Neural Networks and Genetic Algorithms Applied for Implementing the Management Model "Triple A" in a Supply Chain. Case: Collection Centers of Raw Milk in the Azuay Province

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Abstract. To get successful the companies need a combination of several factors, the most important one is the management of Supply Chain. This paper proposes the use of intelligent systems such as Artificial Neural Networks (ANN) and Genetic Algorithms as support systems together with monitoring indicators and monitoring, in order to implement the management model Triple A, which is focused on Agility-Adaptability-Alignment, where the "Agility" is the speed of response to changes in demand, "Adaptability" is the ability to tailor the supply chain front market fluctuations and "Alignment" is to align the chain between consumers and suppliers. The Neural Network was trained to work as a predictor of demand and will improve the "agility" of the supply chain, the genetic algorithm is used to obtain optimal routes of pickup from providers, this support to the "alignment" the product of suppliers in the supply chain to final customers; the Neural Network with the Genetic Algorithm together serve as support to "adapt" the supply chain to variations of demand and the suppliers, however, for successful of the model are need other factors such as the use of indicators and training of staff on the administration of management model triple A in the supply chain.

1 Introduction

Many companies even though they provide an excellent product and have an excellent human talent they fail for mistakes in making logistical decisions that is where tools of Artificial Intelligence such as Artificial Neural Networks (ANN) [1] and genetic algorithms [2] they can serve support in making decisions, in order to reduce losses and increase profits considering the line of business, this paper shows a practical application of such tools for the implementation of the Management Model Triple A [3] in the supply chain of the collection center for raw milk.

In Ecuador, the profit margin of the company is around 20%, so a loss of revenue for errors in logistics management can be the difference between success and failure. Logistics management includes management of physical flows, administrative and information, so that all projects of strategic planning should involve decisions directly in the supply chain. One proposal of logistic management was propounded by Hau Lee in 2004, it called the Triple-A supply chain management model that guides management in three main edges that are Agility, Adaptability and Alignment.

2 The “Triple-A” management model

The management Model Triple A for supply chain, covers several concepts that are not relatively new, for example in 1994 Goldman [4], proposed the "agile" concept refers to the speed of response of the company to changes in demand and supply for calibrating the production process so you can respond quickly to changing market information. The Toyota production model is a practical application of management models "agile" [5]. Another important concept is "lean" used for creating new companies called "lean star-up's" [6] that among its main ideas are:

- Testing ideas and finding customers in a short time and with few resources.
- Apply to the development of a market and a constant focus on the customer.
-The term "minimum viable product" to analyse the market and adapt the product.
-The principle is start small, rapid product launch and get customers.

In short, the "lean" is a philosophy and "agile" is a management methodology they can be supplemented appropriately, so that appears the model "leagile"[7], that integrates both concepts, later in 2003 Stratton [8] proposes an improvement and creates the "mobility" concept which aims to properly plan small inventory levels throughout the supply chain with limited levels of production and distribution so that they are not a

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constraint for get a quick supply chain and agile with zero products expired or obsolete.

Although they represent great strides in managing the supply chain, however, it is born in 2004 Management Model Triple A [9] in the Harvard Business magazine, proposed by Hau L. Lee, who raises with the concept of "Agility", two new concepts: "adaptability" and "Alignment", where adaptability is related to the design of a supply chain, and the "Alignment" raises the integration with suppliers and customers through the use of technology are needed, in short the "mobility" would be charged in a short time to respond to changes in demand, "Adaptability" makes the relevant design and planning of the supply chain in accordance with market changes and the "Alignment" manages the relationship with suppliers and customers in order to improve the efficiency of the supply chain.

In the following graph is outlined the main edges to be considered in the implementation of a management model "Triple A", even though they are raised as independent principles in reality there is a common area between them as seen in the figure below.

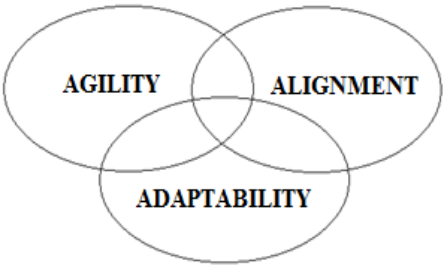

Figure 1. Management model "Triple A" proposed by HAU L. LEE.

