated at 16030 hectares, of which 2952 hectares are by flow, 12892 hectares are by sprinkler, and 174 hectares are by local irrigation. The irrigated areas are 330 hectares of dams, 75 hectares of water barriers, 507 hectares of water sources, 8052 hectares of excavations, 1779 hectares of wells, and 2590 hectares of waterways (services, 2020).

Three central valleys in the State flow continuously through the four seasons. Constantine, while the second is Wadi Al-Naga, whose length is 110 km, on a line parallel to the northern mountain range. Its most important tributaries are Wadi Jamila, Wadi Bou Salah, Wadi Ragas, and Wadi Al-Malah, which are 45 km long.

On the other hand, there are three dams in the State, Bani Haroun al-Kabir Dam (960 million cubic meters), Wadi al-Uthmaniyah Dam (35 million cubic meters), and Karouz Dam (41 million cubic meters). All three dams are used as drinking water, in addition to partial exploitation for irrigation, especially for the southern extension line. Dam Bani Haroun towards Batna is used for irrigation at the municipality level of El Talagama.

2.3. Humans Ressources:

Considering the division of the State into three Hregions, or natural circles, the distribution of the population in these circles is according to the following pattern: 131 thousand people in the area of the northern part, i.e., 16% of the State's population, while the central basins and hills region includes 385 thousand people, or 47% of the population, and the upper plains region is inhabited by 303 thousand people, an estimated rate of 37% of the total population of the State.

The percentage of the population between the ages of (15-60 years) is estimated at 64.58% of the total population of the State, which indicates the presence of enormous human energies that can be exploited by investing in the natural resources available in the State.

Given the urban distribution, the population of rural areas across the State is 273,713, distributed over the three geographical regions. The agricultural labor force in the State of Mila is estimated at 66,356 people, or 19% of the total labor force, or those willing to work, which is estimated in 2020 at 349,242 people distributed over various economic activities. This percentage of agricultural labor is considered insufficient compared to the agricultural area of the State, as we note the evident reluctance to agricultural activities, especially since the beginning of the new millennium, which was caused by the large displacement of the rural population to the cities, in addition to the State adopting a new pattern for stimulating youth employment that depends on financing and facilitating access to economic and service activities in general at the expense of agricultural and productive activities.

2.4. Agricultural capital:

Agricultural capital means the totality of machines, tools, and other fixed production requirements used in agricultural production. 700 harvesters, 4090 tractors, 1,900 vehicles for transportation, and 1,100 tanks for water (messaoud, 2022).

There are also 14 points for storing agricultural products, primarily grains of all kinds, at the state level, which allow the storage of 2,278,500 quintals of the crop, which is a weak storage capacity given the annual production of agricultural materials, in the 2020 harvest exceeded 1,832,228 quintals of durum wheat and 441,072 quintals of wheat. Lin, 505,614 quintals of barley, and 96,140 quintals of oats

2.5. Supervising and administrative accompaniment:

In addition to the State Directorate of Agricultural Services and the Agricultural Chamber, he supervises the supervision of agricultural activity in Mila Province, a group of auxiliary bodies and interests that It includes each of the Regional Fund for Agricultural Cooperation (it owns five local offices and includes more than 3,200 associates), a grain and dry legumes cooperative (it has 13 units with a total capacity of 1,317,000 quintals) as well as each of the agricultural cooperatives for supply and services (six cooperatives) working on supplying various Agricultural materials (fertilizers, fodder, ... etc.) and the National Office of Agricultural Lands, which is in charge of issues related to the management of the agricultural real estate.

3. Estimation and analysis of the agricultural production function in the State:

The agricultural production function in the State of Mila is estimated during the period (1990-2020) in which the National Plan for Agricultural Development was implemented by relying on the original (Cobb-Douglas) function in its linear (logarithmic) form.

3.1. Cope-Douglas production function structure:

Shows a production function model. The Cobb-Douglas relationship between production output and production inputs (factors of production) is used to calculate the ratios of inputs to each other for efficient production and to estimate the technological change in production methods. The general form of the Cobb-Douglas production function for a set of n inputs is:

$$Y = f(x_1, x_2, \ldots, x_n) = \gamma \prod_{i=1}^{n} x_i^{\alpha_i}$$

Where you indicate Y is for output (output), while xi denotes input i, and γ and αi are parameters that determine the overall efficiency of production and the responsiveness of output to changes in input quantities.

