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Leadership in Agriculture: Artificial Intelligence for Modelling and Forecasting Growth in the Industry

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Abstract: *The paper investigates the growth rates of agriculture as one of the leading industries, which serves as a catalyst for economic development and is intended to provide the population with food products and industry with raw materials. The main aim of the conducted research is to analyze the impact of agricultural reforms on the agricultural growth rates in Algeria. The systematic analysis of literary sources and methods of addressing the problem of agricultural growth indicates the existence of socio-economic, political, and institutional inhibitors of effective agricultural reclamation of the agricultural sector. Five inputs were used as parameters characterizing the development of the agricultural industry. These are the volume of agricultural financing, the volume of exploited agricultural area, the volume of developed agricultural machinery, the volume of agricultural labor, and the rural level of agricultural growth. Forecasting indicators of the development of the agricultural industry was carried out using the methods of min max scaler tool, ReLU, and RMSE. A machine learning model from the Python language built the artificial neural network model. The statistical data of the Ministry of Finance and Agriculture and the World Bank served as the information base for the study of the relationship between the amount of adopted and implemented agrarian reforms. The link between the number of agrarian reforms adopted and expressed was investigated using data from several areas of statistics, the Ministry of Finance and Agriculture, and the World Bank. The modelling results proved the positive influence of bank financing, the volume of exploited agricultural areas and the number of the population employed in agriculture on the growth rates of agriculture in Algeria in the long term. An increase in agricultural mechanization by one unit (tractors and agricultural equipment per 100 km^2) contributes to the growth of indicators of agricultural development by 0.21%, and an increase in the number of people employed in agriculture per million will lead to a rise in the level of agricultural development by 12 %. Thus, the results of econometric modelling proved the positive impact of agricultural reforms on the development of agriculture after 2022. It contributes to the increase in the level of employment of the population and, ultimately, will have a positive effect on the future rate of economic growth in Algeria.*
Keywords: leadership in agriculture, predicting, artificial intelligence, agricultural growth, agricultural reforms.
JEL Classification: C29, J01, O13, O49.

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Leadership in Agriculture: Artificial Intelligence for Modelling and Forecasting Growth in the Industry

1. Introduction

Algeria looked outside of the hydrocarbon industry for money because of this. Similar is the desire to increase the country's absolute competitiveness within the context of global competition by attempting to boost the productive capacities across various sectors without turning to those with competitive advantages. With the need for the gradual improvement and development of a number of these sectors to be alternatives that can replace the oil and gas industry sector (George, 2015). The danger of excessive reliance on one resource, one sector, or a few sectors is reduced by the distribution of investments across the economy's sectors (Stephen, 2003: 51). In contrast, the economy undergoes a structural shift in which secondary sectors (manufacturing industries, agriculture) take the place of primary sectors (natural resources, agriculture) (Barghouti, 1988).

According to Abdelwalid (2013), diversification is a process that involves looking for renewable energy sources, creating non-oil economies, and attaining sustainable development. The Fellahi and Rural Renewal Program (2010-2015) is one of the development strategies and initiatives that Algeria has executed (MADR, 2010). The Fallahi five-year extension plan (2015-2019) is similar. The government unveiled its newest agricultural program, the "2015-2019 Five-Year Plan" at the end of 2014; it is based on the nation's Agricultural and Rural Renewal Policy (PRAR).

The program will act as a proving ground for the sector's expansion through the end of 2019 and will supervise ambitious improvements, including the adoption of cutting-edge irrigation methods and a determined plan to enhance water use for fertilizer. Additionally, the government will try to boost local production of essential goods like milk and potatoes. The FAO states that the agricultural capital resource may be described as livestock, planted trees, agricultural technology, agricultural equipment, money spent on land reclamation, and buildings utilized for animal production (Philip, 2019), where it is said that the consumption of agricultural products was 15.89 billion dollars in 2014, compared to 4.80 million dollars in 2000, indicating a consistent increase from year to year. This budget is focused on the agricultural sector.

Research question: This study will be reviewed using the following research question: What are the expectations of the agricultural growth rate after the targeted agricultural reforms?

Hypothesis: There is a positive relationship between the agricultural growth rate during the next ten years after 2022. The paper consists of four sections: introduction, theoretical framework and empirical evidence, methodological issues and data, empirical analysis, and conclusion.

