Model to define the optimal production program in a food processor SME optimizing economic resources

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Abstract

Currently SMEs in the food industry in Mexico have areas of opportunity due to their accelerated growth. One of the areas of opportunity detected is their limited production planning. Being their main goal to meet the demands of customers, they do not have implemented a program or model for the production planning which leads to unforeseen expenses. Due to this, there is a need to design a model to program the production taking into account the restrictions that each company presents. Also, develop a series of steps so that any SME in the food industry can carry out this model. The company that will be taken as a reference to design the model is Valores Alimenticios S.A. of C.V. This company is dedicated to the manufacture of frozen sweet bread and has more than 100 Sku's. The company needs a production program that solves some of the problems it currently has. For the design of the methodology, mathematical models will be made using linear programming and simulations taking into account the demand, inventory and production of the company of reference. A simulation was made using ProModel of the inventory policy determined for a production line. Annual savings of $840,739.60 were defined due to a reduction in costs due to over inventory and shortages.

Keywords: model, planning, production, linear programming, simulation.

1. Introduction

The main function of virtually any organization (small, large, manufacturing, service, commercial or non-profit) is the generation, from certain processes, of some type of product. In order for these organizations to be effective and efficient in customer service, their managers must understand and apply some fundamental planning principles for the generation of the product, and also to control the process that originates it (Chapman, 2006).

Production scheduling, or scheduling, is an operational response to optimize the production of a good or service. There are several production programming techniques (Herrera, 2011). Many researchers recognize that scheduling problems can be solved optimally using mathematical programming techniques (Jain & Meeran, 1998). Nowadays, operations research is a dominant and indispensable tool for making decisions (Taha, 2004); the importance of its application lies in its strength to model and solve complex and large-scale problems (Alvarado, 2011). The theory of restrictions (TOC) focuses on actively managing the constraints that impede the progress of the company towards its goal; earn money today and in the future (Krajewski et al., 2008).

In general, SMEs do not have the tools to plan their production correctly, they need a system that allows them to measure and control quality, there are constant differences in stocks and they usually do not have the capacity to fill large or special orders. There is a poor distribution of work, which becomes in a deficient level in productivity and high operating costs (SAP, 2012).

According to a study by Jurado et al. (1997) in which the main problems of SMEs are established, production is mentioned as one of them and indicates that the majority present a lack of techniques to plan production, of measurement and quality control, of systematization of production procedures, deficiencies in their purchasing systems, inability to fill large orders and poor distribution of work and facilities, leading to a poor level of productivity.

In another study by Beltrán, A. (2006) which lists the 20 main problems of SMEs, he mentions that one of them is the deficit in the distribution of the plant and low level of use of manufacturing programs in planning, production control and integral maintenance. The absence of process lifting for each of the products hinders the coherent development of the same and results in costs that exceed 20% of the total cost of a product. Corrective maintenance prevails over the preventive and, in many cases, represents the main element that interferes with offering an adequate response time to a client's request.

For the development of this project the company Valores Alimenticios S.A of C.V. will be taken as reference. The problems that the company presents by not having an efficient control and production scheduling system according to the annual management report for 2017 are the following:

- Ignorance of the amount of the ideal productive personnel to fulfill with the production program.
- Non-compliance with the sales plan due to poor production planning for 2017, especially during the high season months that go from September to March.
- Unawareness of the production metric of boxes per person and the real standards of the productive personnel.
- Reduction in the gross profit margin of the plant's products due to the low efficiency of the personnel due to the constant changes in production planning.
- Unbalanced inventories of raw material and finished product.
- Shortage of raw material which causes deficiencies in the supply chain.
- Payment of overtime due to non-compliance with the production plan.
- Low productivity of the operating personnel which affects them in their weekly bonuses.

Taking as reference the above, it is concluded that the main problem to be solved is the lack of an adequate production program to optimize the number of operative personnel and operating expenses in a food processor SME in the state of Nuevo Leon.

2. Methodology

The methodology that will be followed will be one of two approaches, previous and subsequent, also called ex ante and ex post. The previous approach will be useful for the data collection and the definition of the inventory policy while the subsequent focus will be used in the simulation. Once obtained the data we will make a comparison between both approaches to analyze the results. A similar methodology was used in the article "An empirical comparison of different reorder point methods" by Eric Porras and Rommert Dekker.

