USE OF METHODS BASED ON TIME SERIES FOR IMPROVEMENT OF THE ACCURACY OF THE DEMAND FORECAST IN A PARTS DISTRIBUTION CENTER: A CASE STUDY

Heráclito Lopes Jaguaribe Pontes
hjpontes@sc.usp.br

Hilano José Rocha de Carvalho
hilanorc@sc.usp.br

Shih Yung Chin
sychin@sc.usp.br

Arthur José Vieira Porto
Escola de Engenharia de São Carlos-USP / Dept. Engenharia Mecânica
Av. Trabalhador São-Carlense, 400 CEP: 13566-590 - São Carlos – SP
ajvporto@sc.usp.br

Abstract: *During some decades, the instability of the economy and the difficulties of forecast hindered the full development and application of demand forecasts methods. Currently, the Brazilian economy is presenting a low inflation and a relative stability, which leads to a more predictable demand of sales. A Parts Distribution Center (PDC) needs a good demand forecast, because its supply has a great amount of parts. The demand forecast can be carried out by two forms: qualitative or quantitative. Currently, the studied PDC uses only the qualitative method of the consensus of executives to make the demand forecast. This method is expensive in terms of cost and time, because it is based on the experience and the specialized knowledge to foresee the future. The objective of this article is to analyze different quantitative methods based on the time series to select the most adequate in comparison to the method used currently for the improvement of the accuracy of the demand forecast. These methods had been applied from a two year period interval data and after it the forecast was realized for one year in the future. This forecast was compared with real a demand of the period.*

Keywords: *Demand Forecast, Time Series, Parts Distribution Center.*

1. Introduction

During some decades, the instability of the economy and the difficulties of forecast hindered a full development and application of demand forecasts methods. Currently, the Brazilian economy is presenting a low inflation and a relative stability, which lead to a more predictable demand of sales.

The differences between the demand forecasts and the real demand are the problems that affect much of the Parts Distribution Centers (PDC). Due to its great amount of parts, a PDC needs accurate information, to manage its supplying better, always aiming at preparing itself for the future events. The use of a demand forecast method with bigger accuracy increases the trustworthiness of the information, providing trustworthy data for decision.

From the interviews with the responsible for the demand forecast, it was identified that the PDC does not possess a systematic approach for accomplishment of the demand forecast. Currently, the necessities are repassed to the responsible for the forecasting, through the summary of sales parts in the previous months and the current month of previous years. Actually, it does not have in the company a culture directed toward the accomplishment of demand forecasts of structuralized form and formal. The method practiced in the company is the consensus of the executives. This method is expensive in terms of costs and time, therefore it is based on the experience and the specialized knowledge to foresee the future.

To make the information more trustworthy for the forecasting responsible manager, it had the necessity of the development of a work where it would be analyzed quantitative methods based on the time series. Through these quantitative methods, it is possible to extract the available last data about a demand process, which is information that will allow the mathematical modeling of its behavior. The assumption of continuity in that behavior allows the accomplishment of forecasts, whose quality and precision are very superior in relation to those with the forecasts carried out with subject base, based only on the experience of the executives.

Amongst the several quantitative methods of demand forecast, this paper dedicated its attention to the following methods: simple moving average, weighted moving average, single exponential smoothing and double exponential smoothing. These methods had been chosen because they had operational simplicity, easiness of agreement, low cost and principally a good accuracy. For Makridakis *et al*. (1998), there are several ways in which criteria for selecting and comparing forecasting methods can be organized. A common approach is to prioritize criteria according to their order of importance in practice, and, as might be expected, accuracy is give top priority.

2. Demand Forecast

For Kotler and Armstrong (1998), demand forecast is the art to estimate the future demand anticipating what the purchasers will possibly make in certain future conditions.

According to Martins and Laugeni (1999), demand forecast is a methodological process for the determination of future data based on statistical, mathematical or econometrical models or still on subjective models supported of a clear methodology of work and previously defined.

