The use of Artificial Intelligence Models in sales Forecasting and Supply Chain Management

استخدام نماذج الذكاء الاصطناعي في التنبؤ بالمبيعات ونمذجة شبكة الإمداد

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Abstract:This study aims to highlight the role of sales forecasting methods in administration and supply chain management. This is done by explaining how to use forecast data in mathematical modeling for the supply chain, which is distinguished by multipurpose objectives. This can only be modeled by multi-criteria methods, where we will try to apply them to RIO, a specialized Algerian firm producing yogurt, by studying its product features in order to forecast their weekly sales by using the Box-Jenkins method and artificial neural networks. Then, we will model their supply chain using a combination of compromise programming and genetic algorithms. As shown by the application of the neural network method in the field of forcasting, it gives better and more accurate results than the application of BOX-JENKINS. Also, by comparing the results obtained from modeling using the genetic algorithm method and the Compromise programming method, we concluded that the latter gives better results than the algorithmic method. In conclusion, it can be said that if the conditions of these methods are respected, the presented study can be generalized to other similar institutions.

Keywords: Box-Jenkins method, Artificial neural networks, Compromise programming, Genetic Algorithms.
JEL Classification Codes: C/C5 : C51,C52,C53 – C/C6 : C61

مستخلص: تهدف هذه الدراسة إلى تسليط الضوء على دور أساليب التنبؤ بالمبيعات في الإدارة سلسلة الامداد. ويتم ذلك من خلال شرح كيفية استخدام بيانات التنبؤ في النمذجة الرياضية لشبكات الامداد التي تتميز بأهداف متعددة والتي لا يمكن نمذجتها إلا بطرق متعددة المعايير، وهذا من خلال تطبيق على احد الشركات الجزائرية المتخصصة في إنتاج الزبادي متمثلة في ملبنة RIO ، حيث قمنا بدراسة ميزات منتجاتها للتنبؤ بمبيعاتها الأسبوعية باستخدام طريقة Box-Jenkins والخلايا العصبية الاصطناعية، ثم قمنا بنمذجة سلسلة الإمداد الخاصة بها باستخدام البرمجة الكمبرومازية والخوارزميات الجينية. تبين من تطبيق طريقة الشبكة العصبية في مجال التنبؤ أنها تعطي نتائج أفضل وأكثر دقة من تطبيق طريقة BOX-JENKINS. كما أنه من خلال مقارنة النتائج المتحصل علها من النمذجة باستخدام طريقة الخوارزمية الجينية وطريقة البرمجة الكمبرومازية، أن هته الأخير تعطي نتائج أفضل من تطبيق طريقة الخوارزمية. ولذلك في حالة احترام شروط هذه الأساليب يمكن تعميم الدراسة المقدمة على مؤسسات أخرى مماثلة.

الكلمات المفتاحية : طريقة Box-Jenkins، شبكات عصبية إصطناعية، برمجة كمبرومازية، خوارزميات جينية.
تصنيف JEL : C/C5 : C51,C52,C53 – C/C6 : C61

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1. Introduction

In recent years, managers of large Algerian businesses and institutions have faced numerous and complex problems, due to the reduced life of products, the change in sales volume resulting from seasonal changes, in addition to the difficulty of the institution expanding its market share resulting from competition. This may result in spending significant sums in purchasing materials to meet their needs and ensure the continuation of their productive activity. Since these materials represent an important part of the capital, it was natural to find mathematical and statistical methods and techniques to help manage an important job or activity in various establishments, regardless of their industrial, commercial or service activities, represented in managing the supply network.

The management of the elements of the supply network is based mainly on forecasting sales in order to meet demand and serve customers. It is not possible to carry out the process of planning production, warehousing or supply without knowing the level of sales required by customers, even if this is done in an approximate manner.