The application of this functional form to the measurement of production is due to mathematician Charles Cope and economist Paul Douglas who used it to consider the relative importance of factors of production, labor, and capital in industrial production in the United States during the period 1899-1922.

In the original model, Cobb and Douglas constrained the parameters of production elasticity α1 and α2 to the range αi∈ (0,1) αi∈ (0,1) and added one, which means constant returns to scale. So the function becomes:

$$Y = \gamma x_1^{\alpha_1} x_2^{1-\alpha_1}$$

where you indicate x1 and x2 as labor and capital, respectively.

We notice from the previous relationship that the production function is nonlinear (nonlinear), which means that the data should be converted from its nonlinear space to linear space, and thus we get the new form of the function as follows:

$$\ln Y = \ln \gamma + \alpha_1 \ln x_1 + (1 - \alpha_1) \ln x_2$$

In the standard model of labor and capital, an increase in capital increases output not only directly, but also indirectly through its effect on labor productivity.

Mathematically, the partial tangential derivative of the production output Y concerning labor x1 and capital x2 is positive. Moreover, given the assumption that $\alpha i \in (0,1)$, the partial second-order partial derivatives of output relating to labor and capital are both negative, implying diminishing marginal returns for each component individually. Adding more labor or capital (but not both) to the production process increases output, albeit at a decreasing rate. Moreover, the elasticity of substitution between inputs is constant and equal to one, depending on the functional form.

3.2. Define variables and formulate the standard model:

Through the final logarithm form, For the Cobb-Douglas production function, the output of the function is reported as the agricultural production in a mile state for the period (1990-2020) (Y) as a dependent variable, while the production inputs in the function are the independent explanatory variables. However, we are unsatisfied with the two elements (labor and capital) included in the original function. However, according to the nature of Algerian agriculture, both the cultivated area and the amount of annual rainfall are added to them, which are determinants that must be included in the function.

- agricultural labor (x1).
- Agricultural equipment (x2).
- Annual precipitation amount (x3).
- Cultivated area (X4).

Equivalent logarithmic function: The transcendental logarithmic function takes the following mathematical formula (Al-Shahawi, 2014).

$$Ln\ Y = ln\beta 0 + \beta 1ln(x1) + \beta 2ln(x2) + \beta 3ln(x3) + \beta 3ln(x4) + \mathcal{E}t$$

$$Ln\ Y = \alpha + \beta 1ln(x1) + \beta 2ln(x2) + \beta 3ln(x3) + \beta 3ln(x4) + \mathcal{E}t$$

In order to avoid problems related to the stability of the time series, we will rely on the methodology (ARDL), the Autoregressive Distributed or Lagging Time Lapse Methodology. This model was developed by Hashem Pesaran and others (M. Hashem Pesaran, 2001), where the (ARDL) methodology has three characteristics that distinguish it from other traditional methods used to test cointegration:

- The stillness is not required to the same degree; it can be used when l(0) and l(1) with the condition that the variable is stable at the first difference.
- It is considered valid in the case of small samples.
- Its use helps estimate the components of the relationship in the short and long terms simultaneously in the form of a single equation.

The model considers that the time series of the dependent variable is a function of slowing down its values and the values of the current explanatory variables by a period or more and is presented through the following mathematical relationship shown in the following Table:

Table (01): Equation for taking autoregressive methodology ARDL

d(Yt)=	*c+λYt-1+βXt-1*	*+1,id(Yt-i)$\sum_{i=1}^{m} a$*	*+2,id(Xt-i)$\sum_{i=0}^{k} a$*	*+εt*
The dependent variable in the first difference	*Long term information area*	*Short term information area*		***residuals***
		The block slows down the dependent variable on the first difference	*The block slows the independent variable at the first difference*	

in which:

- (λ) The value of the dependent variable slowing down for one year in the level is negative and significant.
- (β) The ability of the independent variable to slow down for one year in the level.
- (*a1,i, a2,i*) are the coefficients of the short-term relationship.
- (*d*) in the phrased(Yt) indicates that the data was taken in its first difference.