2.1 Data collection and organization

The first thing that must be done to start the construction of the model in the company is the collection of the data. For this, demand, production and inventories should be obtained and processed to allow an analysis of the general behavior of all product families. It is desirable to have historical data of at least one year to make a model that behaves as similar to reality. The main goal is to find a correspondence with the current reality; therefore the data should be stripped of all possible bias.

Once the data has been collected, we must create a database with them and begin to organize them so that the information will serve us in the subsequent analyzes. The most advisable manner is to order them from highest to lowest according to the unit that is determined.

2.2 Reduction of analysis batch by ABC and XYZ technique

By means of the ABC and XYZ classification, the products on which the greatest analysis and control efforts will be made will be determined.

According to Jung (2006) the characteristic that is used to classify the articles with the ABC analysis is the periodic rotation. It is determined as the product of: the cost of a unit and its consumption rate within a certain period; for this analysis is monthly. If the items are characterized by classes A, B and C, the Pareto ideal principle can be found which establishes that 20% of the products generate 80% of the total demand.

The XYZ analysis distinguishes between items according to their fluctuations in consumption. Classes are summarized as follows (Errasti et al., 2010; Wassermann, 2001):

- X: to a certain extent, consumption is constant.
- Y: stronger fluctuations in consumption, generally due to moderate or seasonal trends.
- Z: completely irregular consumption.

For the XYZ analysis, the characteristic of statistical measurement is the coefficient of variation (Hoppe, 2005; Schoensleben, 2007), which is the relationship between the standard deviation of the consumption of a certain period and the average consumption that can be obtained through the formula 2.2.1.

$$cv = \frac{\sigma}{\mu} \qquad (2.2.1)$$

Because it is a broad spectrum of applications, the ABC analysis is applied regularly as the primary analysis and supported by the XYZ analysis (Hoppe, 2005, Schoesleben, 2007, Reese and Geisel, 1997, Reiner and Trcka, 2004). Therefore, the classification matrix (AX, BX, CX, AY, BY, CY, AZ, BZ, and CZ) evolves. One of the advantages of these analyzes is the integration of elements with similar characteristics to process them with the same materials planning parameters.

2.3 Elaboration of historical demand curve

The demand time series for the products of group A must be built. Each value of the series will represent the cumulative demand observed during the referenced planning period, that is, if the company performs the monthly planning, demand data must be available for *n* monthly periods prior to the moment in which it is forecast. For this model we will work with the historical demand of 12 months.

2.4 Determination of seasonality, trend and normality

The science of administration provides a series of quantitative techniques for forecasting. All of them require the construction of an appropriate mathematical model and the use of data from the past. Historical data is essential in the development and testing of forecast models. In the stock problems it is interesting to forecast the average demand and its variation, in the short and medium term. The forecasts that will be obtained are the result of the extrapolation of the past behavior added to a variable of interest. Historical data, recorded in chronological order, collectively form a series of time. (Mascó and Torrent, 2000).

It is understood that a series of time is a set of numerical values obtained in equal periods in time. The factors that influence a series of time are:

- Trend: pattern of global or persistent long-term movement, up or down.
- Seasonality: fluctuation more or less regular, which occurs in each 12-month period of each year.
- Normality: in a general sense, normality refers to that or that which adjusts to average values

In the case of this model, the seasonality, trend and normality of each product A will be determined to decide which inventory policy is the most convenient and determine how demand for the different products behaves. Simple tools such as Excel or Minitab can be used to determine seasonality, trends and normality.

2.5 Determination of the EPQ inventory policy

Once the products to be analyzed have been determined, the following two issues to consider should be: the frequency with which the inventory is reviewed and the way in which the inventory policy is to be determined.

Regarding the question of how often the inventory is revised, Silver (1998) makes two classifications: periodic and continuous. The periodic review establishes two separate moments in which inventory is known. For continuous review the company at all times has knowledge of the inventory level. This is obtained through integrated systems. In the case of periodic review, a certain period of time may pass when we do not know or have knowledge of the inventory level and no action is taken. In contrast, in a continuous review the changes to modify the inventory are constant.

Once we have determined the inventory review period, we only need to determine the form that the inventory policy will take. Silver asks us two questions that we have to ask ourselves: When will a replenishment order be put in place? And how big should this order be? The most usual policies are presented in table 1.

