System Dynamics Simulation to Test Operational Policies in the Milk-Cheese Supply Chain Case study: Piar Municipality, Bolivar State, Venezuela.

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Abstract
With the purpose of detecting the impact that variations of demand cause in the milk-cheese supply chain, and determining how the operational policies of capacity, inventories or labor force can mitigate this impact, a system dynamics simulation model has been designed based on a survey conducted on a sample of cheese manufacturers and their links with milk farms, transportation companies and cheese distributors.

This supply chain will be consolidated when a milk center that will collect the raw milk is completed. From this center, and after adequate treatment, milk will be distributed to the different cheese manufacturers in the supply chain.

Managing adequately the milk-cheese supply chain represents an important challenge due to the short life of these products. Although this study was done in a region in Latin America, its results can be applicable to food supply chains by introducing some modifications.

The milk-cheese supply chain in this case study contemplates three milk producers, one milk center, five cheese producers and several distributing agents. These companies operate individually under normal conditions, but they have understood that their integration in a supply chain improves the competitiveness of all its members. That is to say, the sum is greater than the parts. For its initial design a simulation software model is used in which the resources of the supply chain are optimized. Later the product of this optimization facilitates some initial values to be used in the system dynamics model in which cause-effect or influence relationships have been previously established considering the most representative variables. Finally, changes in operational policies that can reduce the level of pending orders in the supply chain are tested using other simulation software.

The main contribution of this research is that it can serve as support or contribute to reduce the uncertainty in the decision making process of the supply chain management due to the speed with which individual or combined policies can be analyzed. In response to a variation of demand the most adequate policy may be selected and that can be done before the policy is implemented.

Key words: Supply Chain, Milk Producers, Cheese Industry, Dynamic Simulation, Operational Policies.

1. INTRODUCTION

The sector Milk-Cheese Soft is within Small and medium enterprises, one of the areas most emblematic of the Guayana region, for its traditional cheese Guayanes. Their manufacturers are seeking seek an appellation of origin to ensure quality and able to compete in other national and international markets.

This sector consists 35 cheese producers (18 in Piar), which together produce 7,500 kilograms of cheese per day. Production units are small, they buy raw materials for dairy farms or in the area and sell their products to distributors and customers in general.

2. METHODS

2.1 Methodology for the design of the Model Simulation Event Discreet.

1. Formulate the problem.
2. Conducting conceptual design.
3. Define functional specifications, detailing the system and its variables, entities and their attributes, available resources and the control logic.
4. To make the simulation model.
5. Verifying and validating the information from all involved.
6. Analyzing through statistical evaluation.
7. Recommend options.

2.2 Methodology for the design of the Model Simulation Continuous Process.

1. Identification of the problem is to identify problematic behaviors and important objectives of the process Delivery-Order-Processing (DOP) of the Supply Chain.
2. Identifying the factors Incidents: it is based on isolated situations which appear to interact to create the symptoms observed. They viewed interrelationships and described the factors influencing the response of the operation of the process of DOP Supply Chain.
3. Determine ties Feedback Information Cause-Effect: Consists of delineation of the feedback circuits linking cause decisions with the action, with the changes resulting from new information and decisions. At this stage should be sought in places policies, delays and information sources that determine the dynamic behavior of the system.
4. Policy: This phase seeks to establish those policies acceptable formal decision to describe explicitly, as the decisions emerge from the flow of information available.
5. Development of equations: The policies include decisions, information sources and interaction of the system components. This phase is to make more intelligible information gathering conducted, explanation in a less ambiguous and which may be experienced by indications from the reports. This will provide a model containing the mechanisms of interaction that has been shown between parts of the system described in the preceding paragraphs.
6. Generation of Performance System in Time: At this stage the model takes the place of a real system and simulate their operation in circumstances that are as real as was the original description of the system. This equates to try a new policy or organizational structure, but the cost is insignificant when compared with that of an experiment in real life. This phase requires a vast arithmetic work, which is performed by the computer based on the model. At this point, the machine takes the allegations mathematical model and automatically generates a time recording showing the implications of the description of the system when

it is combined with the entry conditions specified tabular data and prepares required and the graphic curves.
7. Comparison of Results with Real Performance: After the simulation, is the interpretation of the results of the same. Generally, when reviewing the experiment, new problems arise and unknowns. This allows us to visualize if the model is in accordance with the real system, if any of the previous phases were poorly developed, or if the model is closer to reality.
8. Revision of the Model: With the results obtained in the previous stage, there must be progressive revisions and adjustments to the model in order to refine its operations and ensure that their representation is the closest to the real system.
9. Improvement Model: When the results of the simulations represent adequately the characteristics of the model behavior important, step forward in the pursuit of refinement is rethinking the structure of the system and policies. At this point is where the dynamic model will allow experimenting with all the possible alternatives of operational policies. Experimentation will be the model, evaluate all possible interactions and the results in the simulation of the various alternatives. This will get a range of options for decision-making and its consequences.