3.3. A study of the stability (rest) of the time series :

The characteristic of the stability of the time series means that the arithmetic mean and the variance is stable with the change of time and at any period, as it is necessary to test the stability of the time series, treat it in case of instability, and know the degree of its integration because neglecting it leads to finding a false relationship (imaginary regression) (Ashenfelter, 2005). That is, the stability of the time series for the study variables achieves the essential characteristics of the time series.

Approved using a test (Augmanted dickey-fuller (ADF) based on the hypothesis that the time series is generated by the autoregressive process (AR) in order to investigate that the time series of the variables contain unit walls corresponding to the hypothesis (1H0:φ =) expressing the existence of unit walls and therefore the series The time series is unstable, in contrast to the inverse hypothesis (1H0: φ <) which proves that there are no unit walls and therefore the time series is stable, as the results obtained through the use of the statistical program (Eviews 9) are shown in the following Table:

Table (02): Results of the test of static time series variables over the period (1990-2020)

The first difference		**the level**		**variables**
The result	**ADF**	**The result**	**ADF**	
-	-	stable	4.114259-	**LY**
stable*	-6.760279	notstable	-	**LX1**
-	-	stable**	-3.251300	**LX2**
-	-	stable*	-4.875324	**LX3**
stable*	-4.387552	notstable	-	**LX4**

* Stable at a significant level of 1%
** Stable at the 5% level of significance

The Table shows that each agricultural equipment and the amount of precipitation, including the dependent variable, are static at the level, while agricultural labor and the cultivated area are static at the first difference. Accordingly, it is possible to rely on the methodology (ARDL) as the most appropriate approach since the variables are stable at variable differences without the second difference, and thus the given model is as follows:

$$d(Yt)=c+\lambda Yt\text{-}1+\beta X1t\text{-}1+\beta' X2t\text{-}1+'\beta'' X3t\text{-}1+''\beta''' X4t\text{-}1+\sum^{mi=1} a1,id(Yt\text{-}i)+\sum^{ki=0} a2,id(X1t\text{-}i)$$
$$+\sum^{ki=0} a3,idX2t\text{-}i)+\sum^{ki=0} a4,id(X3t\text{-}i)+\sum^{ki=0} a5,id(X4t\text{-}i)+\varepsilon_t$$

3.4. Cointegration test:

The bounds test was relied upon to reveal the possibility of cointegration between the variables of the estimated model, as the results are shown in Table (03), we can see that the calculated value of the limits test (F-statistic = 49.37797) is more significant than all limits at all critical values, and thus we reject the null hypothesis that there is no long-term relationship.

Table (03): Limit test results Bounds Test

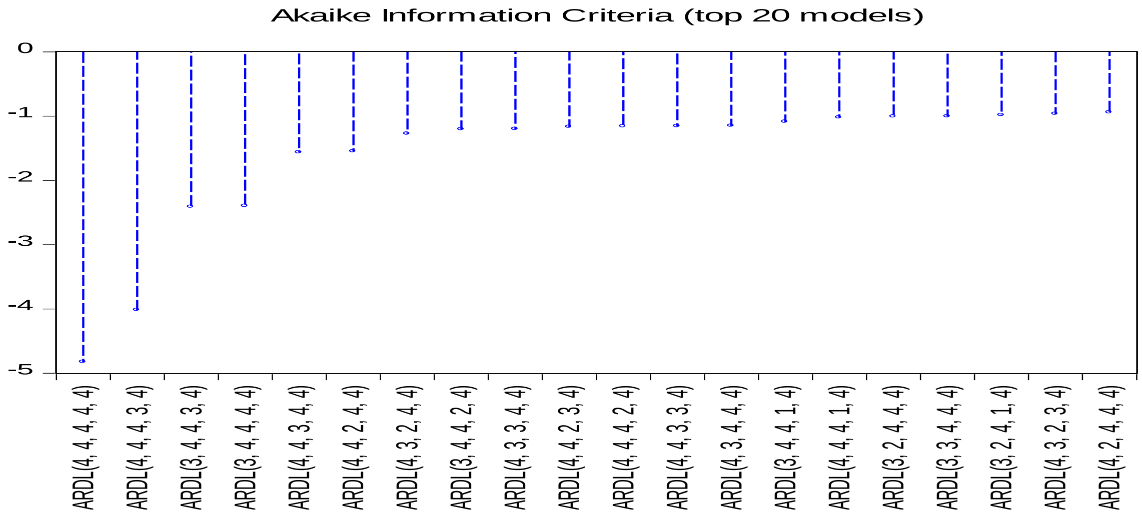
Test Statistic	Value	k
F-statistic	49.37797	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