Table 1. Inventory policies

Inventory policy	Description
(s, Q)	The review system is continuous and a fixed replenishment order (Q) is established when the inventory level falls to an established minimum (s).
(s, S)	The revision system is continuous but the replenishment order is not fixed, this to raise the inventory level to a certain position (S).
(R, S)	The revision system is periodic and the replenishment order is fixed to raise the level to a certain position (S).
(R, s, S)	It is a policy that combines the systems (s, S) and (R, S). Every so often (R) the inventory is reviewed. If it is below the position (s) an order is made to raise it to the level (S). If the inventory level is above the position (s) no action is taken.

2.6 Obtaining the necessary information to determine the inventory policy

Data should be collected about the productive capacity of production lines or equipment, available labor capacity, available storage capacity, production costs, storage costs, etc. In sum, information must be gathered about the particularities of the process and its operational limitations. These data will be necessary for the design of the parameters of the particular model. In table 2 we show all the necessary data as well as the formulas to obtain the data.

Table 2. Data required for the simulation of the model

Daily demand	Daily production rate	Production costs (fixes + variables)	Storage costs	Quantity to produce	Mean	Standard deviation	Fill rate	Safety stock
D	*P*	*A*	*H*	*Q*	*μ*	*σ*	*Z*	*SS*

$$Q = \sqrt{\frac{2*A*D}{h*1-\left(\frac{D}{P}\right)}} \qquad (2.7.1)$$

$$SS = ROP - D_l \qquad (2.7.2)$$

Where D_l is the demand while the production is at hold

$$Z = 1 - \frac{ESC}{Q} = \frac{(Q-ESC)}{Q} \qquad (2.7.3)$$

$$ESC = \int_{x=ROP}^{\infty}(x - ROP)f(x)dx \qquad (2.7.4)$$

$$ESC = -SS\left[1 - Fs\left(\frac{SS}{\sigma P}\right)\right] + \sigma P * fs\left(\frac{SS}{\sigma P}\right) \qquad (2.7.5)$$

Where Fs is the cumulative distribution function and fs is the density function of the standard normal distribution with mean 0 and standard deviation 1.

2.7 Calculation of the standard deviation and the average demand for each product A

We must determine the standard deviation and the average of the demand for each product A; these data will serve us further for the creation of the model and in the inventory policy following the formulas 2.7.2 and 2.7.3.

$$x = \frac{\sum_{i=1}^{N} xi}{n} \qquad (2.7.2)$$

$$S = \sqrt{\frac{\sum_{i=1}^{N}(Xi-X)^2}{n}} \qquad (2.7.3)$$

2.8 Number of replicas

To evaluate the model and have a high degree of reliability it is necessary to establish the number of ideal replicas to obtain the data that will help us to build the production program. The degree of reliability that was determined for the model is 95% and an error rate of 5%. The formula to establish the number of replicas (N) is the following (2.8.1) where e is the error and z is the reliability that in our case is 1.96.

$$N = \left(\frac{z*\sigma}{e}\right)^2 \qquad (2.8.1)$$

2.9 Determination of product or line to model

To carry out the model in an integral way, it is suggested to start with a product or a line depending on the nature of the processes and the company. In our case we will start with a line. Once the same has been determined, modeling will begin. In this project ProModel was used, it is a simulator with animation and optimization to make simulation models and optimize them. The company can opt for some other software or package; however, ProModel is recommended as it is easy to use and does not require much training by the user.

2.10 Analysis of the simulation of the model

What the model will obtain is the following information:

• When we must order (Q) according to an established demand that varies according to the standard deviation and the mean following a normal distribution. The model will generate this information automatically. Once the time to simulate has been established, in our case we will use 35 days, we will obtain the total days that we must produce for each product and on which days the line is stopped. Also the demand will absorb the inventory until reaching the reorder point and trigger the production order. In this way, we will not fall into shortages nor will we have over inventory. The model can keep running but it will behave in a very similar way, that's why we wanted to leave it in 35 days. In this period of time we can visualize the general behavior of the inventory policy.

In the case of each company in particular, this is the substantial information that the model gives us to start programming production optimally, we can also plan human resources and avoid excessive costs for inventory and constant changes in production.

Then we will apply the methodology in a real company located in Nuevo León and validate the results to analyze if the model in question is successful.

3. Case of study

3.1 Company description

The case study will be applied in the company Valores Alimenticios S.A. of C.V. This company is dedicated to the manufacture of frozen sweet bread for the Mexican national market and for export. The company does not have a structured and efficient production control system, which makes it difficult to optimize resources. The company has more than 100 Sku's and the production process is highly manual.

