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PREDICTING SERVICE TIME IN A CALL CENTER

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Abstract

This paper describes – from the study of a case – the problem of forecasting the service average time (SAT), for a given product, in the call center of a large Brazilian company in the sector – Contax – and how it was approached with the use of multiple regression with dummy variables. After highlighting and justifying the importance of the topic, the study presents a brief review of the literature on methods for forecasting demand and its application in call centers. The case is described, initially, contextualizing the company studied and describing, next, the way it deals with the problem of forecasting SAT for the product 103 – services related to fixed telephony. A multiple regression model with dummy variables is then developed to serve as the basis of the proposed forecasting process. This model uses available information capable of influencing SAT, such as the day of the week, the occurrence or not of a holiday, and the proximity of the due date of the telephone bill; and it presented an accuracy gain of 2 percentage points for the study period when compared to the tool previously used.

Keywords: Call Center; Service Average Time; Prediction; Multiple Regression.

1. INTRODUCTION

Call centers are operational centers, installed to use telecommunication and computational technologies, in order to automate a large amount of different activities and telephone services, both received and originated by the center. Inbound-type centers, where calls originate from clients, are characterized as a system consisting of several people (attendants), who receive telephone calls from other people, usually clients - even if potential, willing to get some information, to hire some service , to purchase some product, to respond to some research, to update data, to register occurrences, or to make complaints, among other demands (Grossman *et al*., 2001; Hawkins *et al*., 2001).

Sakamoto (2001) defines call centers as the place where calls are made, or received in large quantities, to support sales processes, marketing, customer services, technical support or other specific activity. For Minghelli (2002), it can be understood as an integrated center of contact between companies and consumers, established remotely and/or virtual, from the use of technology.

From the operational point of view, a call center is basically characterized by a set of telemarketers, gathered in a space and interconnected to the public of a company through telephony systems, receiving and making calls, answering questions, listening to complaints, solving problems or selling products and services. From a business point of view, a call center is a medium focused on the relationship between companies and their clients, whose objectives are: to strengthen this relationship; improve, accelerate and reduce bureaucratic processes; promote customer loyalty with the company through improvements in service; and increase revenues (Weisshuhn, 2004).

Bapat *et* Pruitte Jr. (1998) argue that the call center is the most visible strategic weapon of a company. It is a business battlefront where millions of dollars in products and services are bought, sold and traded. It is also a place where thousands of customers are instantly captured and lost. As leading companies become more creative in disseminating information and adding value to their consumers through telephone lines, it is only natural that they see the call center as their market access point.

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Although, by definition, the call center is a non-contact face-to-face relationship, its use is becoming increasingly intense by companies from various sectors of the economy. Industry, commerce and a multitude of service companies use this type of resource to meet, sell, contact and better understand their customers (Weisshuhn, 2004).

According to Azevedo *et* Caldas (2002), a call center essentially consists of a service sector activity that acts as a link between the company and its customer base. The authors add that the technological innovations in this sector have been very large, provoking a broad restructuring in the functioning of these organizations.

Tens of billions of dollars were spent on call centers in the latter half of the 1990s. The growth of that industry in that decade was in the range of 20% per annum, and growth is expected to remain at this level during the early part of this century. In today's economy, call centers have not only become the primary points of contact between clients and companies, but also a major investment for many organizations (Grossman *et al*., 2001; Weinberg *et al*., 2006).

The call center industry has grown significantly in recent years, particularly in Brazil. The domestic market is already driving sharp financial figures. A good part of the costs involved in the management of call centers comes from human resources. Therefore, it is vital - from the point of view of business competitiveness - to manage them efficiently. For this, it is possible to scale agents based on their abilities, in call routing centers, using, for example, Operational Research techniques (Barbosa *et* Gomes, 2013). An accurate notion of the demand behavior of links becomes, in this case, an indispensable input for efficient scheduling of the agents.

But call center managers and planners have a much more difficult job today than in the past. With more products and services being created, made available in the market, sold and assisted, compared to previous times, they need to understand what is happening in the call centers, to know how their characteristics influence performance indicators. Certainly the use of simple hunches, trial-and-error experiences, intuition, or user-invisible operating software do not represent the best alternative for managers of enterprise headquarters that are intended to be successful (Mehrotra *et al*., 1997) .