It is very important that the company knows to use all the available tools to obtain an anticipation of the future demand with some precision. This can involve to form and to keep a historical database of sales, as well as information that explain its variations and behavior in the past, to use adequate mathematical models that help to explain the behavior of the demand, to understand as factors or internal (for example, promotions) and external variables (for example, climate and economic conditions) which influence the behavior of the demand, to collect information of the market and to be capable to derive from this context a estimate of the future demand. (CORRÊA *et al*. 1997).

In accord with Moreira (2001), it is possible to classify the methods of forecasts for varied criteria, but the simplest classification is the one that takes into account the used type of boarding, that is, the type of instruments and concepts that form the base of the forecast. By this criterion, the methods can be qualitative and quantitative. Qualitative are the methods that rest basically in the judgment of people who, through direct or indirect form, have conditions to think surplus about the future demand. The quantitative methods are those that use mathematical models to arrive themselves at the foreseen values. In this work, the main focus is the quantitative methods.

2.1. Quantitative Method of Demand Forecast

According to Montgomery and Johnson (1976), the quantitative methods define explicitly how the forecast is determined. The logical is determined clearly and the operations are mathematical. The methods involve analysis of historical data to determine the process base generating the variable and, assuming that it is steady, it uses this knowledge to extrapolate the process for the future. Two basic types of models are used: causal models and time series models.

The models based on a time series are a sequence commanded in time of comments of one variable. The analysis of time series only uses the history of the time series of the variable to be foreseen to develop a model to predict future values. The causal models explore the relationship between the interesting series of time and one or more other series. If there other variables are correlated with the interest variable and if it shows to be any cause of this correlation, a statistical model describing this relationship can be constructed. Then, knowing the values of the correlated variable, the model can be used to get the forecast of the dependent variable (MONTGOMERY and JOHNSON, 1976).

The forecasts based on the time series are widely used, because of the simplicity of its model. These methods aim at identifying a trend in the comments of the demand along the time. In general, the raised comments have constant factors (days, weeks, months, years, etc.). One of requisites in those methods is that the projected values can be estimated on the basis of the last values. (MOREIRA, 2001).

For Makridakis *et al.* (1998), quantitative forecasting can be applied when three conditions exist: information about the past is available, the information can be quantified in the form of numerical data, and it can be assumed that some aspects of the past pattern will continue into the future.

2.2. Time Series

A time series is a sequence of comments about an interest variable. The variable is observed in discrete points of time, generally equally spaced (MONTGOMERY and JOHNSON, 1976). Complementing Montgomery *et al.* (1990) it says that a time series is a set of comments about an interest variable, taking sequentially in the time. In general, the variable is observed in discrete times in the time. Typically, time adjacent comments are dependents of themselves. The analysis of the time series consists of describing the processes or the phenomena that give origin to this sequence, as well as studying the existing dependence on the comments.

According to Box *et al.* (1994), time series can be defined as a set of comments generally commanded in time. A similar definition is the one of Levine *et al.* (2000), a time series is a gotten numerical data set during regular periods along the time.

In time series modeling it is possible to use a subset of the known data to forecast the rest of the knowing data, enabling one to study the accuracy of the forecasts more directly (MAKRIDAKIS *et al*.,1998). For Moreira (2001), the term time series indicates a collection of taken values at the demand in specific instants of time, generally with equal spacing. The expectation is that the standard observed in the last values provides adjusted information to the forecast of future values of the demand and that means that the basic hypothesis in the use of time series is that the future values in the series can be estimated on the basis of the last values.

2.3 Quantitative Methods of Demand Forecast based on Time Series

2.3.1. Simple Moving Average (SMA)

The method of simple moving average generates an average forecast with a minor variability than the original data. Therefore, it makes the average combining low values with high values. This method establishes an average of the values, normally most recent, and, as time goes by, new values are introduced, discarding the oldest ones.