2. Literature Review

Rural development patterns are influenced by the expansion of the agricultural sector, agricultural employment, agricultural imports, and the growth rate of the rural population (Power, 2016). Numerous research studies have examined the impacts of the expansion of the agricultural sector, agricultural employment, agricultural imports, and the growth rate of the rural population on rural development. It is vital to build practical, adaptable, and efficient scientific methods and policies to ensure that the development of new rural regions is planned since it is a complicated and long-term process. Although these opinions are debatable, they serve as the cornerstone on which communist nations establish and expand their rural economies and agricultural sectors (Giang and Nguyen, 2016).

In a rural region, agriculture is the most significant industry. Most people living in rural areas are employed in agriculture, either directly or indirectly. The agricultural sector expands when there is a particular interest in agricultural activities, requirements, and production at various levels. Higher production (for crops and cattle), greater quality and diversity of goods, and more job possibilities are all benefits of expanding the agriculture industry. The social welfare of rural residents, their way of life, the environment, and the economic development of rural regions are all impacted by the rise of agriculture (Arif, 2019).

3. Data

The data set consists of five inputs: **Bankf**, which measures the amount of agricultural finance; **Agriland**, which measures the amount of agricultural land that has been exploited; **Agrimach,** which measures the

amount of developed agricultural equipment; **Agriwork,** which measures the amount of agricultural labor; and the degree of agricultural growth in **rural** areas. The statistical segmentation analysis of the input parameters is shown in Figure 1. Some input variables influence the descriptive analysis's findings. The total number of data points for each variable and the analytical parameters used to display pertinent values was included. The connection diagram is shown in Figure 2. Due to the minute variances, multicollinearity problems would not exist in this case. The input coefficient between them significantly impacts the output results when there are issues with a multicollinear connection, which may result in correct findings.