3. RESULTS
3.1 Structure of Supply Chain Milk-Cheese Soft.

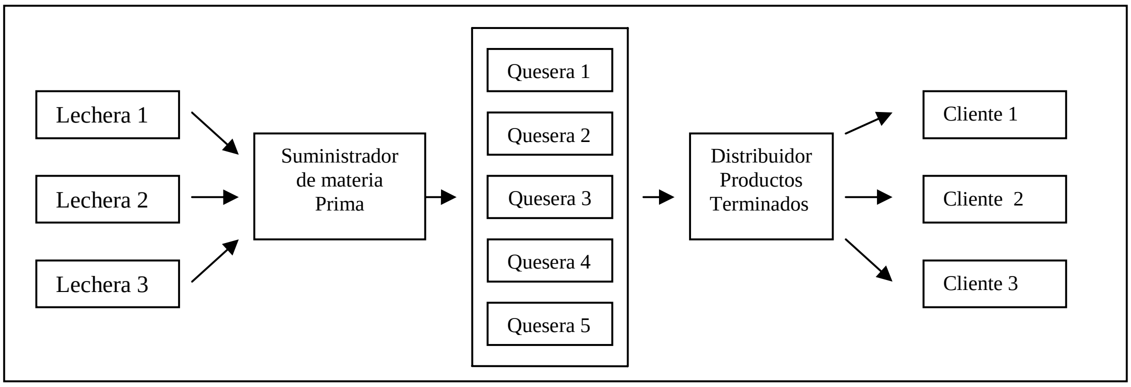


Figure: 1

The structure of the network shown in Figure 1, incorporates a Raw Material Supplier of that collects milk production of three farms. Five cheese producers or production lines and an independent distributor that delivers Products Completed three retail customers. This configuration (3/1/5/1/3) is the initial graphical reference model for designing discreet event simulation environment Arena 9.

3.2 Model Events Discreet to Optimize CS Milk-Cheese Soft.
Figure 2 shows, Supply Chain Milk-Cheese environment simulation Arena 9, which consists of the following elements:

Milk Producers 1, Raw Material Dispatch, Transportation, Delivery.
Milk Producers 2, Raw Material Dispatch, Transportation, Delivery.

Milk Producers 3, Raw Material Dispatch, Transportation, Delivery.
Raw Material Supplier of (RMP).
Cheese Producers, Transportation.
Distributor Products Terminator (DPT).
Distributor Products Terminator, Transport, Client 1
Distributor Products Terminator, Transport, Client 2
Distributor Products Terminator, Transport, Client 3

This model is used to optimize the resources used in the discharge of raw material in the supplier of raw materials, in the process of transformation of milk into cheese and the distribution of the finished products to customers. This provision minimizes the number of entities in the queue in Cheese producers thereby achieves a balanced life.