3.2 Productive process

This company has three types of products: frozen raw, frozen baked and baked ready to eat. The company works in two shifts from Monday to Friday. It has about 50 workers in both shifts. The productive processes are divided into production lines. The production lines are: “Pizza”, “Feite Día”, “Feite Noche”, “Galletería Día”, “Galletería Noche” and “Batidos”. The production program is carried out daily and sent to the production supervisors a day before. The warehouse area is responsible for supplying the raw material and collecting the finished product. The production is programmed following a make to stock policy according to a previously determined inventory level. An inventory of maximum 15 days is required for all products. Due to the variability of demand it is difficult to maintain this level of inventory for all products. What is desired at the end of this model is to improve this production program and reduce the constant changes that occur in it.

3.3 Costing system

The company manages a costing system per unit, which in this case are boxes. The costs are managed in direct costs and indirect costs. For the company, the direct costs represent raw material and labor. For indirect costs, the company manages services, depreciation and others. It also has the storage costs which are the costs per unit in a period of time, for this case a monthly period was determined.

3.4 Data collection and organization

The data obtained from demand, inventory and production for 2017 are shown in appendix 1. As previously mentioned, the company has more than 100 Sku's. Once the information was collected, it was organized in a database, ordering the demand from highest to lowest.

3.5 Reduction of analysis batch by ABC and XYZ technique

According to the demand, a classification of products was carried out using the ABC and XYZ techniques. Appendix 2 shows the classification obtained according to the formulas and procedure seen in the methodology. There were 26 products that are shown in table 3, of which 10 were classified as AY and the remaining 16 as AZ.

An interesting note to take into account is that in the case of this company no X-rated products were detected. This means that we do not have stable products over time; all products have some variability in their demand. In figure 1 we see the percentage of products according to the ABC classification, in figure 2 we do the same for the XYZ classification.

Table 3. AY-AZ products

Code	Description	Demand	Inventory	Production
P104245	BASE CRUDA CONGELADA P/PIZZA BAKERS CRUST 18PLG CJA 10PZ	33087	11493	34759
P128912	MASA (BASTON) P/BASE PIZZA CONG QUINTA LITA 18PLG CJA6/750GR	5424	3891	5323
P134659	PLANCHA DE ZANAHORIA GOURMET QUINTA LITA CJA 2PZ *	3512	1802	3724
P104130	BANDERILLAS CRUDA CONGELADA QUINTA LITA CJA 10.2KG *	3114	1243	3130
P103449	ARRACADA QUINTA LITA CAJA 25PIEZAS/85 GR *	3083	612	3048
P110290	CORNETAS HORNEADAS QUINTA LITA CJA 120PZ 7.8KG *	2769	459	2799
P137260	POLVORON SOL Y SOMBRA CRUDO CONG QUINTA LITA CJA 7.6KG *	2018	1108	2068
P140275	TUBO DE PIÑA CRUDO CONGELADO HEB CJA 10.8KG *	1922	979	1996
P132417	MINI OREJITAS BAKERS BITE CJA 30BLIST/36PZ *	1888	374	1705
P132709	MUFFIN TRIPLE CHOCOLATE QUINTA LITA CAJA32 PZAS/ 100GR	1782	525	1558
P132411	MINI OREJITA CRUDA CONGELADA QUINTA LITA CJA 4.5KG *	7405	3014	7777
P111245	CUERNITO CANELA CRUDO CONG. QUINTA LITA CAJA 6.8 KG *	4915	3285	5293
P137254	POLVORON SANDIA CRUDO CONGELADO QUINTA LITA CAJA 8.2 KG *	4504	3047	4427
P132718	MUFFIN VAINILLA QUINTA LITA CAJA 32PIEZAS/ 85GR	3760	752	3544
P132807	OREJA CRUDA CONGELADA QUINTA LITA CJA 8.9KG *	3704	542	3739
P135399	PIZZA BASE PCC 18PULG BAKERS CRUST CJA 12PZS 7.6KG	3642	1382	3976
P115203	EMPANADA DE QUESO CREMA CRUDA CONGELADA QUINTA LITA 6.8KG	2521	1247	2660
P110303	CONCHA VAINILLA VILLAPAN CAJA 18PIEZAS/120 GR *	2480	1864	2773
P110302	CONCHA CHOCOLATE VILLAPAN CAJA 18 PIEZAS/120 GR *	2310	1747	2515
P132437	MINI OREJITA PACK 6PZAS VILLAPAN CAJA 33PACK/ 80GR *	2238	1760	2882
P135401	PIZZA PRECOCIDA CONG QUINTA LITA 12PLG CJA 10PZ	2108	1120	2082
P115202	EMPANADA DE PIÑA CRUDA CONGELADA QUINTA LITA CJA 6.4KG *	2042	854	2149
P137250	POLVORON AGRIETADO AMARILLO CRUDO CNG QUINTA LITA CJA11.2KG*	2003	1270	2089
P137255	POLVORON SEVILLANO CRUDO CONGELADO QUINTA LITA CJA 7.5KG *	1831	1536	1441
P111247	CUERNITO DANES VILLAPAN CAJA 25PZAS/ 85GR *	1811	1419	2045
P116780	GALLETA DE NUEZ CRUDA CONGELADA QUINTA LITA CJA 8.4KG *	1719	656	1707