According to Tubino (2000), the simple moving average uses data of predetermined number of the periods to generate the forecast. To each new period of forecast it substitutes the oldest data for the most recent ones. Note that the number of data points in each average remains constant and includes the most recent observations. It is obtained by the following equation:

$$M_n = \frac{\sum_{i=1}^{n} D_i}{n} \tag{1}$$

Where: M_n is the forecast of n periods; D_i is the occurred demand in period i; n is the number of periods; i is the index of the period ($i = 1, 2, 3, ...$).

The advantages of the use of simple moving average for forecasts are its operational simplicity and low cost. The small amount of periods used facilitates the operation and the implantation of this method for the organization. Therefore, it uses few historical data, comparing with others methods. The disadvantage is that it requires more storage because of all the n latest observations that must be stored.

2.3.2. Weighted Moving Average (WMA)

The method of the weighted moving average is an extension of the method of simple moving average. Using this procedure, once the most recent comments provide better information on future standards, they should possess greater weight in relation to the oldest data. For Levine *et al.* (2000), the weights assigned for the observed values decrease along the time and that means that the value observed more recently receives the first biggest weight, the previous observed value receives the second biggest weight and that continues on and on.

Considering that simple moving average attributes equal weight for each data set component, a weighted moving average allows each component to be weighted by one factor, about which the addition of all the factors is equal to one. According to Davis (1997), the equation for the forecast for weighted moving average is:

$$M_t = \frac{w_{t-1}D_{t-1} + w_{t-2}D_{t-2} + ... + w_{t-n}D_{t-n}}{n} \tag{2}$$

Where: M_t is the forecast for period t; D_{t-1} is the demand of period $t-1$; w_{t-1} is the weight attributed to period $t-1$; n is the number of periods related in the average.

The weighted moving average has a great advantage over the simple moving average because it is able to vary the effects between recent and old data. The disadvantage of the weighted moving average is that it is needed to determine the weights to be used.

2.3.3. Single Exponential Smoothing (SES)

The method of single exponential smoothing is more sophisticated and more used than the two previous ones. Like in the SMA and the WMA, the forecast immediately reaches, at first, only one period on the front. It has possible adaptations, however, that can extend the forecast to some periods to the front. For the SES, the forecast is given by the following equation (MAKRIDAKIS *et al.*,1998):

$$M_{t+1} = \alpha D_t + (1 - \alpha) M_t \tag{3}$$

Where: M_{t+1} is the forecast for period $t+1$; M_t is the forecast for period t; D_t is demand of period t; α is the smoothing coefficient.

According to Makridakis *et al.* (1998), the single exponential smoothing requires little storage and few computations. It is, therefore, attractive when a large number of items require forecasting. Besides, Moreira (2001), observed that when initiated a forecast sequence, the first value must be gotten from the arithmetical average of the real demands of previous periods or taking only the real demand from the previous period. Also the value of the smoothing coefficient must be chosen, generally in the interval of time zero and one. For Slack *et al.* (1997), the value of the smoothing coefficient determines the balance between the sensitivity of the forecasts to the changes in the demand and the stability of the forecasts. When α has a value close to 1, the new forecast will include a substantial adjustment for the error in the previous forecast. Conversely, when α is close to 0, the new forecast will include very little adjustment.

2.3.4. Double Exponential Smoothing (DES) or Brown's One-Parameter Linear Method

The double exponential smoothing used the same model of the single exponential smoothing, with the difference that it now is applied to the forecast gotten for SES. The difference between the single and double smoothed values can be added to the single smoothed values and adjusted for trend. The equation used in implementing Brown's one parameter linear exponential smoothing is:

$$M_{t+1}^{`} = \alpha M_{t+1} + (1-\alpha) M_t^{`} \quad (4)$$

Where: M_{t+1}\` is the forecast for period $t+1$; $M_{t+1}$ is the single exponential smoothed value for period $t+1$; $M_t$\` is the forecast for period t; α is the smoothing coefficient.