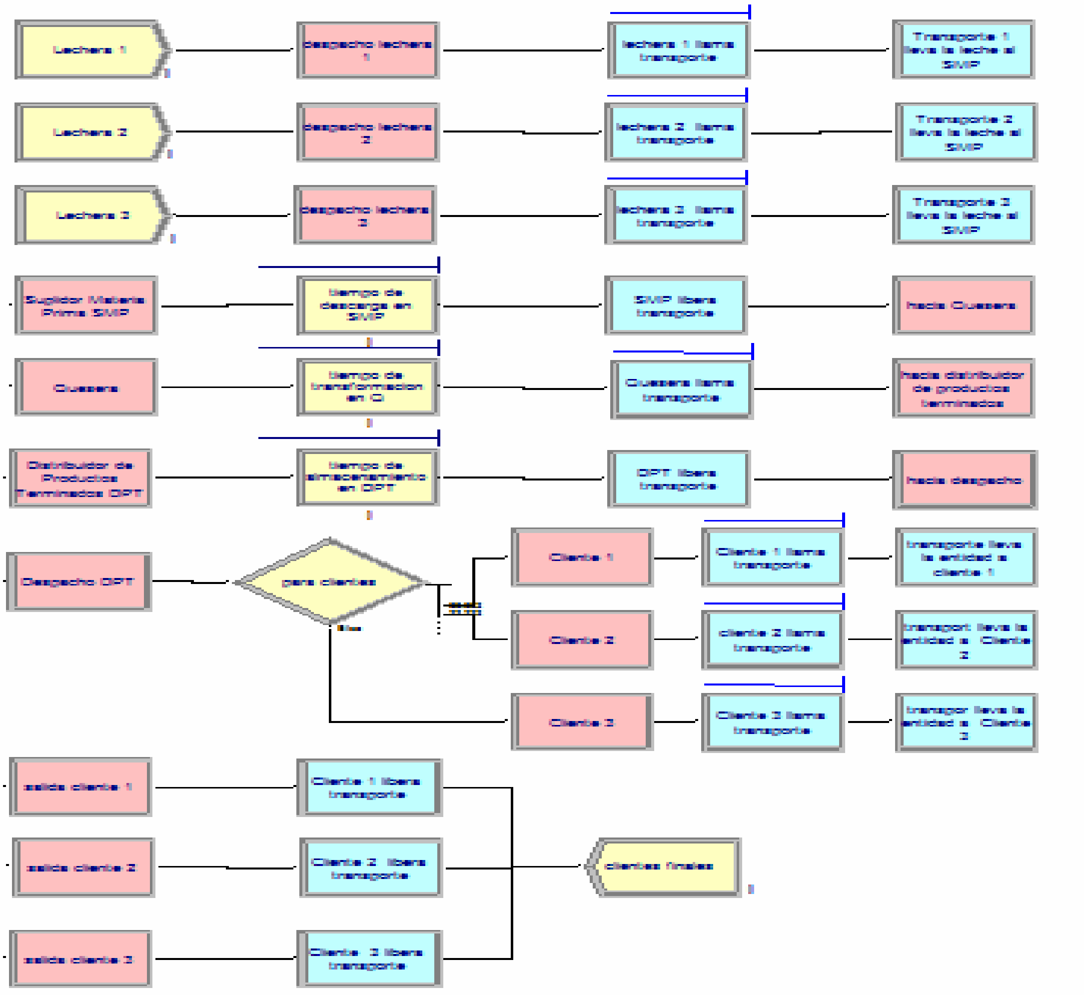


Figure: 2

3.3 Operational Policy.

In the previous section, it was noted as a result of the optimization of Chain number of resources required to minimize queue products in the process of transformation in the Cheese producers. To develop the conceptual model in causal relationships or influence makes use of information provided by the Cheese producers surveyed, which identified more operational policies used in the event of an increase or decrease in demand by customers.

3.4 Model Causal or Influences.

The model is presented in Figures 3, 4 and 5 due to the limited space. Figure 3 shows the causal relationships own supplier of raw material, which states the expected demand and its relationship to the desired order and inventory of raw materials desired. Figure 4 shows the Cheese producers and processing capacity and figure 5 the ability to dispatch.

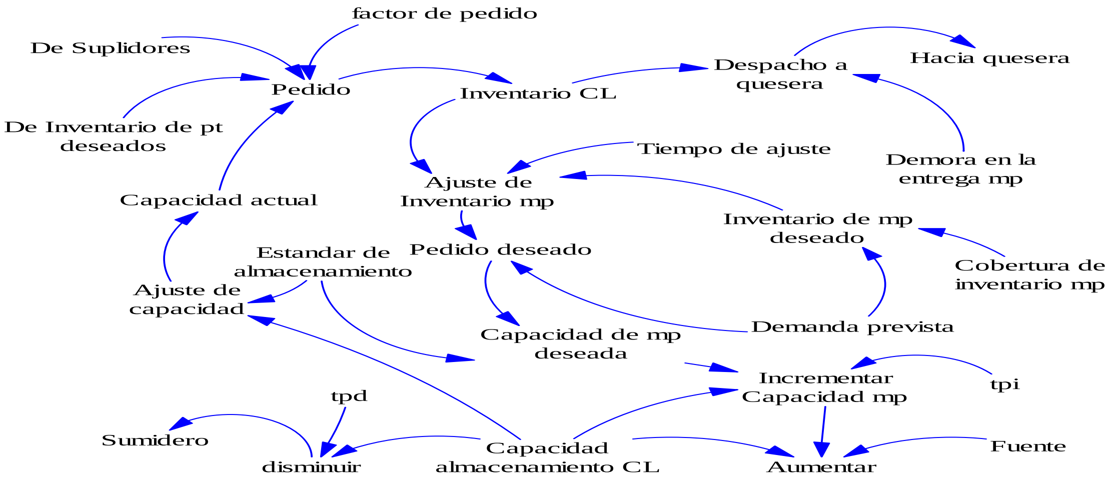


Figure: 3

As the supplier of raw material can be seen in Figure 3, the order desired, as adjusted for the difference between desired inventory of raw material and inventory of raw materials royal guides the calculation of the storage capacity of raw material that desired the divide between the storage standard specifies the need for storage capacity for this level of orders. This level of storage capacity resulting in the ability to be adjusted. In principle there is a fixed capacity, its change is not instantaneous result of the adjustment, there is a delay either to find more storage capacity or to decrease it. It is part of the operational policy that the manager of the chain must shoulder. The calculation initial fixed capacity less than required to store the desired order forced to ask what this capability allows fixed upper hand if it is requested the order desired. Products Cheese producers noted that the relationship with output shown in Figure 4, where the feedstock multiplied by the factor of materials results in the quantity produced. This figure also specifies the relationship between production cheese producers and storage distributor of finished products. It adds the impact of customers' orders in the workforce.