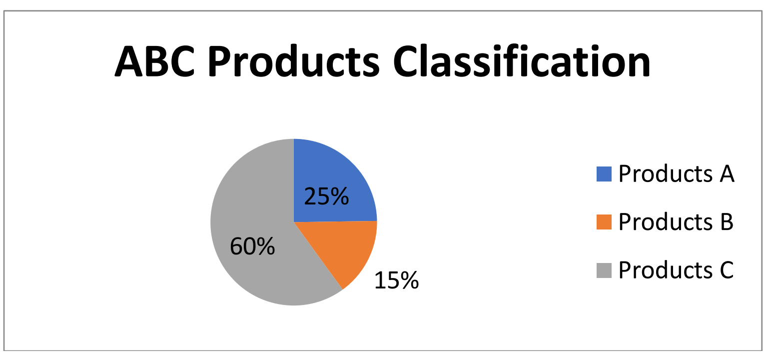


Figure 1. ABC Products Classification

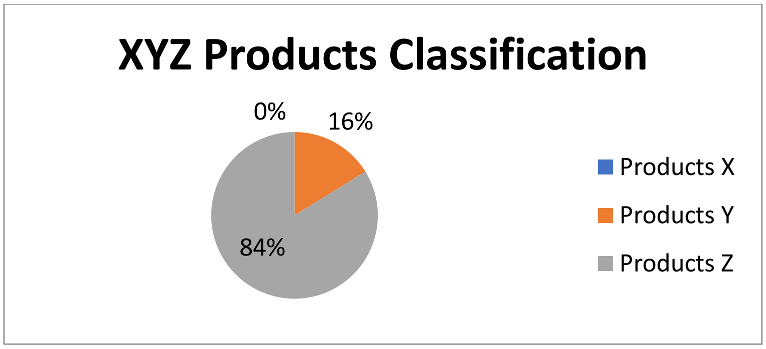


Figure 2. XYZ Products Classification

3.6 Elaboration of historical demand curve

Once the classification is obtained, we will turn our analysis into the A products, those that generate the highest sales for the company. The demand was compiled on a monthly basis so the next step is to develop demand curves to know and analyze the behavior of the different products.

3.7 Determination of seasonality, trend and normality

Once the demand curves have been plotted, it is necessary to determine if there is any tendency or seasonality of the different products. This so that when simulating or forecasting future demand these parameters are taken into account. Both can be obtained using Excel or Minitab in a very simple way. Figure 3 shows the demand for the product and we see a small positive trend. The product does not show seasonality. With the same information and software we check that all products behave in a normal way.

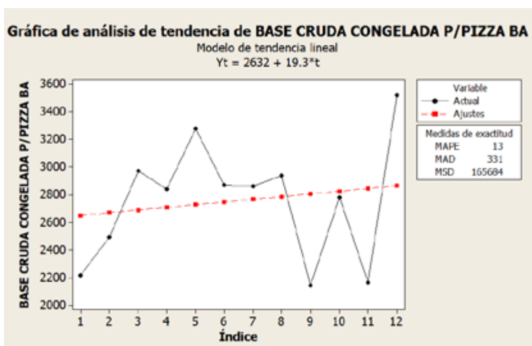


Figure 3. Trend and seasonality curve

3.8 Determination of the EPQ inventory policy

For the company that was taken as reference and as seen in the methodology, the inventory policy we will use will be that of *s, S*. This was determined according to the procedures performed by the company. At all times we have access to the inventory since each transaction is carried out by means of an integrated system. Also, we want to have a safety stock and have less than 15 days of inventory of each product if possible.