In addition, the optimal management of the supply network depends on forecasting sales and integrating its elements, so that a reduction in the period of supply and supplies, inventory at the beginning of the season is sought, taking into account the least risks, etc.... In order to try to achieve all these goals, a group of techniques such as Sales forecasting, techniques and methods of operations research, and the multi-criteria methods used in modeling the objectives of the supply network, in addition to taking some new internal procedures such as accelerating the receipt of goods, which depends on the automated media. In this research, the main question represented in the following problem will be addressed:

How can artificial intelligence models be used in forecasting sales and managing the supply network in the Algerian enterprise?

2. General Concepts:

2.1 The concept of sales forecasting

Sales forecasting is an attempt to estimate the level of future sales by using available information about the past and present, and therefore forecasting is an attempt by the organization to see the future through the eyes of the past and present. Prediction is not an accurate calculation of the future as much as it is an estimate based on technical and scientific foundations, and therefore it is also not a kind of guesswork that is not linked to an ordered system or objective measures that determine the image of the future (1997 ،طلعت).

Predicting this is not just a set of calculations and estimates about the future in isolation from experience, but rather an integrated mixture of science, art and personal judgment required to study and set assumptions on which the prediction is based, especially since the forecasting process is a major guide in the behavior of the departments and sections of the facility when planning for the future. . And there are close relationships between forecasting and supply network management because predictive calculations are not done in isolation from supply network management.

2.2 The concept of supply chain management

Supply chain management is defined as the process responsible for developing and managing the overall supply system of an organization with its internal and external components. On the operational level, it includes and exceeds the activities of both procurement and procurement, in addition to having many areas of strategic focus (2005 ،ثابت المرسى).

In 1991, the Board of Directors of Supply and Distribution defined supply network management as follows: It is the process of planning, implementing, and controlling the effective and efficient flow and storage of goods, services, and information related to this flow and storage from the point of origin to the point of consumption in order to meet consumer requirements (1999 ،السيد ،ماضي).

There have been many and different definitions related to supply chain management, so many authors have tried to put the essence of supply chain management in one definition. Its components are (Stadtler; Kilger, 2000, 2002):

- the goal of management philosophy;
- Target group;
- the goal or objectives;
- appropriate means to achieve these goals.

2.3 The role of sales forecasting in managing supply networks

Sales forecasting plays an important role in managing the supply network, as the latter is concerned with the three areas of operation, which are managing physical distribution, managing materials and managing internal inventory movement, and therefore it can be said that it is responsible for the strategic management of the flow of materials and products to and from within the organization in addition to storing them. The other sub-system constituting the supply network system is concerned with developing the necessary plans to achieve integration between its various activities. From the administrative point of view, coordination activities are divided into the following group of activities (إبراهيم، مصطفى، 2004):

- forecasting sales;
- run commands;
- planning and scheduling operations;

Material requirements planning.

Thus, the sales forecasting process is considered the basic pillar of supply network management. This importance requires that the sales forecast be prepared on sound scientific bases and requires careful consideration in preparing such estimates in order to reflect reality, which facilitates making sound decisions in the light of these estimates.

3. Method and tools:

There are several sales forecasting methods that vary in terms of their ease of application and the degree of accuracy of their results. There are easy and simple qualitative methods that do not require high skills and experience, but rather rely on intuitive perception and figurative extrapolation of the future based partly on statistical data. Some of them are also based on the assumption that the future is an extension of the past and the present, and that the conditions and factors that affected sales remain valid in the same quantity and size. Others depend on a field survey using the investigation of a sample of consumers, then analyze the collected data in order to determine the expected demand through experience in the field. However, what is wrong with these methods is that they are built on the basis of intuition and speculation, which may lead to negative expectations according to the degree of optimism and pessimism of the people assigned to the process. There are also quantitative methods based on the use of standard statistical and economic methods and mathematical methods that are useful in knowing or monitoring the behavior of some variables in the past, and then predicting their future behavior. Prediction is also useful in decision-making at the micro or macro level.