Source: EVIEWS.9 outputs

Furthermore, when relying on a test, Akaike Information Criteria, The number of optimal decelerations can be estimated, as the optimal model was found to be ARDL (4.4.4.4.4).



Source: EVIEWS.9 outputs.

3.5. Appreciation and standard model testing:

After proving the existence of cointegration between the variables, we will estimate the long-term relationship between it, followed by a series of tests for the quality of the estimated model.

3.5.1. Estimation of long-term parameters:

Table (04): Outputs of estimating long-term parameters

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LX1	1.467223	0.281388	5.214227	0.0349
LX2	2.366696	0.386730	6.119768	0.0257
LX3	5.717083	1.319405	4.333078	0.0494
LX4	7.530625	2.843545	2.648323	0.1179
C	-151.522717	41.987003	-3.608800	0.0689

Source: EVIEWS.9 outputs.

The parameters estimated by the model indicate a positive long-term relationship between agricultural production and each agricultural labor, agricultural equipment, annual precipitation, and cultivated area. At the same time, the cutoff was negative and significant at 10%.

3.5.2. Error correction formUECMto approachARDLfor the short term:

Table (05): Outputs of the error correction model UECM

Dependent Variable: LY
Method: ARDL
Date: 04/17/23 Time: 18:04
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): LX1 LX2 LX3 LX4
Fixed regressors: C
Number of models evalulated: 16
Selected Model: ARDL(1, 0, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LY(-1)	0.298124	0.186843	1.595592	0.1237
LX1	0.073369	0.373368	0.196506	0.8459
LX2	2.304649	0.701640	3.284661	0.0031
LX3	0.312443	0.872474	0.358111	0.7234
LX4	-5.267107	3.066096	-1.717854	0.0987
C	53.05743	35.87303	1.479034	0.1521

Source: EVIEWS.9 outputs.

As for In the short term, the results confirmed the capabilities of the long term, as there was a positive relationship between the growth of agricultural production and employment, equipment, and the amount of precipitation, and a negative relationship between the cultivated area and the growth of agricultural production.

3.5.3. Test the quality and significance of the estimated model:

Table (06): Testing the quality and significance of the model

R-squared	0.999659	Mean dependent var	15.24971
Adjusted R-squared	0.995568	S.D. dependent var	0.474494
S.E. of regression	0.031589	Akaike info criterion	-4.822848
Sum squared resid	0.001996	Schwarz criterion	-3.622999
Log likelihood	90.10845	Hannan-Quinn criter.	-4.466070
F-statistic	244.3441	Durbin-Watson stat	2.571235
Prob(F-statistic)	0.004084		

Source: EVIEWS.9 outputs

The Durbin-Watson statistic, which is greater than (R-squared), indicates that the model is acceptable, that is, free from false regression, in addition to the high value of the (R-squared) statistic, which indicates an explanatory power of more than 99% for the independent variables of the dependent variable.

3.5.4. Error autocorrelation test:

Table (07): Test link self for errors

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.145387	Prob. F(1,1)	0.7681
Obs*R-squared	3.427173	Prob. Chi-Square(1)	0.0641

Source: EVIEWS.9 output

As the probability value, The F-statistic of the Breusch-Godfrey Serial Correlation LM test exceeded the 5% significance level, thus accepting the null hypothesis, which states that there is no autocorrelation of errors in the estimated model.