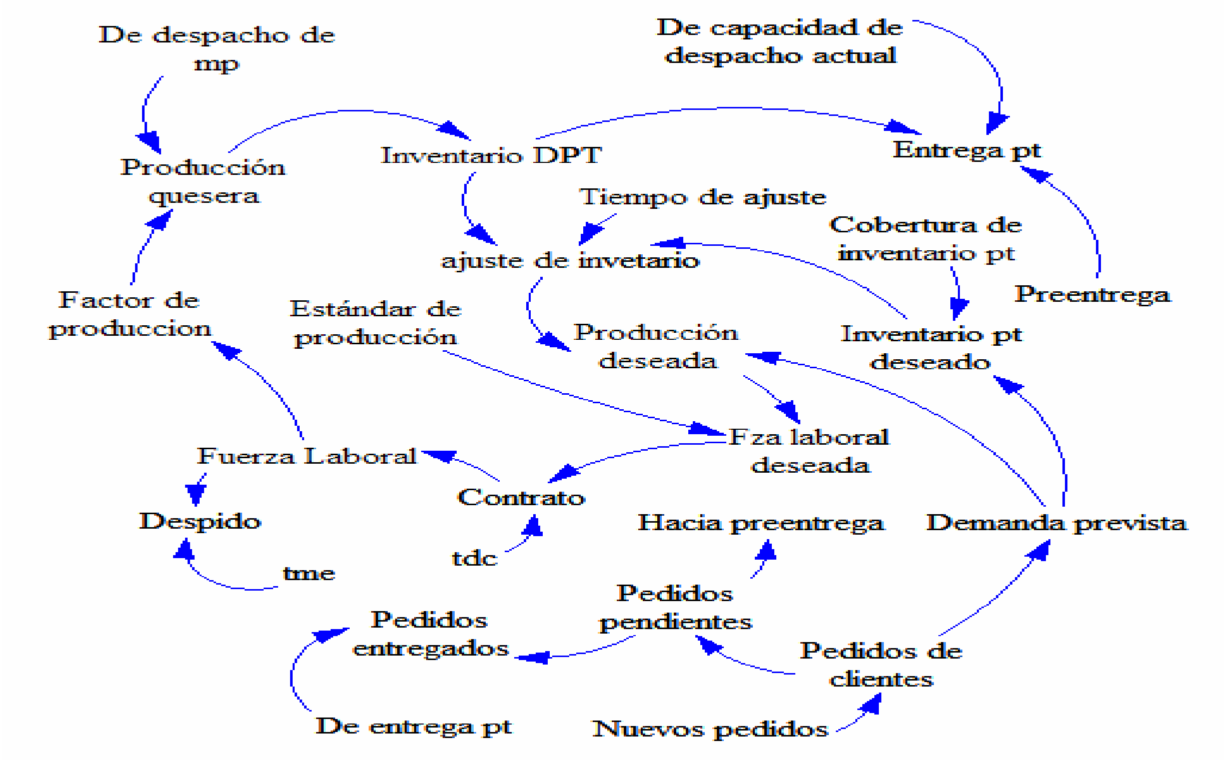


Figure: 4

The expected demand drives the desired production and inventory desired to be set against actual inventory in a given period of time adjustment. The desired yield more inventory adjusted determine manpower desired, which divided by the standard production indicates the amount of workforce to be contracted. Upon completing the manufacture products go to store finished products distributor (DPT) who delivers to the customer.

As was done in the SMP, it should be noted the ability to dispatch to verify the quantity to be dispatched. It introduces the term Pre-Delivery. If this Pre-Delivery is less than the actual inventory is delivered the amount requested by the client, if it is delivered only increased in the inventory. Then, if it exists in the inventory capacity is sufficient clearance is given the order but only if insufficient delivery capacity which allows clearance.

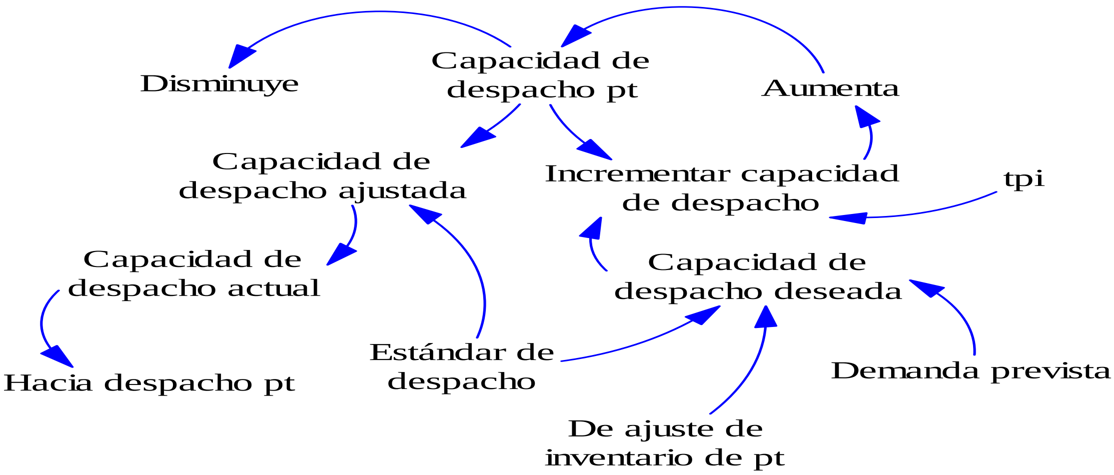


Figure: 5

Figure 5, said the relationships inherent in the level of ability of DPT, where the expected demand relates to the capacity desired clearance, which divided between the standard determines the capacity for that level of orders. Moreover, the standard multiplied by the level of clearance capacity in the current DPT determines the adjustment capacity of Chambers and defines the capacity of current office. In principle there is a capacity to release fixes its change is not instantaneous result of the adjustment, there is a delay either to seek more capacity for office or to decrease it. The calculation initial fixed capacity less than what is necessary to deliver the desired order forced to ask what this capability allows fixed upper hand if it is requested the order desired. In other words, the same restrictions presented in the RMP.
The causal relationships between or influence of Raw Material Supplier, Cheese producers and Distributor Products Terminator, shown in the last three figures are expressed in the computer model that provides a basis to test the operational policies.