Considering that the personnel cost represents approximately 70% of the total industry, the raw material for the efficient management process (satisfactory levels of service at a reasonable cost) of a call center is to forecast demand - both in terms of number of calls and length of service - and the resulting workload, which need to be estimated as realistically as possible. This need gives the phone call demand forecasting the status of critical activity during the search for efficiency and for the effectiveness of the business. An accurate prediction of the system parameters is a prerequisite for a consistent level of service, representing one of the most important steps in the process as a whole (Hall *et* Anton, 1998; Alam, 2002; Gans *et al.*, 2003; Reynolds, 2005; Bouzada, 2006; Weinberg *et al.*, 2006).

Thus, the following research problem is outlined: how is it possible to predict the average handling time of calls made to a call center?

This paper aims to describe and attack the problem of a large Brazilian call center company that, despite having a series of potentially useful information for the task of predicting the service average time (SAT) during calls, cannot fulfill this task in a satisfactorily accurate manner.

2. LITERATURE REVIEW

A great emphasis has been placed on improving the decision-making process in government and business organizations. In view of the highly competitive environment of today's business world, it has become the basic goal to optimally allocate the ever-scarce resources available in various competing activities. In the case of call centers, this objective is made feasible, in part, through a more precise forecasting process. In the 1970s, due to technical limitations and mainly computational resources, administrators often used their own feelings and intuitions to aid in the decision-making process. Today they are complementing this feeling towards the industry or the economy with the use of forecasting techniques, a trend reinforced by the diffusion of the use of microcomputers in the business environment, because to predict and monitor sales evolution has become a managerial concern (Hanke, 1992; Pizzinatto *et* Spers, 2006).

Call center supervisors, responsible for their operational planning, need to efficiently scale their teams in order to provide satisfactory levels of service at reasonable costs, as was done in the work of Barbosa et Gomes (2013). Proper management of the power plants requires the estimation of some operational characteristics that lead to the recommended dimensioning of the service team. Among these characteristics, we highlight the number of customer connections and the average service time, issues to be addressed permanently in this type of business (Weinberg *et al*., 2006; Klungle, 1997).

According to Matan *et* Nourbakhsh (1998), to generate accurate call forecasting, call center managers need to aggregate information from a variety of sources, from market estimates to, eventually, the length of the commercial ranges served in the media. However, important part of the information comes from call history statistics that can usually be adjusted for current or expected trends.

Electronic Journal of Management & System
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According to Mehrotra (1997), the time series models have been the most used approach for the treatment of the forecast in call centers. However, other models have been successfully applied in some call center environments, such as sales centers based on their estimates of incoming product shipments and advertisements sent to potential customers. In other industries, rather than ready-made theoretical formats, specially constructed models for the case in question and integrated models - using quantitative techniques and qualitative information - are widely used, often predicting more accurately, as in the case described in the work of Girardi *et al*. (2013).

But in the case of call centers, forecasting activity is inherently difficult because of the relatively small size of the time intervals used in practice. Established techniques, such as Winters exponential damping and multiple linear regression, are useful for this type of business. Generally, using an appropriate approach will greatly reduce forecast errors. However, many call centers encounter difficulties in this process because of the technical knowledge necessary to adapt these techniques to the complex call patterns and to the unorganized aspect of the data (Grossman *et al*., 2001).

The forecasting process consists of both art and science. In art, because, after all, the future is being estimated and the accuracy will depend in part on the judgment and experience of whoever is leading the process. But also in science: a step-by-step mathematical process that uses past history to predict future events. Thus, an understanding of specialized statistical techniques is necessary for the process to be well done. Managers who have workforce management software, which automates the predictive process, cannot think that this alone is enough. Understanding these calculations is as critical as owning the software: not only to verify the accuracy of the results but also, and perhaps more importantly, to explain the numbers to the management. That is, even with the tools, it is worthwhile to understand the fundamentals of this process (Reynolds, 2005; Bouzada, 2006).

In addition, the importance of the forecasting process can be understood by the potential financial impact of estimation errors, estimated to be 6% of the company's annual revenues, according to a study carried out by Veiga *et al*. (2012).