3.1 The BOX-JENKINS method

The researchers BOX-JENKINS (USA) proposed in 1976 a technique for forecasting for a univariate time series based on the autocorrelation function and using the principle of moving averages and the principle of autoregression. chain subject. This method allows identifying and estimating a good model that relates a variable to its previous values. The methodology of this technique goes through the following stages:

- Extracting the characteristics of the time series, where the time series is analyzed and its components of randomness, general trend, and seasonal changes, if any, are extracted, and its stability is tested using the Philips-Perron test, and the autocorrelation function is shown.

Model recognition: The assortment of stochastic models consists of autoregressive (AR) models, moving average (MA) models, and mixed models of autoregressive and moving average (ARMA) models. One of the conditions for using these models is that the time series must be stable. In addition to the extended models (ARIMA, SARIMA) for unstable time series, which are converted to stable time series using the difference method with respect to their previous values or the regression method. Then the nature of the prediction model is determined using the simple and partial autocorrelation function statement and the following criteria:

Akaike criterion (1969), Schwars criterion (1978) and Hannan-Quinn criterion (1979).

We choose the model that achieves the smallest value of these criteria.

- Estimating the parameters of the model: The parameters of the model are estimated using the method of least squares or the method of greatest possibility. Estimation in this way depends mainly on the fact that the errors are independent and follow the normal distribution.

Model quality test: After estimating the model parameters, the result or quality of this estimation must be tested using the Student test to test the quality of the features, the Box-Pierce test to ensure that the residual or prediction error is a white error, and the Jarque-Bera test to ensure that the prediction error It is subject to a normal distribution.

Prediction using models of this technique, which is the last stage.

Each stable series can be approximated using AR(p), MA(q) or ARMA(p,q) models.

3.2Artificial neural networks

The first computational model for artificial neurons was proposed by neuroscientist Warren MuCulloch and logician Walter Pitts in 1943 (Akshay, 2018, p. 5). This model has known several developments and additions over time as it is a function. Flexible non-linear, these models take the general form (عدالة، 2010، صفحة 181):

$$Y = F\lfloor H_1(X).H_2(X).\dots.H_n(X)\rfloor + \mu$$

where:

- independent variables X: input;
- dependent variable Y: output or output;
- neural network functions H: hidden layers;
- Functions of neural networks F: the output of the hidden stimulus function.

3.3 Compromise programming

that works to solve economic problems with conflicting goals and their optimal solutions are unknown and the mathematical analytical expression for this model is as follows (Ignizio, 1982):

$$g_i = \begin{cases} g_i^* = Max \quad f_i(x), x \in F \\ g_i^* = Min \quad f_i(x), x \in F \end{cases}$$

$$C_l(x) \leq 0, \quad l = 1, 2, ..., L$$

That is, we have two goals $f_1(x)$ and $f_2(x)$, so that we want to maximize $f_1(x)$ and $f_2(x)$ minimize under certain restrictions $C_l(x)$.

The process of solving such mathematical models using this method goes through two basic steps:

The first step: searching for the maximum or minimum value for each target separately under the constraints using linear programming.

The second step: Solve the model using linear programming with weighted objectives, so as to allocate importance (w_i) to each objective as follows:

$$Min \quad Z = \sum_{i=1}^{m} w_i (\delta_i^+ + \delta_i^-)$$

$$sujet \quad à$$

$$\begin{cases} f_i(x_j) + \delta_i^- - \delta_i^+ = g_i^* \\ f_i(x_j) + \delta_i^- - \delta_i^+ = g_i^* \\ C_l(x) \leq 0, \quad l = 1, 2, \ldots, L \\ x_i \leq 0 \quad avec \quad i = \{1, 2, 3, \ldots, n\} \end{cases}$$

whereas:

δ_i^- and δ_i^+ : They are the negative and positive deviations, respectively, of the achieved targets from their optimum limit.