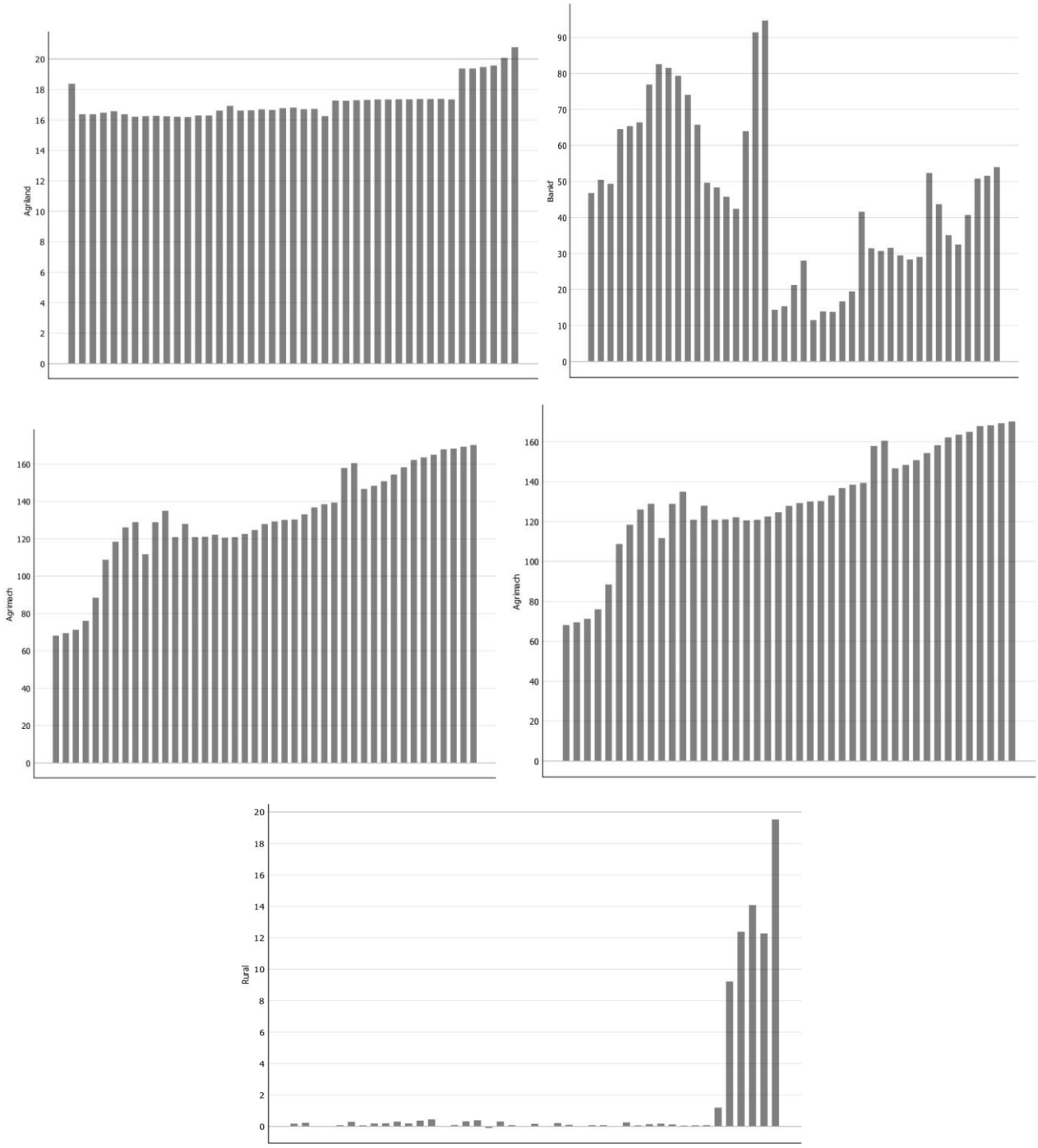

Figure1.The Distribution of the Input and Output Parameters

Source: Compiled by the author, 2023

1.2219		0.1265	0.0019	0.1052	0.0801	12.4101	0.1011	0.4708	0.2201	0.0310	0.0911	0.1041	0.1654
1.2219	0.000	2.092	1.590	1.197	1.184	1.138	2.670	2.123	2.507	2.922	2.546	1.442	1.236
0.1265	2.092	0.000	0.588	1.422	1.020	2.486	2.019	1.216	2.249	2.174	2.117	0.658	0.958
0.0019	1.590	0.588	0.000	1.238	0.744	2.073	2.089	1.358	2.326	2.263	2.216	0.236	0.688
0.1052	1.197	1.422	1.238	0.000	0.525	1.695	2.033	1.232	1.633	2.323	1.687	1.003	0.560
0.0801	1.184	1.020	0.744	0.525	0.000	1.749	2.098	1.265	1.965	2.350	1.947	0.515	0.211
12.4101	1.138	2.486	2.073	1.695	1.749	0.000	2.963	2.386	2.692	3.217	2.775	1.954	1.780
0.1011	2.670	2.019	2.089	2.033	2.098	2.963	0.000	1.006	1.168	0.320	0.871	2.019	1.896
0.4708	2.123	1.216	1.358	1.232	1.265	2.386	1.006	0.000	1.083	1.260	0.924	1.245	1.089
0.2201	2.507	2.249	2.326	1.633	1.965	2.692	1.168	1.083	0.000	1.455	0.313	2.158	1.831
0.0310	2.922	2.174	2.263	2.323	2.350	3.217	0.320	1.260	1.455	0.000	1.154	2.220	2.144
0.0911	2.546	2.117	2.216	1.687	1.947	2.775	0.871	0.924	0.313	1.154	0.000	2.069	1.790
0.1041	1.442	0.658	0.236	1.003	0.515	1.954	2.019	1.245	2.158	2.220	2.069	0.000	0.454
0.1654	1.236	0.958	0.688	0.560	0.211	1.780	1.896	1.089	1.831	2.144	1.790	0.454	0.000
0.1071	1.994	0.316	0.457	1.462	1.042	2.360	1.913	1.192	2.251	2.055	2.103	0.587	0.943
-0.1264	2.675	2.601	2.630	1.956	2.292	2.785	1.209	1.402	0.456	1.461	0.571	2.469	2.146
0.0209	2.031	1.152	1.292	1.083	1.132	2.292	1.177	0.183	1.110	1.439	0.996	1.160	0.972
14.1000	2.321	3.290	2.986	2.650	2.743	1.189	3.544	3.051	3.220	3.774	3.328	2.896	2.749

Figure 2. The Connection Diagram

Source: Compiled by the author

4. Model

The following models are employed to determine how agricultural reforms affect agricultural growth rates and to forecast it over the long term: Model for Classification Prediction founded on LR. The prediction function is quick, straightforward, and has an excellent capacity to generalize to new data. The outputs of the linear function are mapped to the s-type function (sigmoid function) in a linear binary classification model. The algorithm's prediction function is displayed.

$$h_\theta = \frac{1}{1+e^{\theta T}} \qquad (1)$$

The value range of h X in the formula is between 0 and 1, indicating the chance that the outcome value is 1.