The average service time is one of the targets attacked by the method proposed by Shen *et* Brown (2002), which is applied - among other purposes - to model the standard (time-dependent) of SAT of customer calls received in the call center of an Israeli bank. The understanding of such variable behavior of this magnitude is, in the opinion of the authors, essential to understand the operating environment of a system, and also to predict dynamically its future workload.

Weinberg *et al*. (2006) propose, in their article, a multiplicative model to predict the call center demand of a North American commercial bank. Additionally, any prior knowledge based on past experience of the manager can be incorporated into the model, as well as components only observed afterwards. Comparing the predictions for the following day provided by the model of these authors and by classic statistical models, they could perceive improvements of up to 25% by their model in relation to the standards.

In general, if the variable to be predicted is strongly correlated with other variables that are subject to large variations, a multivariate model is required. The multiple regression method, in particular, is relatively robust with respect to deviations from the assumptions of normality and homoscedasticity. Moreover, a possible occurrence of multicollinearity between the explanatory variables does not affect the predictive capacity of the model, causing only problems regarding its parsimony and understanding the real effect of the independent variables on the behavior of the dependent variable (Silver, 2000; Levine *et al.*, 2000; Corrar *et al.*, 2007).

3. METHODOLOGY

The present study can be characterized, from the point of view of its purpose, as: applied, because it was motivated by the need to solve a practical problem in the operation of call centers - forecasting demand; and methodological, since it elaborates and proposes the implementation of a forecasting tool, which consists of an instrument to capture reality.

With regard to the means, this is a study of a single case, since it is restricted to only one unit (company), allowing a greater depth and a greater level of detail during the analysis.

Initially, the company that served as the stage for the application of the case study was presented succinctly. Next, it was described how the company performs the forecast of the average time of service of the connections, without the use of the tool proposed in this article. The model suggested here was then constructed to predict the behavior of the service average time (SAT) of the connections made to the central responsible for dealing with the problems related to the customers' telephone bill.

Multiple Linear Regression was used to explain SAT in each day, depending on the occurrence of holidays, the day of the week and the proximity to the arrival and due date of the telephone bill. These data were obtained from the company, together with the SAT effectively occurred on each day of the period from 07/25/2005 to 03/15/2006.

In the regression model, dummy variables were used to represent the holidays and the days of the week. The 0.05 le-

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vel of significance was used in the inferential analysis. After the final model was obtained, efforts were made to validate it, including verification of the waste and its serial autocorrelation, as well as quantitative and qualitative analysis of the prediction errors.

4. DESCRIPTION AND ANALYSIS OF THE CASE

4.1 The company

Contax emerged in late 2000, as a natural extension of Telemar's business, in a sector of the economy that invested little in technology and service qualification, in order to assist its clients in the operational management of the customer service, adding value in the relationship with end consumers. In Brazil, currently, it is the fastest growing company in this industry, having billed R$ 1,129 million in 2005, almost 60% more than in the previous year. It is characterized as the largest company in the field in terms of number of telephonic service positions, and the second largest in terms of billing and number of employees, within the national territory.

The firm makes more than 100 million contacts a month, through telephone, mail, email, torpedoes, Internet and chat. There are more than 22,000 service positions and almost 50,000 employees in the 16 plants located in ten Brazilian cities: Brasília, Salvador, Recife, Fortaleza, Porto Alegre, Belo Horizonte, Nova Lima (MG), Rio de Janeiro, Niterói (RJ) And São Paulo. This last city houses the most modern contact center complex in Latin America.

Contax is a company with 100% national capital and today it operates with more than 40 clients, the main one being Telemar itself, which accounts for approximately 60% of revenues. The main products related to this client are: (i) 102 - which receives calls from customers seeking help from the telephone directory; (ii) Velox - which includes technical support and the help desk for Telemar's broadband Internet service customers; (iii) 103 - which covers customers seeking services related to fixed telephony, such as change of billing address and doubts or problems with the telephone bill; (iv) Telemar technical support and defect repair; and (v) OI - which covers all customer service for Telemar's mobile telephony services.