3.4 Genetic Algorithms

Scientist David Edward Goldberg mentioned the following points in his book, Points of Difference between Genetic Algorithms and Traditional Research Methods (Goldberg, 1989, p. 7):

- It depends in its work on the function of validity or fitness and the objective function, while the other methods depend on derived functions and additional information;
- Genetic algorithms search for the solution from a group of points, not from a single point;
- It works to represent the variables of the issue in the form of a chromosome;
- Research in genetic algorithms depends on the principle of probability, while other methods depend on pre-determined fixed steps.

The steps of applying genetic algorithms begin with encoding the problem presented and the constraints of the study, so that the process of evaluation, selection and reproduction that represents the genetic processes is completed. This process ends with the generation of a group of generations containing the optimal generation that represents the solution.

4. Rio Dairy Corporation Case Study (Product Supply Network Modeling) :

In order to clarify the above, a case study will be carried out in an Algerian institution (RIO dairy). Its products are considered (yoghurt), which has specialized since 2007 in producing the following types:

- Yoghurt with fruits packed in TONIC bowls weighing 450 g;
- Flavoring yoghurt packed in TONIC bowlscalled “Haliby” weighing 450g;
- Flavoring yoghurt packed in simple plastic bowls weighing 450 g.

The process of studying the characteristics of the three products produced by Rio Dairy Milk is very important in the process of forecasting its sales, as well as in the process of modeling its supply networks so that the appropriate method for the forecasting process cannot be determined unless the nature of the product and the range to be forecasted (long, medium, short or short term). Also, the modeling process does not take place without knowing the various objectives to be achieved and the objective conditions or restrictions that they impose.

We noticed that there are common characteristics between the three types of production, such as the stages of production, most of the components of these products, and their shelf life. They differ in other important characteristics such as quality, cost price and profit resulting from selling each unit of these products...etc. After conducting a detailed study of the costs of purchasing raw materials and storing them, the costs of producing and distributing finished products, the various stages of yoghurt production and the time taken for that, the characteristics of dairy products are summarized in Table No. (1).

Table01.characteristics of RIO dairyproducts

Products	**Flavoring yoghurt packed in simple plastic bowls**	**Flavoring yoghurt packed in TONIC bowls**	**Yoghurt with fruits packed in TONIC bowls**
Production period of 2300 bowls	25 hour 45 minute	26hour15 minute	27hour 15 minute
Selling price per bowl (AD)	36	40	52
The cost price per bowl (AD)	30.68	33.55	43.62

Source: prepared by the researcher

Through our study of the characteristics of the Rio dairy products, it was noted that there are many restrictions that limit the achievement of these goals, including the short shelf life of these products, which does not exceed 30 days, in addition to the fact that the customers of this company are retailers, and this is what imposes prediction in the very short term (forecasting In weekly sales) so that the storage period of Rio Dairy products does not exceed a period of one week, in order to allow sufficient time for retail stores to sell their products before the expiry date of the yoghurt expires. This imposes a study of the weekly sales of these products for the years 2021 and 2022 in order to be able to model them and predict using the most effective Box-Jenkins model in such cases and compare them with the method of artificial neural networks.

The limited daily production of this product and the length of its production time are also taken into account, in addition to the poor supply process resulting from several reasons. The process of achieving the objectives of supply network management (relatively) requires the use of one of the multi-criteria methods represented by the cambromaze programming method and comparing the obtained results with the results of applying multi-objective genetic algorithms.

4.1 Forecasting sales for the first week of the year 2023 for the three products using the Box-Jenkins method

The following forecasting models were extracted using Eviews 10:

-Fruit yoghurt packed in TONIC bowls:

$$\Delta YEFT_t = -0.86\varepsilon_{t-1} + \varepsilon_t$$

$YEFT_t$: sales of yoghurt with fruit at time t.

$$\Delta YEFT_t = YEFT_t - YEFT_{t-1}$$

ε_t: white error in period t.