3.9 Obtaining the necessary information to determine the inventory policy

To begin with the planning of the inventory policy we have to gather the necessary information for the products A. As defined in the methodology, this includes costs, personnel per line, demand, production rate and other data. Once compiled for all products A, the construction of the inventory policy will proceed. These data must be as accurate as possible in order for the policy to achieve its objective. In table 4 we see the data collected for the product MINI OREJITA CRUDA CONGELADA QUINTA LITA CJA 4.5KG with code P132411.

Table 4. Data collected for the inventory policy

Code	P132411
Description	MINI OREJITA CRUDA CONGELADA QUINTA LITA CJA 4.5KG
Period	January
***D* = Daily demand**	30
***P* = Daily production rate**	110
***A* = Production costs**	$135.98
***h* = Storage costs**	$0.43
***Q* = Quantity to produce**	202
***SS* = Safety stock**	68
***F* = Fill rate**	99.43%

3.10 Calculation of the standard deviation and the average demand for each product A

In the same way as the previous step, the standard deviation and the mean are calculated following the formulas seen in the methodology. In table 5 we show these two data for code P132411.

Table 5. Standard deviation and mean

Standard deviation	20
Mean	30

3.11 Determination of product or line to model

As previously mentioned, there are six production lines. It was decided to start the model with the line "Feite Día" since it is a line with a high quantity of products that fall into category A and it is a challenge to model this line. Table 6 shows the AY-AZ products by production line. The simulation and the results will only be shown from this production line. Once we have evaluated these results, we will continue with the rest of the lines.

Table 6. Production lines

Code	Description	Line
P134659	PLANCHA DE ZANAHORIA GOURMET QUINTA LITA CJA 2PZ *	Batidos
P132709	MUFFIN TRIPLE CHOCOLATE QUINTA LITA CAJA32 PZAS/ 100GR	Batidos
P132718	MUFFIN VAINILLA QUINTA LITA CAJA 32PIEZAS/ 85GR	Batidos
P140275	TUBO DE PIÑA CRUDO CONGELADO HEB CJA 10.8KG *	Feite Día
P132417	MINI OREJITAS BAKERS BITE CJA 30BLIST/36PZ *	Feite Día
P132411	MINI OREJITA CRUDA CONGELADA QUINTA LITA CJA 4.5KG *	Feite Día
P132807	OREJA CRUDA CONGELADA QUINTA LITA CJA 8.9KG *	Feite Día
P115203	EMPANADA DE QUESO CREMA CRUDA CONGELADA QUINTA LITA 6.8KG	Feite Día
P132437	MINI OREJITA PACK 6PZAS VILLAPAN CAJA 33PACK/ 80GR *	Feite Día
P115202	EMPANADA DE PIÑA CRUDA CONGELADA QUINTA LITA CJA 6.4KG *	Feite Día
P104130	BANDERILLAS CRUDA CONGELADA QUINTA LITA CJA 10.2KG *	Feite Noche
P110290	CORNETAS HORNEADAS QUINTA LITA CJA 120PZ 7.8KG *	Feite Noche
P103449	ARRACADA QUINTA LITA CAJA 25PIEZAS/85 GR *	Galletería Día
P110303	CONCHA VAINILLA VILLAPAN CAJA 18PIEZAS/120 GR *	Galletería Día
P110302	CONCHA CHOCOLATE VILLAPAN CAJA 18 PIEZAS/120 GR *	Galletería Día
P111247	CUERNITO DANES VILLAPAN CAJA 25PZAS/ 85GR *	Galletería Día
P137260	POLVORON SOL Y SOMBRA CRUDO CONG QUINTA LITA CJA 7.6KG *	Galletería Noche
P111245	CUERNITO CANELA CRUDO CONG. QUINTA LITA CAJA 6.8 KG *	Galletería Noche
P137254	POLVORON SANDIA CRUDO CONGELADO QUINTA LITA CAJA 8.2 KG *	Galletería Noche
P137250	POLVORON AGRIETADO AMARILLO CRUDO CNG QUINTA LITA CJA11.2KG*	Galletería Noche
P137255	POLVORON SEVILLANO CRUDO CONGELADO QUINTA LITA CJA 7.5KG *	Galletería Noche
P116780	GALLETA DE NUEZ CRUDA CONGELADA QUINTA LITA CJA 8.4KG *	Galletería Noche
P104245	BASE CRUDA CONGELADA P/PIZZA BAKERS CRUST 18PLG CJA 10PZ	Pizza

P128912	MASA (BASTON) P/BASE PIZZA CONG QUINTA LITA 18PLG CJA6/750GR	Pizza
P135399	PIZZA BASE PCC 18PULG BAKERS CRUST CJA 12PZS 7.6KG	Pizza
P135401	PIZZA PRECOCIDA CONG QUINTA LITA 12PLG CJA 10PZ	Pizza

3.12 Analysis of the simulation of the model

With the information collected in points 10 and 11, we will start modeling the "Feite Día" line to obtain information on when to send production, how many days the line will be stopped and whether or not we will fall into shortages.