A statistical approach known as a regression tree can be used to replace regression techniques (Breimann, 1984). The complete dataset is divided into two or more uniform sets using the regression tree approach to develop a model. When the splitting process is completed, a node is designated as a terminal node. A decision node is a single value that divides each node into sub-nodes. A regression tree model with input considerations and a response parameter is built using repeating binary splitting.

$$R_1(j,s)=\{X|X_j \le s\} \text{ and } R_2(j,s)=\{X|X_j > s\} \qquad (2)$$

where *s* and *j* are the variables and the splitting point, respectively. Furthermore, *s* and *j* are employed to get the most uniform splitting group.

The embedding framework in (Atkeson, 1997) proposes that, given a historical record S, the issue of one-step forecasting may be approached as a supervised learning problem. Supervised learning is modelling the relationship between a set of input variables and one or more output variables that are thought to be somewhat reliant on the inputs using a finite set of observations. Once the mapping model is complete, it may be utilized for one-step forecasting. The *n* prior values of the series are known in one-step forecasting, and the forecasting issue can be treated as a general regression problem.

The objective of a multi-step time series forecasting assignment is to anticipate the following H values [yN+1,...,yN+H] of a historical time series [y1,..., yN] made up of N observations, where H>1 specifies the forecasting horizon (Casdagli, 2002). A one-step model is trained first using the Recursive approach (Sorjamaa, 2007).

$$y_{t+1} = f(y_{t.....},y_{t-n+1})+w_{t+1}, \qquad (3)$$

by concatenating the H forecasts to get a multi-step forecast with t = (n.....N-H) and h = (1,.....,H). The estimates for the study inputs are calculated using the direct method.

First, no statistical relationships between the predictions are considered because the H models are learnt independently. The second direct techniques frequently demand more considerable functional complexity than iterated ones to describe the stochastic dependency between two series values at two distant instants

(Tong, 1983). Finally, this approach requires much computing effort because the horizon's size equals the number of models that need to be learned.

5. Results

The ANN model LSTM used the same data as the RF and XGBoost models. In the case of artificial neural networks, the technique employs stacked hidden layers, and the data findings may differ depending on the Epoch. The LSTM model uses Python's Keras deep learning tool to examine the prior data. Furthermore, the LSTM employs the Keras deep learning package with a default activation function that produces a value between 1 and 1 through the hyperbolic tangent process. As a result, the input values are similarly transformed to a measure between 0 and 1 by employing the min max scaler. The behavior of the LSTM model might vary based on the optimizer and activation function employed. Consequently, because tweaking the parameters influences the resultant value, acceptable values for the parameters were determined using a grid search strategy within a given boundary while the overall structure remained constant. ReLU activation was employed in this study since it has been shown to be the most effective. Furthermore, the dropout and recurrent dropout parameters were each adjusted to 0.1 to prevent overfitting and enhance model performance. The epochs were set to 100, and an early stopping function with a patience setting of 10 was implemented to ensure that the loss function output did not rise during training.

Then, all conceivable combinations were tried by setting the number of units as 8, 16, 32, the learning rate as 0.01, 0.05, 0.1, and batch size as 16, 32, and 48 as variables. Consequently, the RMSE was minimized for Period 1 when the parameters were unit 16, learning 0.001, batch size 16, and for Period 2 when the parameters were unit 16, learning rate 0.05, batch size 32. The specified parameters were utilized for each period to develop the model. Figure 3 depicts a graph comparing actual and predicted agricultural growth outcomes.