- Flavoring yoghurt packed in TONIC bowls:

$$YEAT_t = 1.007YEAT_{t-1} - 0.99\varepsilon_{t-1} + \varepsilon_t$$

$YEAT_t$: sales of flavoring yoghurt packed in TONIC bowls at time t.

- Flavoring yoghurt packed in simple plastic bowls:

$$\Delta YEAS_t = -0.71\varepsilon_{t-1} + \varepsilon_t$$

$YEAS_t$: salesflavoring yoghurt packed in simple plastic bowls at time t.

$$\Delta YEAS_t = YEAS_t - YEAS_{t-1}$$

4.2 Forecasting sales for the first week of the year 2023 for the three products using artificial neural networks

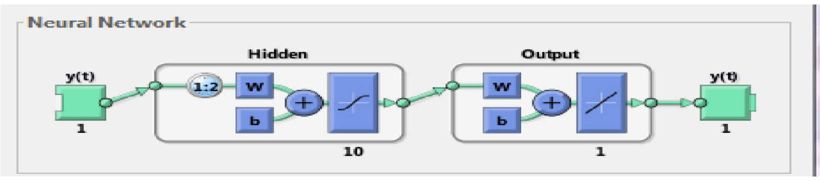
The first product: After determining the study variable, the time series of the weekly sales of the first products for the years 2021 and 2022, which is equivalent to 116 views representing the input network. We processed the time series data using the MATLAB R2015a program, then identified the input network representing the weekly sales series in order to predict its future values (based on its past values). It is considered a form of non-linear autoregressive prediction, and the time series takes the following form:

Yt = f(Yt-1.... Yt-d)

After determining the network, we trained it, as the results of the initial training were poor, so we retrained the network by changing the degree of slowing down from 2 to 1 while maintaining the same previous conditions, and this did not give a good result. We retrained by increasing the number of hidden layers, then decreasing the number of hidden layers, and it did not work until the change in the proportions of the sample, then raising the proportion of the training group from 70% to 80%, i.e. from 82 observations to 92 observations (R = 0.58), a change in the group Confirmation from 15% to 10% (R = 0.66) and also for the test group from 15% to 10%, i.e. from 17 observations to 12 observations each (R = 0.66).

As we noticed that the histogram of the residuals is symmetrical, and therefore the residuals follow a normal distribution, and the autocorrelation function of the errors is observed to be stable. After adopting the trained network, it was verified by estimating the correlation coefficient for the network as a whole (R = 0.63), which reflects the presence of a positive correlation between the inputs and outputs, and the mean squared error, which was acceptable, as it was estimated at 6693.18. It was also found that the best performance of the network was achieved at the sixth attempt that was presented. The smallest mean squared errors of the training, investigation and test samples. Figure 1 represents the graph of the supported network.

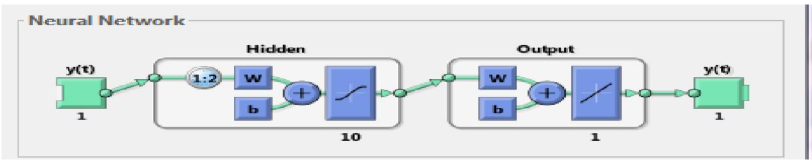
Figure 01. the graph of the supported network for the first product



Source: prepared by the researcher

<u>The second product</u>: the same thing for the second product. It was treated in the same way. After defining the network, we trained it, as the results of the initial training were poor. So we retrained the network by changing the degree of slowing down from 2 to 1 while maintaining the same previous conditions, and this did not give a good result. . We retrained by increasing the number of hidden layers, then decreasing the number of hidden layers, and it did not work until the change in the proportions of the sample, then raising the percentage of the training group from 70% to 80%, i.e. from 82 observations to 92 observations (R = 0.64), a change in a group Confirmation from 15% to 10% (R = 0.58) and also for the test group from 15% to 10% i.e. from 17 observations to 12 observations each (R = 0.61). As we noticed that the histogram of the residuals is symmetrical, and therefore the residuals follow a normal distribution, and the autocorrelation function of the errors is observed to be stable. After adopting the trained network, it was verified by estimating the correlation coefficient for the network as a whole (R = 0.59), which reflects the existence of a positive correlation between the inputs and outputs, and the mean squared error, which was acceptable, as it was estimated at 2737.06. It also turned out that the best performance of the network was achieved at the seventh attempt that was presented. The smallest mean squared errors of the training, investigation and test samples. Figure 2 represents the network diagram.