4. DISCUSSION OF RESULTS.
The result of three Tests in the Supply Chain Milk-Cheese Soft are shown here, where the Test 1 which serves as a basis remains constant level of orders over the span of simulation, and sets the values the test protocol which provides: Parameters of Decision System volumes, flow rates and Operational Policy. With this first run is set the first reference behavior. In Trial 2, there is an increase in demand following a known function and adjusting operational policies and the Test 3, is tested with a decrease in demand for expedited manner.

Test 1: Order Constant along the Simulation:
In this trial simulation, the effects were tested in the chain where customers' orders are constant throughout the simulation. The results of 30 iterations performed in the simulator, are shown in Figures 6 and 7. The external variable that remains unchanged throughout the simulation period is the request of customers at the rate of 100 units per day observed in Figure 6, which orders delivered is equal to the rate in day 7, and then kept below the rate

request by about eleven units which means a backlog of outstanding orders. The production rate drops from 400 units per day to match the rate of customer asked about the day 11 with moderate fluctuations and the rate request of raw material, which starts with 200 units on day 1, climbs up 281 units on 11 and concludes around 250 units, always above the rest of the fees. This behavior toward equalization of the rate of orders without very pronounced oscillations is typical system stable, but it can accumulate levels of backlog that you do lose customers in the medium term, as shown in Figure 7. The level of backlog is located at the end of the simulation at 344 units and the level of inventory of raw material remains above the level of inventory of finished products in 90 units, and the inventory finished product desired is located at 200 units.

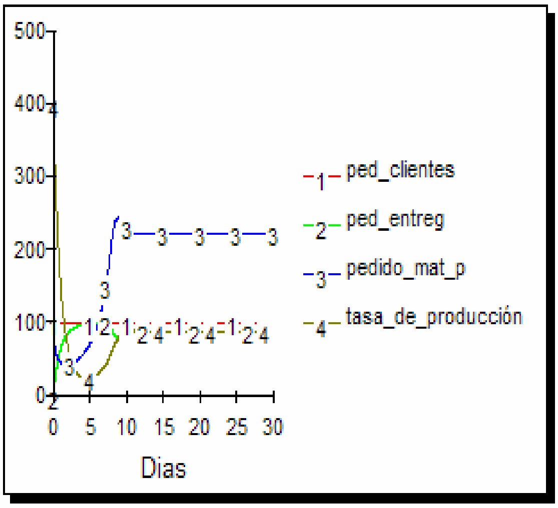


Figure 6: Fees

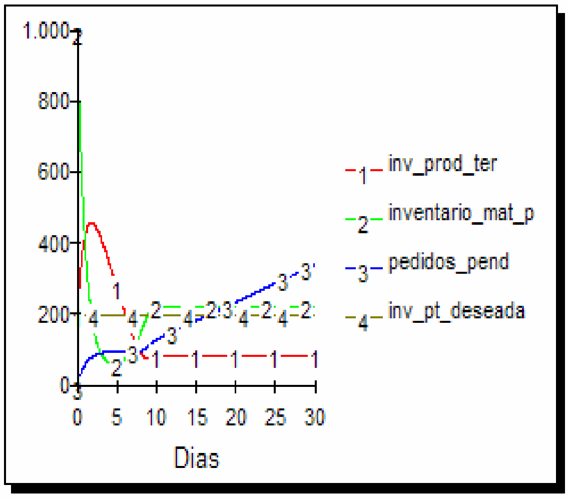


Figure 7: Levels.

It is noted that with a rate of customer orders units per day, the chain does not satisfactorily delivery from the day 8, since there is no inventory of finished product enough. The level of workforce, contained 9, which began with 15 people as an initial value, rises to 24 at the end of the simulation, the amount necessary to increase the level of delivery, but still inadequate after the day 8. The storage capacity and clearance rise moderately. Aspect noted that the need for adjustment limited capacity for this level of orders.