This method has also the initialization problem with smoothing coefficient α. If the smoothing parameter α is not close to zero, the influence of the initialization process rapidly becomes less significant as time goes by. However, if α is close to zero, the initialization process can play a significant role for many time periods ahead (MAKRIDAKIS *et al.*, 1998).

2.4. Errors of Demand Forecast

In the demand forecast, there is always an uncertainty with regard to its precision. Hardly a forecast with 100% of precision is obtained, on the contrary, in the majority of the cases it doesn't even get close. The corresponding uncertainties of forecast and errors come from two distinct forms: the first one of them corresponds to the market of low previsibility, and the second one corresponds to the system of demand forecast. The low previsibility of the market is part of its nature, and not much can be done to improve it. In relation to the system of demand forecast, a good system of forecast can make difference on the level of the company performance facing its competitors. Therefore, the forecast system deserves special attention about the quality and precision of the forecast (CORRÊA *et al.*, 1997).

In accord with Wheelwright and Makridakis (1985), the predominant criterion to evaluate the demand forecast is the accuracy. In many cases, the word accuracy refers to "better adjustment to it", which represents how well the forecast model is capable of reproducing the data that are already known.

A measure of accuracy that can be calculated is the mean error (ME) of forecast, in which the values of the errors are added and the average is calculated. The obtained result is next to zero, since the positive errors cancel the negative errors. To prevent this problem, the absolute error can be calculated, commonly called mean absolute error (MAE), which is simply the average of the absolute error. The previously mentioned measures of errors depend on the scale used in data. Following this direction, they can cause problems or inexpressive results when they are used as parameter in different intervals of time series. Thus, to carry out comparisons between data that possess different measures, the use of percentage measures of the error becomes necessary, which means to measure the mean percentage error (MPE). To avoid that the positive errors cancel the negative errors, it is calculated the mean absolute percentage error (MAPE). Besides, another measure of accuracy is the mean squared error (MSE). One of the differences between the MAE or MAPE and the MSE is that MSE penalizes the forecast more for the extreme shunting lines than for stops small shunting lines (WHEELWRIGHT and MAKRIDAKIS, 1985).

$$E_i = \textit{Demand Forecast - Real Demand} \quad (5)$$

$$ME = \frac{\sum_{i=1}^{n} E_i}{n} \quad (6)$$

$$MAE = \frac{\sum_{i=1}^{n} |E_i|}{n} \quad (7)$$

$$MSE = \frac{\sum_{i=1}^{n} E_i^{2}}{n} \quad (8)$$

$$PE = \left(\frac{DemandForecast - RealDemand}{DemandForecast} \right) \times 100 \quad (9)$$

$$MPE = \frac{\sum_{i=1}^{n} PE_i}{n} \quad (10)$$

$$MAPE = \frac{\sum_{i=1}^{n} \left| PE_i \right|}{n} \quad (11)$$

Where:
E_i = error of forecast for the period of time i;
PE_i = percentage error of forecast for the period of time i;
n = number of periods of time;
i = period (i = 1, ...n).

3. Parts Distribution Center (PDC)

In accord with Mulcahy (1994), Parts Distribution Center is defined as a physical space responsible for the storage of a variety of products from suppliers or from the firm itself (where the product was produced) and after that the products are set free for the customers. For Frazelle (2002), PDC is a place that stores products of diverse manufacturers for a determined period until these ones are set free for the warehouses of each customer.

According to Moura (1989), there are two distinctions for the warehouses. The first distinction is related to the warehouses with the necessities of the production cycle, such as the raw material storage and components. The second distinction refers to the distribution cycle, with the storage of destined products for sale such as central warehouse (Distribution Centers) and secondary warehouses. In terms of types of materials stored in this second distinction, there are two categories. The first category would be the not elaborated materials, half-not elaborated (that they pass to the production process), consumable (all the supplements that still do not compose the finished product). At the second mentioned category, it can be included all the finished products. The PDC in study is part of the second category of finished products.