4.2 The current process for forecasting the service average time

In the opinion of the company's operating team, the search for customer satisfaction is still performed inefficiently. In fact, there is a consensus that the costs resulting from this search for satisfaction are still high, presenting great reduction potential. The sector responsible for improving the operational efficiency of the company is Traffic Planning. The main tool used by this industry to assist operational management planning decisions is TotalView software, fully integrated with the telephony infrastructure. The product consists of a workforce tool used to size and control service, which assists managers - among other activities - in forecasting demand (by time and day of the week).

According to the company's Traffic Planning manager, the main concern is to be able to improve the demand forecast, both in terms of the number of connections and in terms of the SAT. The accuracy of the forecasts is not good for some products and he himself evaluates that the company has all the information that could provide a better prediction, especially for the product 103; however, it needs a more appropriate method. This information basically refers to the amount of bills sent to customers on each date, usually 5 to 6 days before maturity, and their own due dates. The impression of the management and coordination of the product 103 is that the service time for the product is influenced by the arrival of the bill and by its own expiration date, when there would be a differentiated access to the service by the customers. The problem is that the system used for demand forecast does not take this information into account, revealing a potential for improvement in the process.

The first step in the forecasting process for this product is the generation of a basic estimate, performed by TotalView's workforce management software. One of its modules is forecasting. It works with the demand history and forecasts SAT based on the last 13 weeks by calculating a weighted average, with weights differentiated, which are larger for the latest weeks and lower for the more remote weeks. The forecast is generated for each half-hour interval or block, also taking into account the seasonality of the day of the week. Thus, to calculate the SAT of the following Tuesday, from 10:30 a.m. to 11:00 p.m., for example, TotalView considers the demand history of this same half hour, calculating a weighted average of the SAT of the last 13 Tuesdays.

The second step is a criticism by the co-ordinating analysts of these numbers generated by TotalView. The software searches the history of the day in question in the last 13 weeks, but if there is any information contaminated by a specific event, such as a drop in the system, resulting in a lower SAT during the period, a cleanup must be done by the analysts. They should use their common sense and analytical power to perform the adjustment manually, if there is any major deviation in the historic, modifying or expurgating the discrepant data from the historic, and generating the forecast again in a timely manner. This monitoring happens daily.

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After generating the preview of the estimate from the initial number of TotalView and the team's initial criticism, the third step is to incorporate into the predicted values the possible impact caused by some specific events, such as a carnival Monday or a different occurrence in a Saturday, for example. The way to incorporate such impacts depends on whether the event is new or unknown and the prior knowledge of its consequences. Some of the special events can have their expected impact in a better way, when the analyst team is subsidized by some premises received from other sectors, capable of impacting the SAT, such as: implementation of new plans and services in fixed telephony; changes in the procedure (service itinerary), which can cause the operator to talk more or less during the service; changes in the Audible Response Unit (URA).

These premises also involve the behavior of customers' telephone bill cycles, information from Telemar's billing industry and which helps forecast the demand for the product 103. This information basically consists of the amounts of bills sent to customers in each date, normally 5-6 days before expiration. According to the forecasting team, it is useful because, in relation to the product, the SAT is influenced by the events of the arrival of the bill at the destination and its due date, which is the date on which there would be different access to the service by customers for clarification and/or complaint purposes.

In fact, during the entire period of 4-5 days in which the bill is held by the customer from arrival to the due date, a change in the SAT pattern occurs, but the greatest impact occurs at the time of arrival of the bill at the client's residence, according to the opinion of the coordinator responsible for the product. According to analysts, the post-expiration impact occurs when the customer who forgot to pay the bill calls to know how to proceed, but it is small, and it is not significant in terms of modification in the SAT.

The problem is that TotalView does not take this into account; The seasonality of the day of the week is considered, but not the distance of the day in relation to the arrival of the bill or its expiration date. For example, a customer's bill expires on the 10th of each month, not on the second Wednesday of the month; thus, in the month that day 10 falls on a Tuesday, that day of the week should be more impacted than the others, whereas in the month that day 10 falls on a Wednesday, the greater impact should be included on this day. But TotalView considers, in terms of seasonality, every Tuesday the same way, following the same reasoning for the other days of the week. In addition, there are months in which bills are not sent exactly 5 days before expiration, and its arrival to the destination should also be considered as a special event.