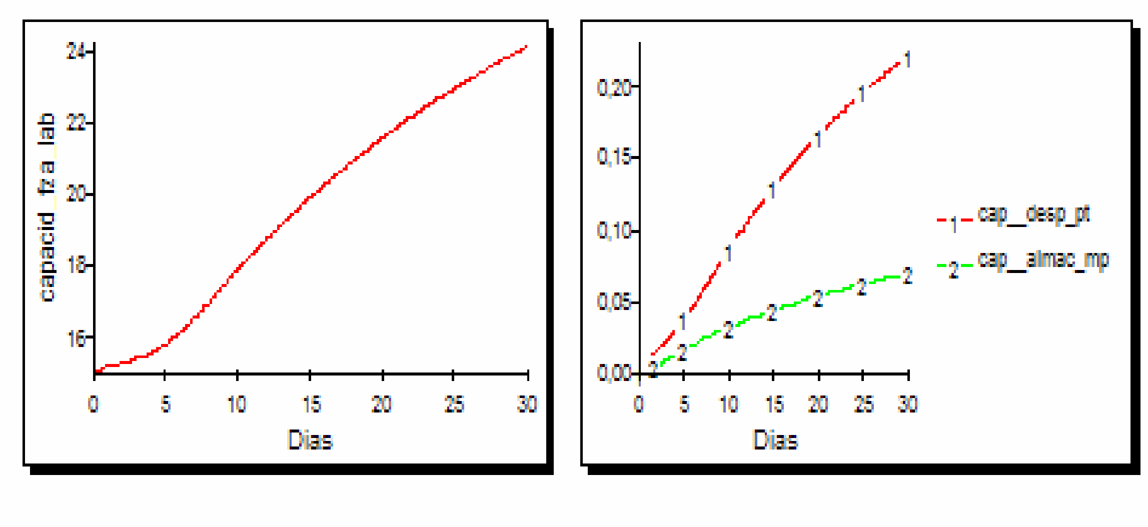


Figure 9: Levels Fza labor and Dispatch and Storage Capacity.

The Test number 1 shows that there is no excess capacity to a level of orders for 100 units, but noted the need to hire more person to try to fulfill customers' orders, considering that after the day 8 Chain enters breach. The inventory policy regarding coverage to forecast inventory as security can be adjusted from 1 to two days, in order to seek to reduce the back log in part.

Test 2: Order Growth:
In this essay, orders are increasing in the form of the logistic function from 100 units at day 0, to 600 units per day on day 15, a run of 60 days. Fits factor asked the daily demand and the coverage factor of inventory of finished goods desired maintains two days. The capabilities in shipping and raw materials were reduced to 200 and 1000 units per day, respectively. This test is intended to observe the behavior of the network to an increase in demand of 500% in 15 days. The rate of customer orders is increased from 100 to 600 units per day asked, in the space of two weeks, following a record rate logistics remains constant until the end of the simulation, see Figure 10. Under this level of orders increased generating a pending 18,000 thousand units at the end of period sham, see Figure 11. In other words, the network goes into default since the day 15 or so. The production rate fluctuates and is matched with the rate orders delivered from the day 30. And both rates remain below the line of customer orders that remains constant at 600 units. The request for raw material increases in an accelerated manner and in less than ten days rises to 1000 units and concludes around the 500 units. The level of raw material is maintained until 17 above the level of outstanding orders, then the effect of the logistics function, the latter begins to rise rapidly to conclude 18000 thousand units, while the inventory of finished goods concludes around of the 2800 units, see Figure 11. It is noted that this policy can not be met on time.

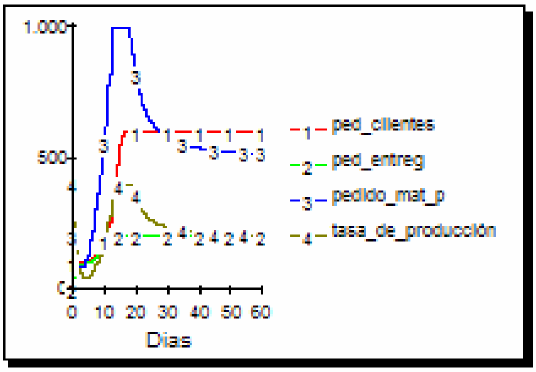


Figure 10: Fees

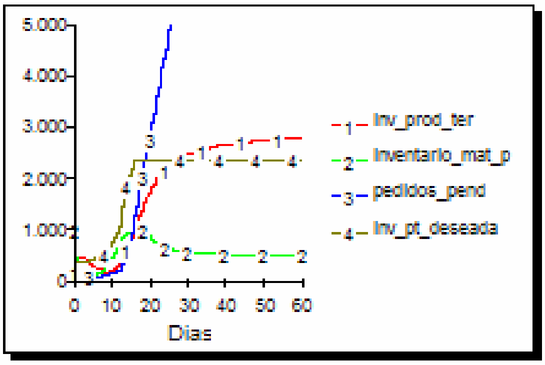


Figure 11: Levels

Orders from customers are not delivered successfully hence the daily accumulation of earrings. The ability of workforce, as shown in Step 12, which began with 15 concludes with 166 person at the end of the simulation, and the storage capacity and office are increased from baseline which implies the need for adjustment in these variables.