4. A Case Study

The company used as study base is a multinational of heavy machines. The PDC of this company is located in São Paulo. It has approximately 50 workers and they work in three turns and cover all 24 hours of the day. This PDC has around 200.000 parts in supply and takes care of currently until 85% of parts requested. The parts are divided in two categories: National and Import.

For the supply replacement, the PDC counts with three types of suppliers: the industry of the group in Brazil itself, national suppliers and one supplier for import parts. About the sales, the PDC supplies parts for seven national customers. These customers are dealers authorized.

The demand forecast by the method used currently presents expensive in terms of costs and time and generates a result with little accuracy. This lack of precision in a PDC that has a little changeable demand can be attributed to the total empirical method used by the responsible department for the forecast demand, without foundation in any quantitative method. For some time this lack of mathematical foundation was hidden by the high supplies kept in the PDC. With the increase of the competition and the necessity of reduction of cost, this lack of a mathematical method to make the demand forecast is affecting the two main objectives of the PDC in question: to give a service of quality to the customers (to take care of all the calls requested) and to keep the cost of the operation of distribution low (not to keep great stocks).

4.1. Data Series Collection

To carry out simulation with the forecast methods, to evaluate and to get an immediate result for the choice of the most adjusted method it was necessary to raise the demand data of the monthly calls from the last 24 months before the accomplishment of the work. The data series collection had as time horizon the period from January of 2002 to December of 2003. For this collection was elaborated a sheet of daily collection data, that contemplated the amount of daily calls for each category of parts, that were, lately, putted together by months in such a way that made easily the analysis of the data.

In Tab. 1, there are the historical data obtained directly of the company in study. In this table, it was initially inserted one column with the months. Then, other columns were created with the amount of calls for each category of parts by year. For a better visualization of the behavior of the historical demand, the categories (National and Import) are illustrated in Fig.1.

Table 1. Historical data in the period from January 2002 to December 2003

	2002		2003	
Months	National	Import	National	Import
January	3596	2388	3970	2395
February	4111	1673	3552	2107
Mars	3113	1664	3619	1676
April	2837	2193	3781	2359
May	3407	1722	4057	2256
June	2931	1670	3127	1831
Juliet	4118	2315	3898	2344
Augusts	2901	1618	4370	2127
September	3745	1656	3321	2495
October	2980	1941	3655	1682
November	3293	1694	2959	2317
December	4094	2231	3730	2443

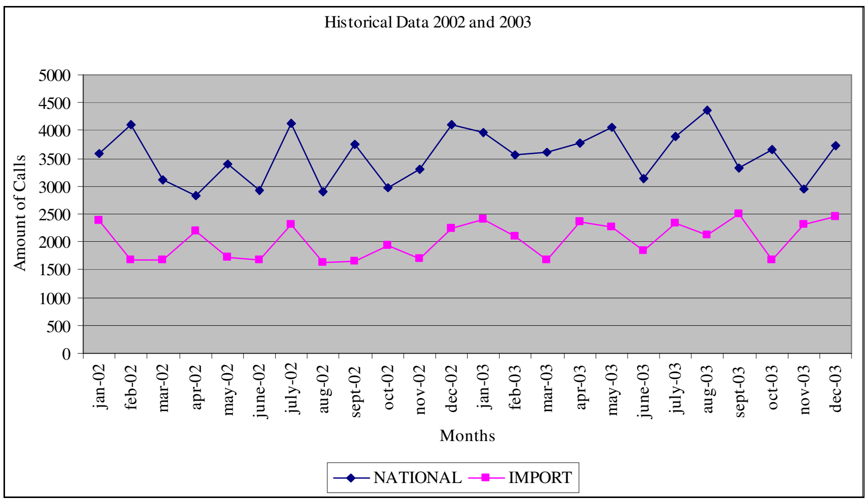

Figure 1. Historical data in the period from January 2002 to December 2003.