This information is taken into account in the forecasting process, but not automatically. All the analysis is done by the forecasting team, not by the software, which: (i) receives and evaluates the schedule of the billing area, with the number of bills being posted and expiring on each date; (ii) checks the impact of the events of arrival and due date of the bills in the historic, for the cycle, that is, the grouping of bills in each branch, in question; (iii) adds, outside of TotalView, the historical impact of such events, such as 5% and 3%, respectively, to the SAT initially provided by the tool; (iv) criticizes the results; and (v) feedbacks the software, adjusting the forecast that had previously been generated. During this process, analysts neither take into account a possible impact from one and two days before the expiration date of the bill nor the post-expiration period; only the effect of the moment of the due date.

Under the eyes of a more detailed analysis, the magnitude of the SAT has varied greatly throughout the day, assuming, in the afternoon, values 35-40 seconds higher than the morning times, according to the coordination of the area. The overall impression is that this is mainly due to the greater concentration of new operators in the morning. During the night, the SAT is even higher, especially - in the opinion of the forecasting team - because of the lower level of service offered in this period, which can cause the customer to wait more queue time and complain about it before starting to deal with the main subject, itself, increasing the time of service.

The forecast is prepared monthly, always 45 days in advance in relation to the need to hire operators. This deadline is justified for this product, because of the process of validation with the client, the time of selection of the new employee and the 30 days required to train the operator in their future activities.

Physically, there are service centers of the 103 in Rio de Janeiro, Minas Gerais and Ceará. However, in organizational terms, it works as if there were a single call center, potentially covering customers of all states. Since demand overlaps for all plants, it is only necessary to prepare a consolidated forecast for the whole of Brazil, as if there were a single central service.

4.3 The suggested process for forecasting the average time of service

4.3.1 Proposition of the process

Currently, the basic forecast is taken from TotalView and the coordinator performs all this analysis in Excel. The general view is that billing information could be used in a more systematic way so that a more accurate forecasting method can be constructed, taking all these aspects into account, not just the seasonality of the day of the week, as TotalView does.

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

The idea is to move away from this non-methodical post--analysis in Excel - which depends heavily on the analyst's intuition - and to have a necessary tool for the team at the moment, using the billing information in the forecasting process, thus avoiding manual labor, which increases the possibility of error. The tool is not intended to replace the intuition and experience of the forecasting team, but rather to support its decision-making. In other words, the opinion of the experts should not be discarded; it should be used to enrich the model that basically seeks to make subjective information, relevant to the forecasting process, objective. Operationally, the forecasting team would collect, with the usual advance, the necessary inputs from the billing sector and feed the forecasting tool, set in an Excel spreadsheet. The output of the tool would consist of the average service time for each future date.

The method chosen was that of multiple regression, since it is able to capture the specific impact of each event and information in the SAT of each day. For example, what impact would the day in question cause in the SAT by falling on a Thursday? What is the impact if the day is a holiday? And the arrival of 200,000 bills for customers on the day in question? And the fact that it is the day prior to the expiration date of 500 thousand bills? The idea is to check the distance of the specific day in relation to special events, the arrival and the expiration of the bills, and calculate the number of bills in the following situations: **A** (arrival day), **E** (expiration date), **E - 1** (expiration eve), **E - 2** (two days before expiration), **E + 1** (one day after expiration), **E + 2**, ... and so on.

4.3.2 Application of the model

With the billing schedule provided by the forecasting team for the period from July 2005 to March 2006, it was possible to consolidate the information in terms of the date of arrival and the due date of the accounts, as presented partially in Tables 1 and 2, respectively.

In order to be able to develop the multiple regression model capable of predicting the SAT in each date, it was necessary to have access to this great historic. Due to strategic secrecy, these values could not be revealed in their full magnitude; however, a constant of proportionality was applied to them, and the results, from July 2005 to March 2006, provided by the company, are presented graphically in Figure 1. As can be seen, the series does not present a tendency of growth or decrease, but only an erratic behavior, thus dispensing with the need to include a variable associated with the passage of time.