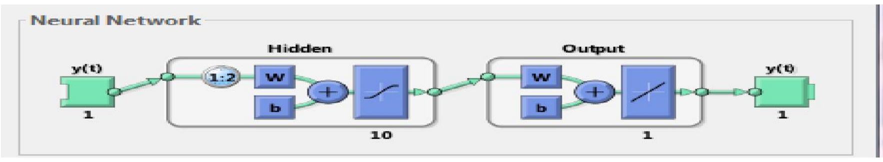
Figure 02. the graph of the supported network for the second product



Source: prepared by the researcher

<u>The third product</u>: the same for the third product. It was treated in the same way. After defining the network, we trained it. The results of the initial training were good, as the training group achieved 70% of 82 observations (R=0.89), and the confirmation group of 15% (R=0.89). 0.78) and also for the test group of 15%, equivalent to 17 observations for each (R = 0.82). As we noticed that the histogram of the residuals is symmetrical, and therefore the residuals follow a normal distribution, and the autocorrelation function of the errors is observed to be stable. After adopting the trained network, it was confirmed by estimating the correlation coefficient for the network as a whole (R = 0.86), which reflects the presence of a positive correlation between the inputs and outputs, and the mean squared error, which was acceptable, as it was estimated at 86.9508. It was also found that the best performance of the network was achieved at the seventh attempt that was presented. The smallest mean squared errors of the training, investigation and test samples. Figure 3 represents the approved network diagram.

Figure 03. the graph of the supported network for the third product



Source: prepared by the researcher

4.3 Mathematical formulation of the supply network management process using the programming method with quantum objectives

The objectives of managing the company's supply network are as follows:

- Reducing the total costs of supply;
- maximizing total profit;
- Maximizing sales quality.

Quality is rated as follows: Good: 16/20, Good: 14/20, Fair: 12/20.

$$\begin{cases} Min \quad Z_1 = 43.62x_1 + 33.55x_2 + 30.68x_3 + 8220 \\ Max \quad Z_2 = 8.38x_1 + 6.45x_2 + 5.32x_3 - 8220 \\ Max \quad Z_3 = 16x_1 + 14x_2 + 12x_3 \end{cases}$$

whereas:

x_1:The produced quantity of fruit yoghurt packed in TONIC bowls;

x_2: The produced quantity of flavoring yoghurt packed in TONIC bowls;

x_3:The produced quantity of flavoring yoghurt packed in simple plastic bowls.

However, there are several objective restrictions or conditions that limit the optimal achievement of these goals, which are:

-The production volume should not exceed the forecast sales volume for the first week of January 2022.

- The volume of production of fruit yoghurt must exceed 5000 containers, the volume of production of flavoring yoghurt packaged in TONIC containers must exceed 2000 containers and the volume of production of flavoring yoghurt packaged in plastic containers must exceed 9000 containers because the weekly demand for the three products in the last weeks of the year 2022 did not falls below these quantities.

- Limitation of production capacity and product characteristics.