3.5.5. Contrast instability test:

Table (08): Test ARCH for not stability contrast errors

Heteroskedasticity Test: ARCH

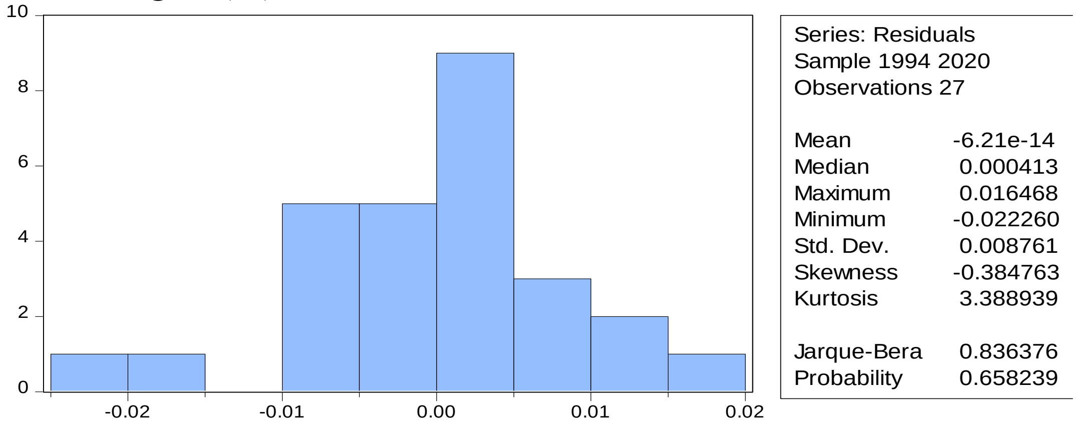
F-statistic	0.400269	Prob. F(1,24)	0.5329
Obs*R-squared	0.426511	Prob. Chi-Square(1)	0.5137

Source: EVIEWS.9 outputs

Previous table shows to test (ARCH) that the probability values of the F statistic are more significant than the level of significance of 5%, and therefore we accept the null hypothesis that there is no homogeneity in the variance. Therefore the model is acceptable in terms of the problem of instability of the variance of errors.

3.5.6. Test for normal distribution of errors:

Figure (02): Test results for the normal distribution of errors

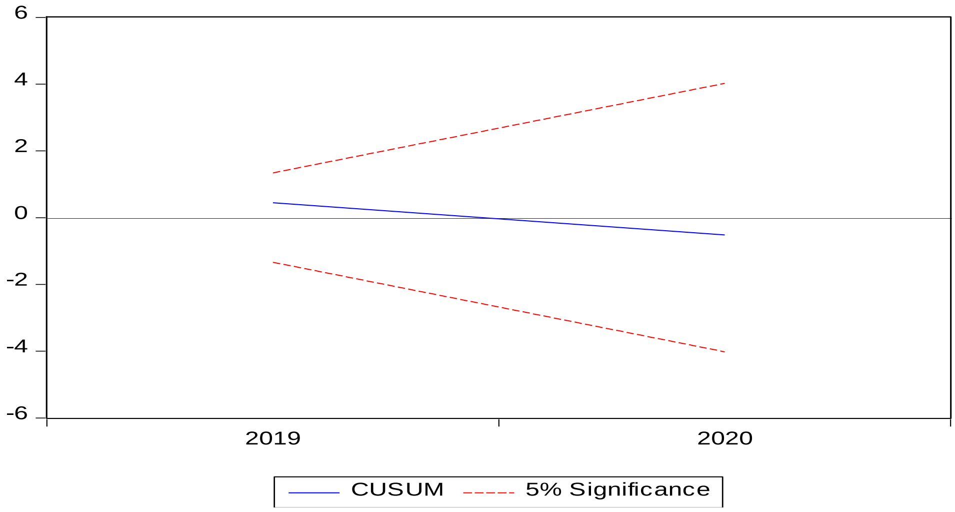


Source: EVIEWS.9 outputs

From the graph, the normal distribution of errors is evident, and this judgment confirms the probability value of the coefficient (Jaque-Bera), which is equal to 0.83, which is the immense value of the 5% level of significance, meaning that the errors or residuals of the model follow the normal law.