3 Intelligent systems and its application to implement the model “Triple A”

Intelligent systems for the implementation of the management model "Triple A" in the supply chain to be used are the RNA's and Genetic Algorithms, where the RNA's are used as a predictor of demand in order to use the prediction to respond in short time for potential changes in demand ("Agility") and make appropriate modifications and adjustments in the supply chain in accordance with variations of the market ("Adaptability"); the genetic algorithm is used to route optimization in order to "align" the milk collection processes in order to get the optimal route for collection of the product from suppliers.

Although intelligent systems are powerful management tools, however, the real success in logistics management is in the skill and knowledge of the processes of all staff involved in the flow of the supply chain, combined with an adequate level of empowerment in making critical decisions in order to achieve economic, financial and business objectives.

3.1 Neural network

Among the various applications of neural networks that serve as support in logistics operations, has been very successful prediction of future demand based on historical behavior, this document uses an Artificial Neural Networks in forecast the milk sales.

A neural network is an infinite connection from neurons, in Figure 2 the relationship between a biological neuron and artificial neuron are shown.

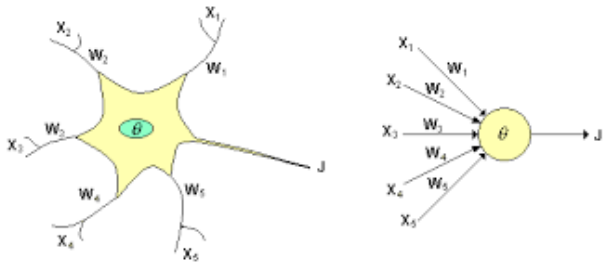

Figure 2. Biological Neuron and its mathematical representation [10].

Inside the human brain there are about a hundred billion (10^{11}) of neurons [11], in the case of artificial neural networks, are handled in the order of hundreds[a] and thousands, grouped by layers with an input layer, an output layer and one or more hidden layers, the connections are made between neurons of adjacent layers, in Figure 3, an example of a ANN shown as artificial neurons are connected.

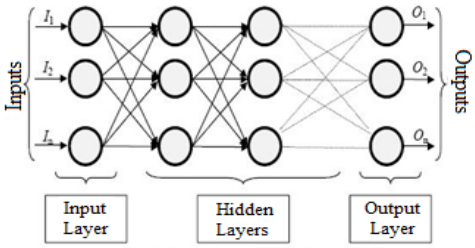

Figure 3. Artificial Neural Network (ANN) Example.

In the case of the implementation of the Model "Triple A" was done a prediction of liters of milk sold, with real information of collection center for a period of four years, from January 2008 until December 2012. Figure 4 shown movement of liters diaries in the collection center.

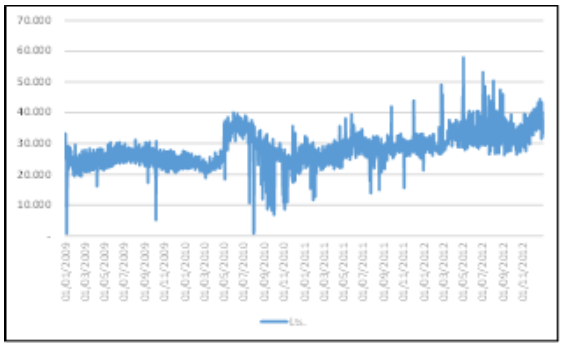

Figure 4. Diary movement of milk liters.

[a] IBM in 2015 conducted a simulation with Compass which was 65 billion neurons, but they are isolated cases and not used commonly in applications with Artificial Neural Networks, for more detail can review the document in http://www.modha.org/blog/SC12/SC2012_Compass.pdf

In order to improve the prediction of liters of milk, it must perform a pre-processing to remove noise, for which was used the moving average of thirty days before, with the formula.

$$\overline{X_k} = \frac{1}{30}\sum_{j=1}^{30} X_{k-j+1} \quad (1)$$

The following graph shows a comparison between the original values in blue and the average value of liters in red where you can see the elimination of fluctuations by the use of moving average.