Recording the available weekly working hours: The estimated weekly hourly volume available for the production process is about 2160 minutes (for Thursdays, Saturdays, Sundays and Mondays), where the time allotted for producing one unit of the three products was calculated as follows: x_1: 0.124 minute, x_2: 0.098 minute, x_3: 0.085 minute.

$$\begin{cases} 5000 \le x_1 \le 11177 \\ 2000 \le x_2 \le 4164 \\ 9000 \le x_3 \le 17459 \\ x_1 + x_2 + x_3 \le 27600 \\ 0.124x_1 + 0.098x_2 + 0.085x_3 \le 2160 \\ x_i \ge 0 \quad avec \quad i = \{1,2,3\} \end{cases}$$

To solve the previous mathematical model, the programming method was used with quantum objectives, following the following stages:

- Searching for the optimal solution for each objective separately under the aforementioned constraints.

Giving weights to the previous three goals according to the importance of each goal.

- Searching for the ideal solution that achieves the three objectives in an approximate manner.

The final mathematical form of the model takes the following form:

$$Min \quad Z = 0.20\delta_1^+ + 0.50\delta_2^- + 0.30\delta_3^-$$

Weights were given to the three goals according to their importance to the organization's managers. So that the goal of maximizing profit is the most important, followed by maximizing quality and finally minimizing costs.

Under restrictions:

$$\begin{cases} 43.62x_1 + 33.55x_2 + 30.68x_3 + 8220 + \delta_1^- - \delta_1^+ = 569540 \\ 8.38x_1 + 6.45x_2 + 5.32x_3 - 8220 + \delta_2^- - \delta_2^+ = 133586.22 \\ 16x_1 + 14x_2 + 12x_3 + \delta_3^- - \delta_3^+ = 298088 \\ 5000 \le x_1 \le 11177 \\ 2000 \le x_2 \le 4164 \\ 9000 \le x_3 \le 17459 \\ x_1 + x_2 + x_3 \le 27600 \\ 0.124x_1 + 0.098x_2 + 0.085x_3 \le 2160 \\ x_i \le 0 \quad avec \quad i = \{1, 2, 3\} \end{cases}$$

Where:

- δ_1^- and δ_1^+: They are the negative and positive deviations, respectively, of the realized costs from their minimum;
- δ_2^- and δ_2^+ : They are the negative and positive deviations, respectively, of the achieved profit from its maximum;
- δ_3^- و δ_3^+: They are the negative and positive deviations, respectively, of the achieved quality from its maximum.

By using the Lindo61 program, we find the following optimal solution:

$$\begin{cases} Z_1 \min = 771213.78 \\ Z_2 \max = 133214.22 \\ Z_3 \max = 293640 \\ x_1 = 7959 \\ x_2 = 4164 \\ x_3 = 9000 \end{cases}$$

4.4 Mathematical formulation of the supply network management process using the method of genetic algorithms

To solve the previous model using genetic algorithms, the following form was designed for the studied problem:

Algorithmed'optimisation

```
Variable
        Output [F1 F2 F3] :Float
        X [X(1) X(2) X(3)] :Int
Constant
        LB :Int
        Nvars :Int
        A : Float
        b : Float
start
        LB←[5000 2000 9000]
        UB←[11177 4164 17459]
            Function←obj(X)
            F1←43.62*X(1)+33.55*X(2)+30.68*X(3)+8220
            F2←-8.38*X(1)-6.45*X(2)-5.32*X(3)-8220
            F3←-16*X(1)-14*X(2)-12*X(3)
            output←[F1 F2 F3]
            return output
            end function

        A←[1 1 1; 0.124 0.098 0.085]
        b←[27600 2160]

            Function gamultiobj (@obj.Nvars.A.b.LB.UB)
            Nvars←3
            Return output.X
            End Function
Stop
```

After generating the maximum number of generations, which is estimated at 50 generations, with the help of a program, and then obtaining the best possible solution to the problem at hand, in the third generation.

$$\begin{cases} Z_1 \text{ min}=773217.60 \\ Z_2 \text{ max}=150029.25 \\ Z_3 \text{ max}=290709.81 \\ X_1=9669.35 \\ X_2=2000.00 \\ X_3=9000.00 \end{cases}$$