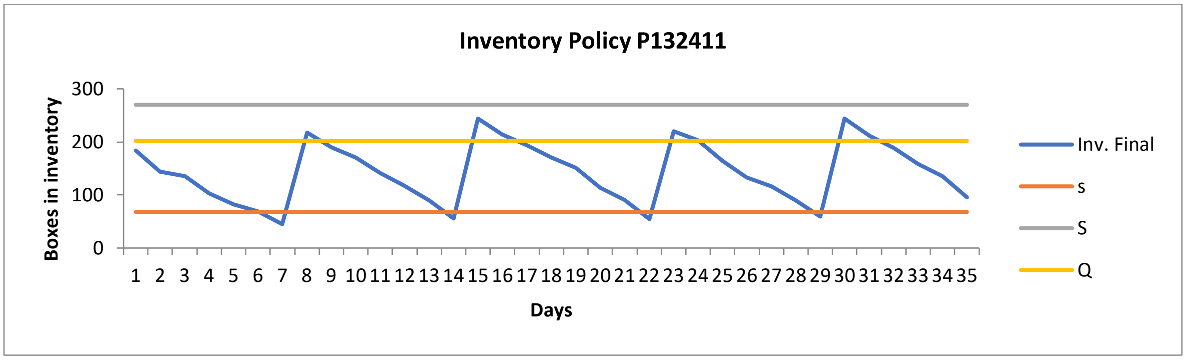
As we explained previously, we used the ProModel software and a data that we obtained that is calculated from the information collected previously is the minutes per box produced. This parameter will serve as the production rate. In table 7 we see how the product TUBO DE PIÑA CRUDO CONGELADO HEB CJA 10.8KG with code P140275 behaves for 35 days. We start with an initial inventory determined by the model since we cannot start from an inventory in zeros. As this product has a high production rate and low demand, it only asks us to order the day 21 of the 35 days. The rest of the days the inventory is consumed by an established demand. Number one in the order column triggers the Q to meet the demand.

Table 7. Inventory policy for P140275

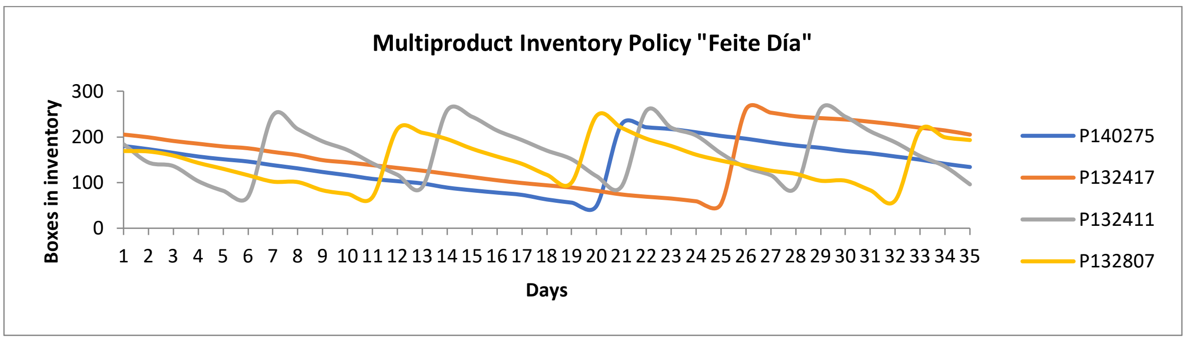
P140275				
Day	Initial Inventory	Demand	Final Inventory	Order
1	185	5	180	0
2	180	7	173	0
3	173	8	165	0
4	165	8	157	0
5	157	6	151	0
6	151	5	146	0
7	146	8	138	0
8	138	7	131	0
9	131	8	123	0
10	123	7	116	0
11	116	8	108	0
12	108	5	103	0
13	103	5	98	0
14	98	9	89	0
15	89	6	83	0
16	83	5	78	0
17	78	5	73	0
18	73	10	63	0
19	63	7	56	0
20	56	7	49	0
21	49	7	42	1
22	192	6	186	0
23	221	4	217	0

4. Results

By applying the model to the line for 35 days, we observe the following results. In graphic 1 we can see the inventory policy for the product with code P134211. In graphic 2 we observe the inventory policy for 4 different products.