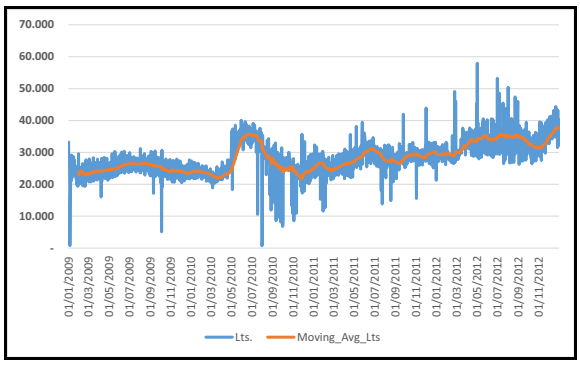

Figure 5. Daily liters and Moving Average of liters.

For the collection center may have an "agile" response, the time prediction required is a month as output, for this reason was used ninety-four inputs that are described in the Table 1.

According to what indicated in the previous paragraph, outputs would be the prediction of thirty days from the day zero to twenty-nine.

For training, 1371 pairs of input-output samples were used, of which 90% were used in the training and 10% for validation.

Table 1. Inputs for the Artificial Neural Network.

Inputs	Description
Year	year of the zero day
Month	Number of month of the zero day (1-January, 2-February …)
Num_week	Week number of the zero day
Weekday	Week day of the zero day (1 is Monday,. 7 is Sunday)
Lt_i	Liters of milk in the i-th day prior to the day zero, where i varies from one to ninety (three months).

3.2 A Genetic algorithms for optimizing routes

Genetic algorithms [12] perform the following steps:

1. Encode information in genes and chromosomes.
2. Define the adaptation function
3. Generate a base population
4. Evaluation and Selection
5. Reproduction
6. Mutation
7. Termination condition

In the seven steps, the genetic algorithm performs an iterative process until meet the termination condition in order to get the best possible solution for complex systems and nonlinear.

There are several models for the detection of optimal routes such as the proposed by Eslava and Quiroz [13]. In the case of route optimization analysis, the coding it is performed according to the distances matrix between collection points. For modelling were taken five points, which generated the matrix shown in Table 2.

Table 2. Distances in kilometers between the collection center (Point A) and collection points.

Km.	A	B	C	D	E
A		9.4	15.2	10.4	14.3
B	9.4		20	11.4	7.2
C	15.2	20		7.8	10.7
D	10.4	11.4	7.8		6.5
E	14.3	7.2	10.7	6.5	

Distances by road were taken from the site: http://maps.google.com as can be seen in the Figure 6 below.

According the trajectory which cover all points in Table 2, the information is encoded such as shown in Table 3, in order to separate it in genes and chromosomes, each section between two points was represented by one bit where if the section is used in the trajectory is "one" and if it not be used is "zero".

Figure 6. Measured distance between two points by road in Maps.Google.com.

Table 3. Coding the trajectory of collection center

AB	BC	CD	DE	EA	AC	BD	AD	BE	CE
B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

Then it is defined the adaptation function to minimize by:

$$f(W) = g(W) - 0.1 \cdot h(w) \quad (2)$$

where:

$$g(W) = 1 - \frac{|R - \sum_{i=1}^{L} B_i|}{R} \quad (3)$$

$$h(W) = \frac{\sum_{i=1}^{L} B_i \cdot D_i}{\sum_{i=1}^{L} D_i} \quad (4)$$

R: is the number of waypoints
L: Number of bits used (L=10)
*B*_i: i-th bit of the byte "W"
*D*_i: Cost/distance of ith section, see table 2

With encoding and adaptive function, an script was executed in Matlab with Genetic Algorithms for the optimal route, a hundred runs were performed with the case information on the best analysis results are given in Table 4, where the journey begin and ends at E, following the sequence A-C-B-D-A-E. For more collection points only must recalculate the distances matrix and encoding of vector binary and thus it can be run in Matlab. To get the optimal route, other possible encodings are proposed by Bildhardt [14], but in the case of analysis the best result is raised in this document.

Table 4. Results of calculated optimal route by Genetic Algorithms.