5. Results and discussion:

From the analysis of the time series of the weekly sales of the three products, it was found that they are stable in the first degree, knowing that the fruit yoghurt sales series is affected by the random error of the previous period, which may have occurred in one of the time periods and began to affect the subsequent values. As for the series of sales of fragrant yoghurt packaged in TONIC containers, it is affected by its previous value and the random error of the previous period, while the series of sales of fragrant yoghurt packaged in regular plastic containers is affected by the random error of the previous period. After analyzing the weekly sales of the three products for the years 2021 and 2022 and extracting forecast models for each product, the expected sales were extracted in the first week of January 2023 by both methods. As it became clear to us from comparing the forecast for the first week of January 2023 using the artificial neural networks method, it provided higher results compared to the results achieved by the BOX-JENKINS method. Table No. (2) explains this. In order to determine which one achieves better results, we used one of the indicators to measure the accuracy of the forecast. contained in Table No. (3).

Table 02. Forecasting sales for the first week of the year 2023

Forecasted weekly sales	Yoghurt with fruits packed in TONIC bowls	Flavoring yoghurt packed in TONIC bowls	Flavoring yoghurtpacked in simple plastic bowls
Box-Jenkins method	11177	4164	17459
Artificial neural networks	19089	5360	18371

Source: prepared by the researcher

Table 03.measure forecasting accuracy indicators

Measure forecasting accuracyindicators	products	Box-Jenkins method	Artificial neural networks
MSE	First product	2.64E+09	6693.18
	Second product	2.29E+08	2737.06
	Third product	4.80E+09	86.95
RMSE	First product	51380.93	81.81
	Second product	15132.75	52.31
	Third product	69282.03	9.32

Source: prepared by the researcher

Through our comparison of the values of the mean squared error index (MSE), it was found that the prediction errors resulting from the application of the BOX-JENKINS method were greater than the application of the artificial neural networks method, which reflects obtaining pessimistic predictions, i.e. the probability of error is greater, and since this indicator allows solving the problem of elimination However, the process of squaring inflates the values of errors and maximizes them, so to remedy this problem, we calculated the square root mean squared error index (RMSE). When calculating the square root index of the mean square error, which eliminates the effect of large values of errors, the results of the application of the neural networks method achieved the lowest values of the RMSE index, which reflects that the predicted values will deviate from the actual values by a lesser percentage than our application of the BOX-JENKINS method. Accordingly, we can say that the application of the neural networks method gives better predictions than the BOX-JENKINS application.

It was also shown from the comparison of the results obtained from the process of modeling the supply network of Rio yoghurt using the method of multi-objective genetic algorithms and the programming method with quantum objectives, that the latter gives better results than the method of multi-objective genetic algorithms in terms of high accuracy in management and production. Although genetic algorithms are compatible with most problems, there are algorithms and methods that are more efficient and closer to the optimal practical level.

6. Conclusion:

Through this research, it has been shown how to use sales forecasting models as well as methods and techniques of operations research as a strategic tool for managing supply networks, which is considered as a technology to control the flows of raw materials, semi-finished products and finished products from the original suppliers to the final customers at the lowest costs and the required quantities and in the right place and time.

It can be said that these technical methods applied in the economic field have shortcomings. For example, the computer programming method lacks standardization of measurement units, which makes its results somewhat limited. As for the Box-Jenkins methodology, it seems more complicated than the exponential smoothing techniques, but it helps the decision-maker to achieve a certain profit in Quality is also widely applied in business and research that uses partial economic data and successive processing of a large number of relatively stable time series that are not greatly affected by environmental changes or the effects of the organization's marketing policy. Based on our study, it was found that the application of the neural networks method in the field of predictions gives better and more accurate results than the application of BOX-JENKINS. Also, by comparing the results obtained from modeling by the genetic algorithms method and by the programming method with quantum goals, we concluded that the latter gives better results than the algorithms method genetic. Accordingly, it can be said that if the conditions of these methods are respected, the presented study can be circulated to other similar institutions.

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