4.2. Methods Application

From historical data of the years 2002 and 2003, it was possible to use the four quantitative methods based on time series to foresee the demand of the year 2004 and the forecast made for the responsible department was also obtained using the qualitative method used currently, as well as the real demand for the period. In Tab. 2, these results are founded. Figures 2 and 3 had been developed for a better visualization of the comparative of the demand forecasts carried through for each method for the two categories in the year of 2004.

For the SMA and the WMA *n* equal to twenty four was used, that is, it implies to say that the foreseen demand for any month will be always the arithmetic average or weighted average of the demands from the twenty four last months. With this value of *n*, the distributed seasonal effects along the year are completely annulled, but, on the other hand, there is a slower reply to the variations in the demand. The method WMA presented difficulty to determine the weights to be attributed to each one of the considered periods. Ten simulations with different combinations had been carried through (using two decimal houses) to get the best result.

The calculations of single and double exponential smoothing had used the smoothing coefficient α, with different values according to each category (National and Import). The determination of the value of these coefficients generated certain difficulty due to the possibility of variation from zero to one. For the determination of these values, simulations had been done with twenty different combinations working with two decimal houses with subdivisions of five in five units. The best results had been gotten when assuming α equal 0.3 for National category, that means that was assumed a percentage of 30% of error from the previous period for elaboration of the forecast for the next period, and for Import category was assumed α equal 0,1, that means that was assumed a percentage of 10% of error from the previous period for elaboration of the forecast for the next period. A small value of α gives a considerable smoothing.

To monitor the demand forecasts, it had been done the calculations of the error in the forecasts. These calculations had as objective to verification of the accuracy of the forecast data and to realize the choice of the method with better accuracy. In Tab. 3 there are founded the diverse errors that have been calculated for each method and category.

Table 2. Demand Forecast of period 2004.

	Real Demand		Current Method		SMA		WMA		SES		DES	
Month	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**
Jan	3666	2194	3800	2145	3549	2033	3434	2215	3605	2205	3607	2083
Feb	3302	1987	4100	2410	3551	2025	3553	2159	3623	2204	3612	2099
Mar	4113	1759	3700	2245	3518	2038	3453	2159	3527	2182	3586	2107
Apr	3829	2498	4100	2070	3559	2042	3669	2038	3703	2140	3621	2110
May	3783	2179	3550	2465	3601	2055	3746	2100	3741	2176	3657	2117
June	4116	1705	3750	2320	3616	2074	3733	2145	3753	2176	3686	2123
July	3968	2482	4100	2235	3666	2075	3887	2026	3862	2129	3739	2123
Aug	3372	2261	3925	2435	3660	2082	3884	2026	3894	2164	3785	2127
Sept	3839	2399	3515	2245	3679	2109	3750	2159	3737	2174	3771	2132
Oct	4103	2203	3900	2385	3683	2140	3746	2218	3768	2197	3770	2139
Nov	3336	1795	4100	2255	3730	2151	3829	2285	3868	2197	3800	2144
Dec	3987	2158	3700	2365	3732	2155	3691	2129	3709	2157	3772	2146

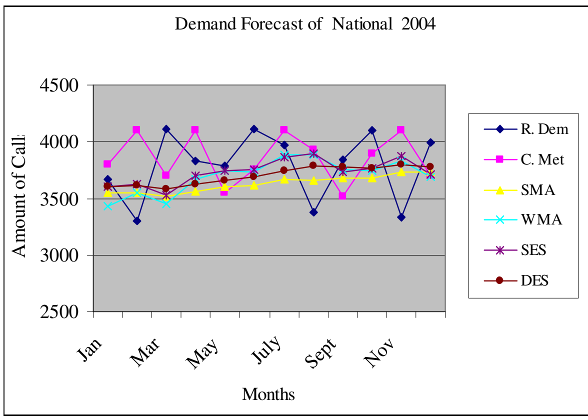

Figure 2. Demand Forecast of National 2004.