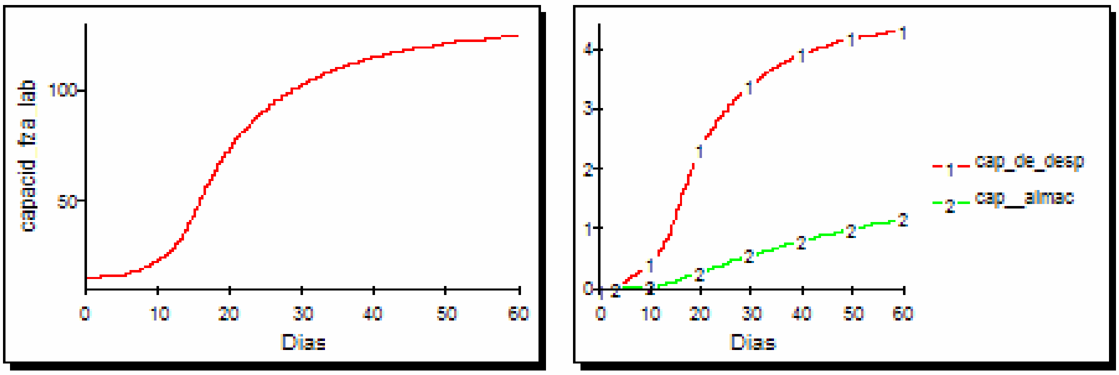
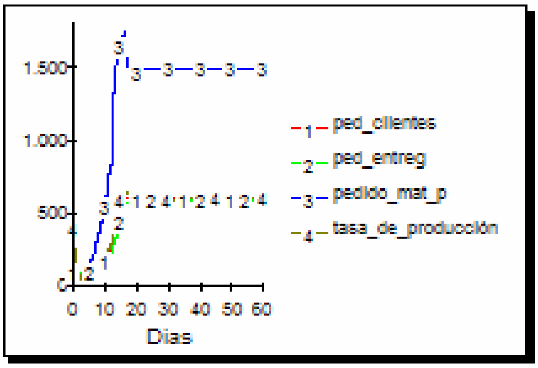


Figure 2: Levels Fza labor and Capacity Storage and Dispatch.

The policies of clearance variable capacity and coverage of two days of finished products are not sufficient to reduce the backlog below the inventories of finished products. Over the period simulation 60 days, the level of outstanding orders was higher than the inventory of finished products from the day 17 and with greater intensity toward the end of the simulation. In other words, coverage inventory security two days in finished products, and the decrease in delay in increasing the capacity of office does not make a Chain Rapid Delivery Order. But a change in the ability of combined office and increasing an adjustment in the standard release, which originates the level of orders falls below the line of inventory of finished products, see Figure 14.



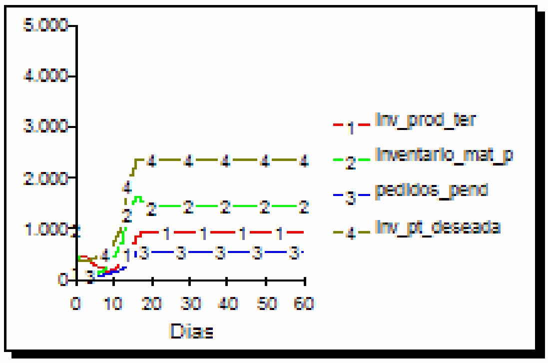


Figure 13: Fees

Figure 14: Level.

It also can be seen in Figure 15, that the ability to release increases, as well as the storage capacity of raw materials, in order to comply with orders.

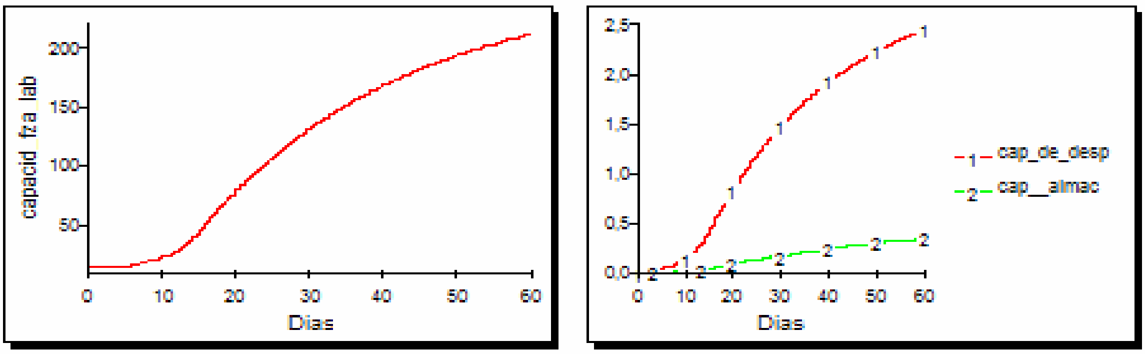


Figure 15: Levels Fza Labor and Delivery and Storage Capacity.

Test 3. Order Declination Fast Track:

In this test simulation check the effects on the Chain of Low accelerated request of clients, from 100 units to 0, in 15 days, on a run of 30 days. Fits factor asked the weekly demand and the coverage factor of inventory of finished goods desired maintains two days. In this case the external variable: orders by customers changing from 100 to 0 units requested in day 15 and so remains constant until the end of the simulation. It is noted in Figure 16, that customers' orders and purchase orders have the same behavior, ie decline from 100 to 0 on day 15. The production rate begins to rise because of the initial raw material and the initial orders but then drops to zero. The request for raw materials is the latest in decline, see Figure 16. The level of inventory of the art low since its initial value of 600 units, the level of outstanding orders drops to zero and the desired inventory of finished products also decreases.