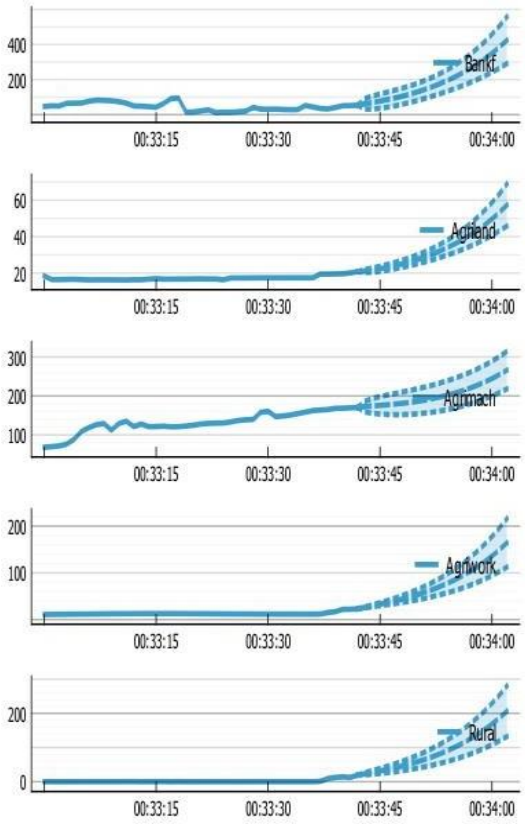

Figure 3. Graph Comparing Actual and Predicted Agricultural Growth Outcomes

Source: Compiled by the author, 2023

Forecasting the values of the time series inputs revealed an increase in all variables of agricultural reforms, including the agricultural labor variable, which offered favorable results for increasing agricultural growth rates in Algeria in the following years, beginning in 2023.

6. Conclusion

The role of agriculture in achieving economic development (Hwa, 1989; Pingali et al., 2019: 165) as it is impossible to think about economic growth without considering agriculture as a beginning and a priority for development (Dollar, 2002: 223). The agricultural sector is considered the missing link that must be recovered to complete the economic development of any country, which requires the results of new agriculture (Janvry & Sadoulet, 2006: 236). Considering that Algeria is one of the countries that sought to develop agriculture and establish safety nets (Van den Meer, 2006: 23) in addition to adopting programs that target poor rural families with income support that depends on the number of children in the family, which among its objectives is to enhance food security at the national level, which inevitably passes through research within the range Algeria has also adopted other programs for afforestation and rehabilitation of agricultural lands through the concession system, and plans, the latest of which is the Agriculture Action Plan 201 9 Which came in response to the challenge raised, which is to achieve food security under the new growth model. (Brumm, 1996).

Efficiency in development and economic growth reduces poverty, famine and undernourishment and achieves food security, especially in developing countries with dry lands. Numerous studies have shown that efficiency in economic growth will positively impact food security. However, food security can directly or indirectly affect economic growth (Manap, N.M.A., & Ismail, 2019), and many studies have identified significant issues related to food security: modernization, economic dependence, urban bias, population pressure, and ecological, evolutionary processes. Moreover, some studies have Measuring food security at the macro level. Where policy makers condition food security at the micro level in terms of household access to food in local markets and household resources. Therefore, food security has an impact on economic growth.

According to our study, forecasting the overall agricultural growth rate is critical in the context of agricultural reform policies. As Algeria has grown increasingly reliant on new exports other than hydrocarbons, and agricultural reform programs are being implemented rapidly, accurate forecasting of agricultural growth is critical. It is because difficulties in the agriculture sector may be properly handled while also planning for the economy's steady expansion. The development of agricultural product contribution to GDP alternated between growth and decline, and the lowest value of agricultural sector contribution was during the years (1982, 1983, 1984) by Contribution calculated at: (5.96%, 5.28%, 5.21%), respectively. The years with the highest levels of this contribution were (1989, 1992, 2001, 2003, and 2016), with an estimated contribution of (9.60%, 9.45%, 9.67%, 9.78%, and 12.29%). Despite these advances, particularly in recent years, the agricultural sector's contribution to GDP remains far from equal. What is anticipated of it as a potential industry with the credentials to play a positive role in the Algerian economy, especially given the concerns that Oil sector revenues have been reduced.

The findings of evaluating the long-time association revealed that agricultural bank financing positively influences agricultural growth, implying that agricultural bank financing has a major effect on the change in agricultural growth rates in Algeria over the long run. Agricultural mechanization has a positive and significant influence on agricultural growth, which implies that increasing agricultural mechanization by one unit (a tractor and agricultural equipment per 100 km^2) increases agricultural development in Algeria by 0.21% to 1.3%. Agricultural lands have a positive and considerable effect on agricultural growth, which indicates that agricultural lands have a long-term influence on the change in agricultural growth rates in Algeria. Over the long run, a million more people employed in agriculture will increase agricultural growth in Algeria by 12%. It is because agricultural labor has a favourable and considerable influence on agricultural growth. Based on the outcomes of long-term projections, we notice that the new agricultural reforms effectively affect agricultural development after 2022, which raises employment rates, all of which are reflected in Algeria's future economic growth.

Conflicts of Interest: Author declares no conflict of interest.

Data Availability Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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