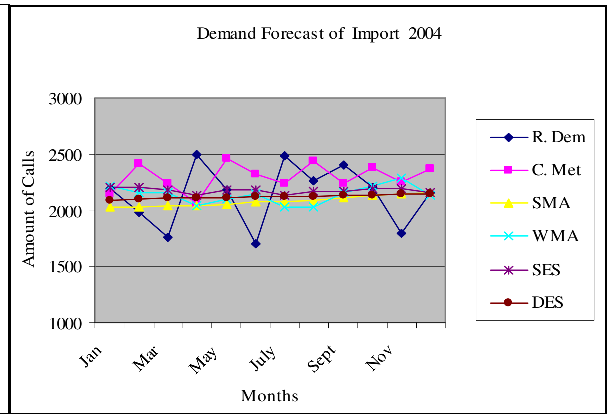

Figure 3. Demand Forecast of Import 2004.

Table 3. Errors of Forecast of period 2004

	Current Method		SMA		WMA		SES		DES	
Errors	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**	**Nat**	**Imp**
ME	68,83	162,92	(155,88)	(53,28)	(86,52)	16,85	(51,92)	40,19	(83,96)	(13,83)
MAE	373,17	309,25	311,02	226,99	295,91	239,41	281,22	214,03	281,75	218,29
MSE	185.208	121.942	115.170	73.046	121.748	92.010	113.898	76.918	101.712	68.148
MPE (%)	1.32	6,70	(4,34)	(2,61)	(2,53)	0,46	(1,53)	1,76	(2,33)	(0,66)
MAPE (%)	9,601	13,509	8,580	10,931	8.051	11,212	7,533	9,860	7,610	10,293

4.3. Discussion of the Results

In relation to the process of comparison and selection of the methods presented, the mean absolute percentage error (MAPE) is the most used measure of accuracy of the demand forecast (KAHN, 1999). More precisely, this measure is used at around 52% of the times (MENTZER and KAHN, 1995).

The method of demand forecast that got minor MAPE was admitted as the most precise, that means that it has a bigger degree of accuracy. In this direction, having as a base the previous proposal, it was evidenced that the single exponential smoothing is the most appropriate amongst the presented methods to generate demand forecasts for the pertaining data to the categories National (MAPE=7,533%) and Import (MAPE = 9,860%).

In relation to the current method of demand forecast used at the PDC in question, the qualitative method consensus of executives, it was evidenced that this method is classified as the worse performance amongst the methods in the two categories National (MAPE = 9,601%) and Import (MAPE = 13,509%).

In accord with Lewis (1997), the values of the mean absolute percentage error can be related with the potentiality of the forecasts: MAPE < 10% - forecast is potentially very good, MAPE < 20% - forecast is potentially good, MAPE<30% - forecast is potentially reasonable, MAPE > 30% - forecast is potentially inexact. In this direction, in accord with the above mentioned author, it is evidenced that in the two categories the method of single exponential smoothing revealed itself potentially very good.

In the National category all the methods analyzed of demand forecast have revealed themselves potentially very good, although the qualitative method used currently in the PDC was very close of being classified as potentially good. At the comparison between the best method (SES) and the current method, the MAPE passed from 9,601% to 7,533%, which means a relative decrease of 21,539%.

At the Import category the single exponential smoothing method was the only one with MAPE below 10%, which means that it was the only method classified as potentially very good. The others methods had a MAPE above 10%, which classifies them as potentially good. At the comparison between the best method (SES) and the current method, the MAPE passed from 13,509% to 9,860%, which means, it happened a relative decrease of 27,011%.

5. Final Considerations

From the results above, this paper suggests that the PDC in study adopts single exponential smoothing to develop its demand forecast in virtue of its easiness of operation (exception in the determination of the smoothing coefficient) and because it obtained better results in comparison with the others methods. Allied to the mathematical method, it is important that the company continues using the qualitative method mainly in periods when it can have brusque changes in the demand due to any external factor (promotion, new product, economic conditions).