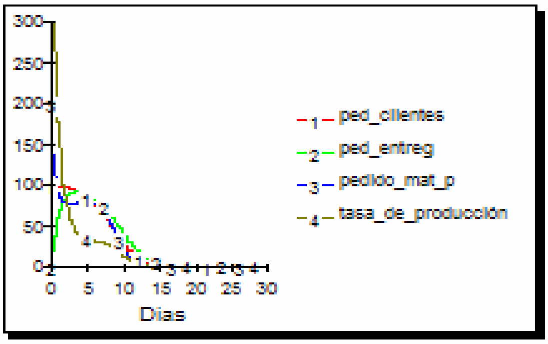


Figure 16: Fees

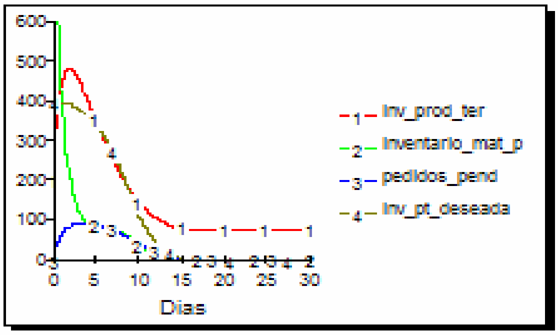


Figure 17: Levels

The level of inventory of finished goods, rises because no orders or are in decline and then stabilizing at 100 units until the end of the simulation, in principle rises in the level of raw material accumulated figure 17. The ability of workforce, as shown in Step 18, which began with 15 people decreases to 0 until the end of the simulation. Variations of additional storage capacity to add to the capabilities Fixed decline. Aspect pointing to the need not to make adjustments either in storage or in office.

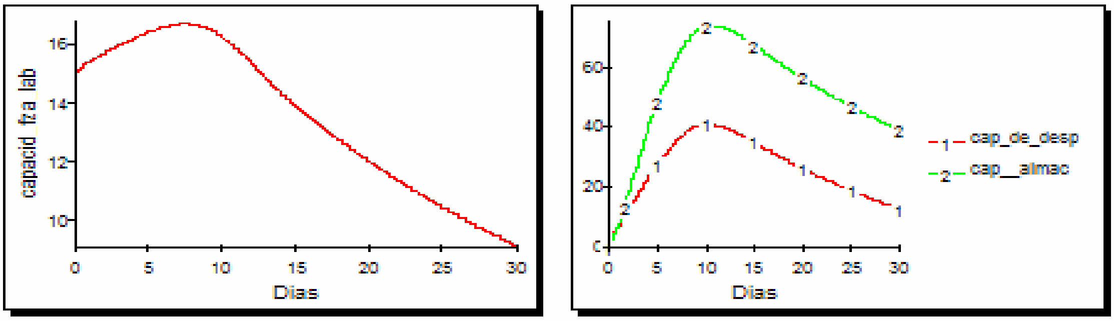


Figure 18: Levels Fza Labor and Capacity Storage and Dispatch.

Policies capacity fixed inventory of raw materials and dispatch are excessive demand for this behavior, over the period simulation 30 days, provided the level of finished goods was higher than the backlog. That is the coverage of inventory safety of two days for the inventory of finished products was not justified in ordering decline.

5. CONCLUSIONS

1. Optimizing the Supply Chain Milk-Cheese Soft, resulting in a chain balanced in the sense that there are no units in the queue. This balance is achieved after allocating appropriate resources to the supplier of raw materials, in Cheese producers and distributor of finished products. Otherwise, queues are generated in the chain and specifically in the Cheese producers.

2. The policies of variable capacitors to maintain inventory of raw materials and finished goods clearance, indicate that there is a moderate deficit of capacity to a level of orders of 100 units per day, and the need to hire more person to try to meet the orders from customers. However, after the day 8, this need becomes more evident since the Chain enters into default. On the other hand, and as a short-term measure, the policy of inventories on the insurance for forecasting inventory as security, can be adjusted from 1 to 2 days to partially reduce the backlog of customers.

3. For orders growing link asked demand, maintain clearance variable capacity and coverage of two days of finished products, are not enough to reduce the backlog below the inventories of finished products, throughout the period simulation of 60 days. The level of outstanding orders was higher than the inventory of finished products from the day 17 and with greater intensity toward the end of the simulation. That means coverage inventory security two days in finished products and decreasing the delay in the adjustment of the capacity of office, do a chain rapid delivery of orders. But an adjustment in the ability of combined office and keeps constant, adjusting the standard office and decreasing the time to increase capacity reduces the level of outstanding satisfactory levels.

4. Policies capacity fixed inventory of raw materials and dispatch are unnecessary to conduct accelerated decline in demand. In this case shows that whenever the level of finished goods was higher than the backlog, as it should be in order to decline. That is the coverage of inventory safety of two days for the inventory of finished products was not justified in ordering decline, and maintain the flow of orders because of inventory increases raw material that is not converted into finished products for the lack of orders.

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