3.5.7. Cumulative sum test

Figure(03): Test results CUSUM



Source: EVIEWS.9 outputs

We notice from the figure that the aggregate values lie between the two lines in red, meaning that the estimates are stable over time, which confirms that the variables are stable over time, and the result is that the estimated equation for agricultural production is stable over time.

3.6. Analysis of the results:

The results of the estimation and the various tests of the estimated model indicate the validity of the model starting from the applicability of the autoregressive slow distributed gaps method (ARDL), i.e., the possibility of applying the methodology in the agricultural production function, where the following was reached:

- The results of the unit test roots embodied through the test (ADF) showed that the time series of the variables of the agricultural production function is stable (static) at the level (I0) and the first difference (I1).
- On the one hand, there is a long-term relationship between agricultural production and of agricultural labor, agricultural equipment, amount of precipitation, and cultivated area.
- The equation for the growth of agricultural production is characterized by structural stability, as shown by the test (CUSUM), i.e., the estimators are constant over time.
- The large explanatory ratio given by the independent variables of the model is represented by (X1, X2, X3, X4) for the dependent variable (Y), and this is reflected in the value of the determination coefficient (99.99%), meaning that the growth of agricultural production is susceptible to agricultural production factors, especially since this regressive causal relationship is not false due to the (Durbin- Watson=2.57) is greater than the coefficient of determination.
- Correcting errors in the long-term error correction model (UECM) is possible.
- There is no problem of serial autocorrelation of errors; in addition to the lack of homogeneity in variance, the residuals follow natural law.

4. Conclusion:

This study presented an estimation and analysis of the agricultural production function in Mila State from 1990-2020 using the ARDL approach for model testing and inference. The key findings are as follows:

4.1. Results:

- The study found a significant positive long-run relationship between agricultural employment (X1) and agricultural production (Y), with an estimated elasticity of 1.46. A 1% increase in labor is associated with a 1.46% increase in output, confirming Hypothesis 1. However, the magnitude suggests labor contributes relatively less than other inputs.
- Agricultural capital in the form of equipment (X2) also demonstrated a significant positive association with output, with an estimated elasticity of 2.36. The results align with the Cobb-Douglas theoretical specification that increased capital raises productivity. Hypothesis 2 is thus validated.
- Annual precipitation (X3) positively correlates with agricultural production, with a 1% increase in rainfall corresponding to a 5.71% increase in output. This conforms to Hypothesis 3 given Mila's reliance on rainfall rather than irrigation.
- Cultivated land area (X4) has a positive elasticity of 7.53, indicating that a 1% expansion in land leads to a 7.53% rise in production. This finding for the predominant cereal crops aligns with Hypothesis 4.
- In summary, the statistical analysis confirms the hypothesized positive relationships between key inputs (labor, capital, rainfall, land) and agricultural output in Mila over 1990-2020. The magnitude of the coefficients provides insights into the relative importance of each factor. These results can guide resource allocation policies aimed at sustainably increasing productivity.

4.2. Recommendations :

- Continue agricultural support policies that incentivize investment and attract new entrants to the sector. This can increase production and employment in the long run.
- Leverage irrigation infrastructure like the Bani Haroun Dam to enable multiple cropping seasons per year on agricultural lands. This raises productivity of existing cultivated areas.
- Facilitate access to agricultural land through concessions to bring more areas under cultivation. This expands the production possibility frontier.
- Conduct market and cost analysis around specific crops and products to prevent unsustainably low prices that lead to farmer losses. The Agricultural Directorate and Chamber should address this.
- Promote adoption of advanced agricultural techniques and equipment to boost yields without necessarily expanding land usage. This improves efficiency.
- Develop climate-resilient infrastructure like greenhouses and water storage to mitigate effects of variable rainfall. This stabilizes production.
- Increase access to agricultural financing and insurance to facilitate adoption of new technologies and buffer against climatic risks.
- Enhance agricultural extension services for knowledge transfer and capacity building among farmers.

The policy recommendations primarily aim to sustainably increase productivity through efficient utilization of resources, technology adoption, supportive financing and insurance, market development, and climate change adaptation. A multi-pronged approach can improve livelihoods and resiliency.

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