The interest for the use of one quantitative method of demand forecast by the company emphasized her preoccupation with the improvement in the precision of the foreseen data. However, to reach a precision standard, the organization must dedicate special attention to the degree of accuracy of the used method and to the monitor of the forecast errors. This last aspect is important for the taking of corrective actions, when necessary.

With the accomplishment of this work the company in study got a quantitative method (mathematical) to, combined with the current method used, carry through forecasts with greater accuracy. After this work have shown to the company which was the best quantitative method, it fits to the company to make the relation of this method with the used one currently to get a demand forecast with bigger accuracy.

6. References

BOX, G. E. P.; Jenkins, G. M.; Reinsel, G. C., 1994, "Time series analysis: forecasting and control", 3º ed. Englewood Cliffs: Prentice Hall,

CORRÊA, H. L.; Gianesi, I. G. N.; Caon, M., 1997, "Planejamento, programação e controle da produção: MRP II/ERP: conceitos, uso e implantação", 3º ed, Ed. Atlas, São Paulo, Brasil.

DAVIS, M. M.; Aquilano, N. J.; Chase, R. B., 1997, "Fundamentos da administração da produção", 3ª ed, Ed. Bookman, Porto Alegre, Brasil.

FRAZELLE, E. H., 2002, "World class warehousing and material handling", Ed. McGraw-Hill, New York, USA.

KAHN, K. B., 1999, "Benchmarking sales forecasting performance measures", The Journal of Business Forecasting Methods & Systems, v. 17, n. 4, p. 19-23.

KOTLER, P.; Armstrong, G., 1998, "Princípios de marketing", 7º ed, Ed. Prentice Hall do Brasil, Rio de Janeiro, Brasil.

LEVINE, D.; M.; Berenson, M. L; Stephan, D., 2000, "Estatística: teoria e aplicações usando o Microsoft Excel em português"**,** Ed. LTC, Rio de Janeiro, Brasil.

LEWIS, C. D., 1997, "Demand forecasting and inventory control", Ed. Wiley, New York, USA.

MENTZER J.T.; Kahn, K. B., 1995, "Forecasting technique familiarity, satisfaction, usage and application", Journal of Forecasting, Chichester, v.14, n.5, p.465-476.

MOURA, R. A., 1989, "Logística: suprimentos, armazenagem e distribuição física", Ed. IMAM, São Paulo, Brasil.

MULCAHY, D. E., 1994, "Warehouse distribution & operations handbook", Ed. McGraw-Hill, New York, USA.

MAKRIDAKIS, S.; Wheelwright, S.C; Hyndman, R. J., 1998 "Forecasting: methods and applications**",** 3º ed., Ed. Wiley, New York. USA.

MARTINS, P. G.; Laugeni, F. P., 1999, "Administração da produção", Ed. Saraiva, São Paulo, Brasil.

MONTGOMERY, D. C.; Johnson, L. A., 1976 "Forecasting and time series analysis", Ed. McGraw-Hill, New York, USA.

MONTGOMERY, D. C.; Johnson, L. A.; Gardiner, J.S., 1990, "Forecasting and time series analysis", 3º ed., Ed. McGraw-Hill, New York. USA.

MOREIRA, D., 2001, "Administração da produção e operações", Ed. Pioneira, São Paulo, Brasil.

TUBINO, D. F., 2000, "Manual de Planejamento e controle da produção", 2º ed, Ed. Atlas, São Paulo, Brasil.

SLACK, N; CHAMBERS, S; HARLAND, C; HARRISON, A; JOHNSTON, R., 1997, "Administração da produção". Ed. Atlas, São Paulo, Brasil.

WHEELWRIGHT, S. C.; Makridakis, S., 1985, "Forecasting methods for management" 4ª. ed, Ed. John Wiley & Sons, New York, USA.