AB	BC	CD	DE	EA	AC	BD	AD	BE	CE
0	1	0	0	1	1	1	1	0	0

4 Key indicators of management "Triple A"

Although the intelligent systems can serve for support to improving the supply chain management, however for the success of Management Model "Triple A" is necessary to monitor, measure and interpret information through indicators to manage the entire supply chain [15], in Table 5 the processes most common of average company are shown, for which are defined the subprocesses which exist in the collection center.

Table 5. Processes of Supply Chain.

Processes	Sub processes
Supplying	• Collection - Shopping • Storage • Commercial
Production	Does not apply to the collection center.
Dispatch	• Distribution to milk processors
Support Processes	• Preventive Maintenance • Human Talent Management • Accounting • Strategic management

Then, an Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) were done in order to make a SWOT analysis where the strength was used to overcome weaknesses and the opportunities to overcome threats, after that, the sub processes of the supply chain the indicators from Tables 6, 7 and 8 were proposed, which will be used to monitor and manage the supply chain in order to obtain "mobility", "Alignment" and "Adaptability" that is a management model "Triple A".

Table 6. Indicators for sub processes of Suppliers.

Sub-processes	Indicator
Collection-Shopping	• % Savings for optimal route selection by Genetic Algorithms • Earnings per collection route • Minimum number of liters collected per route • % non-compliance Delivery by supplier • Delay of deliver by supplier • Milk quality by supplier • Strategic alliances
Storage	• Using Warehouse • % Using cooling equipment
Commercial	• Level of deliveries on time • Increase in new customers

Table 7. Indicators for sub processes of Dispatch.

Sub processes	Indicators
Distribution to milk processors	• Earnings per trip • Accuracy of the Forecast of the Artificial

Table 8. Indicators for sub processes of Support.

Sub processes	Indicators
Preventive Maintenance	• Level of implementation of the maintenance plan • Stops by mechanical failure
Human Talent Management	• Level of knowledge of the processes of the supply chain • Penetration of the use of intelligent systems.
Accounting	• Increase Sales • Costs by downtime of machinery • Costs for non-compliant milk. • % of logistic costs • Percentage of saving in provisioning
Strategic management	• Degree of implementation of the strategy.

In the tables above, the core indicators for the implementation of the Management Model "Triple A" for the Collection Center are proposed. However, the proposed intelligent systems such as an Artificial Neural Network and Genetic Algorithms only would impact on two indicators, that is, although they are excellent systems the real impact depends on many other factors including both staff and the management of all the processes involved in the chain supply.

5 Conclusions

The supply chain covers the entire management chain from suppliers to the end customer. So an efficient supply chain management is vital importance for the success of a company, since it allows an overview of end to end across the enterprise, in the case of the Collection Center the chain starts from the milk collection to delivery to large processors so the implementation of Model

management "Triple A" should cover the whole entire chain.

In the management model of triple A, the "agility" is responsible for respond in short time to the changes in demand. Instead the "alignment" manages the relationship between suppliers and end customers for this reason the most indicators are proposed in order to align the processes of supply chain. Finally the "adaptability" has adjustments in the design of the supply chain as to adapt to changes in the market. Indicators, Artificial Neural Network and Genetic Algorithms were designed to implement the Model Management "Triple A", however, they are useless tools if the company fails to implement in processes, or in to promote its application, nor has clearly defined its goals short and long term.

All strategic planning in their fundamentals must have an analysis of the supply chain in order to identify and define the competitive advantages and disadvantages of the chain to define the strategies appropriate for sustainable success of the business.

The success of intelligent systems is based on it can be implement in these systems, the criteria of all knowledge and experience of experts for optimal solution to solve problems in a company.

In summary, the decision-making in the supply chain management is a key factor in the success of businesses, incorrect decisions can generate losses that could lead to bankruptcy, the question arises: is there any way can provide support in logistics decisions and minimize losses ?, the proposal herein is management model "Triple A" with the aid of the use of intelligent systems such as tools to support decision-making, that enable the company to "Agile", "Align" and "Adapt" its supply chain to market needs, the company and customers and get increase their economic returns, however they are not enough at all, the contribution of strategic planning accompanied by the training of all personnel involved in the supply chain is always necessary.

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