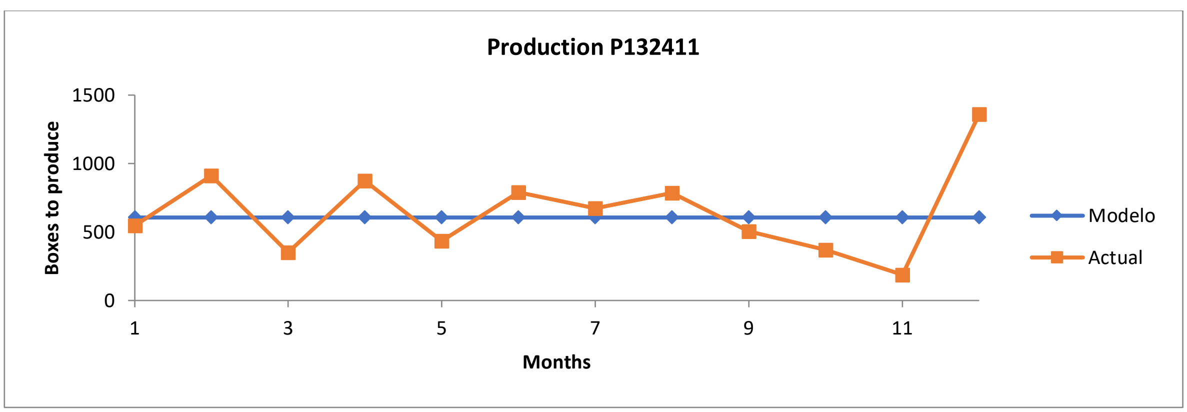


Graphic 1. Inventory policy for P132411

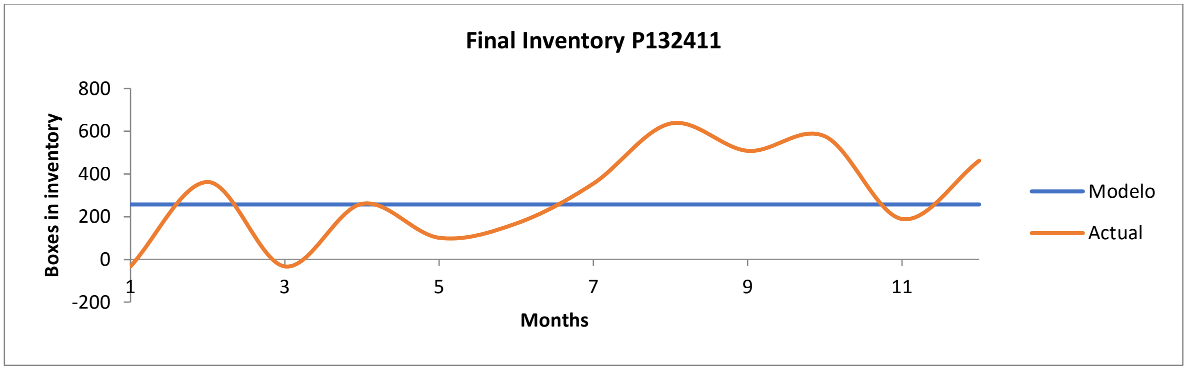


Graphic 2. Multiproduct inventory policy for “Feite Día” production line

In graphic 3 and 4 we can see the production and inventory for the product with code P134211. In both graphics we observe the difference between the actual production and inventory and the results obtained with the model.



Graphic 3. Comparison between the actual and the model monthly production



Graphic 4. Comparison between the actual and the model monthly final inventory

The fill rate obtained using the formula seen above was of 99.43%.

5. Conclusions

Properly planning production, consuming inventory to a certain reorder point and not generating over inventory will help SMEs reduce costs and increase efficiencies and productivity. In table 8 we can see the comparison between the actual indicator and the one obtained with the model. We accomplish the over inventory costs goal, the fill rate and the methodology. The indicator of gross margin is not accomplish at the level desired.

Indicator	Actual	Model	Accomplishment
Over inventory costs	$160,725.32	$136,207.90 18% reduction	✓
Fill rate	99%	99.43%	✓
Gross margin	$3,890,923.09 38.8%	$3,915,440.51 39%	✖
Methodology	✖	✓	✓

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