Table 1. Accounts grouped by expected arrival date, September to October 2005

Expected Arrival Date	Total
06/09/05	3.360.569
13/09/05	801.143
14/09/05	432.670
15/09/05	709.437
26/09/05	1.315.342
27/09/05	820.855
28/09/05	1.555.097
29/09/05	2.506.038
04/10/05	1.808.735
05/10/05	1.167.447
07/10/05	800.105
11/10/05	1.890.364
18/10/05	709.437
26/10/05	1.731.518
28/10/05	587.118
Total	20.195.875

Source: The authors

Table 2. Accounts grouped by maturity date, September to October 2005

Due Date	Total
04/09/05	2.142.215
07/09/05	1.918.920
11/09/05	2.177.552
13/09/05	798.630
15/09/05	1.456.656
17/09/05	801.143
20/09/05	432.670
23/09/05	709.437
01/10/05	2.136.197
04/10/05	2.142.215
07/10/05	1.918.920
11/10/05	2.177.552
13/10/05	798.630
15/10/05	1.456.656
17/10/05	801.143
20/10/05	432.670
23/10/05	709.437
Total	23.010.643

Source: The authors

With all of this information, it was possible to elaborate a spreadsheet with the necessary data for the construction of the multiple regression model within which the behavior of the SAT dependent variable could initially be explained on a specific day - by 9 independent variables : (i) day of the week; (ii) Holiday -

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

whether the specific day is a holiday or not; (iii) arrival (A) - the number of bills that are expected to reach the customer on the specific day; (iv) expiration date (E) - the number of bills due on a specific date; (V) E - 3 - for the number of bills that specific day corresponds to, 3 days before expiration, or, in other words, how many bills will expire 3 days after the specific date; (vi) E - 2 - for the number of bills that that specific day corresponds to two days before the due date; (vii) E - 1 - for the number of bills that that specific day corresponds to, one day before the due date; (viii) E + 1 - for the number of bills that that specific day corresponds to, one day after the expiration date, that is, how many bills will have expired on the day before that specific date; and (ix) E + 2 - for the number of bills that that specific day corresponds to, two days after the due date. Table 3 presents, in part, the data sheet in question.

It should be noted that the independent variables *day-of--week* and *holiday* were treated as dummy (0 = No; 1 = Yes). A dummy variable was created for the occurrence *holiday* and six dummy variables for the day of the week: **Sunday**, **Monday**, **Tuesday**, **Wednesday**, **Thursday**, and **Friday**. It is worth noting that n-1 dummy variables are required to represent a qualitative variable with n possible values, that is, one of the possible values must be left out (in the case in question, the value Saturday was arbitrarily selected). Thus, for Aug 06, 2005, for example, the dummy variable holiday assumed the value 0; and dummy variables **Sunday**, **Monday**, **Tuesday**, **Wednesday**, **Thursday** and **Friday** assumed the value 0, thus characterizing and excluding the day in question as being a common Saturday (non-holiday) .

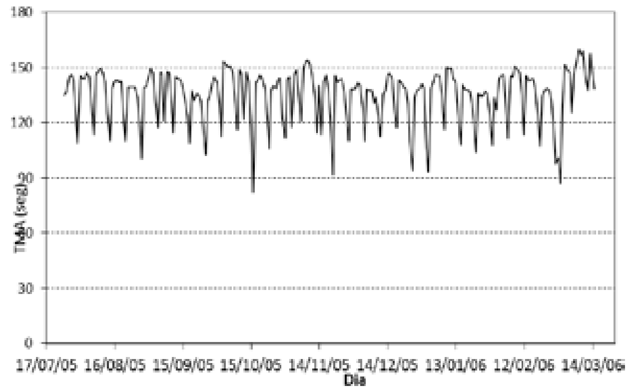

Figure 1 - SAT per day, July 2005 to March 2006

Source: The authors

Legend: Dia = Day; Dia da semana = Day of the week; Feriado = Holiday; Chegada (C) = Arrival (A); Vencimento = Expiration date (E); V = E (expiration date); TMA = SAT; 2ª feira = Monday; 3ª feira = Tuesday; 4ª feira = Wednesday; 5ª feira = Thursday; 6ª feira = Friday; Sábado = Saturday; Domingo = Sunday; Não = No

After running the regression, the first analysis points to a model with a good explanatory potential, since the adjusted R-square indicates that 79% of the data variation can be explained. In this case, one can infer the real influence of the explanatory variables in the average time of service and accept the model with high confidence, since the p-value found for the F statistic was lower than 0.00001.

The contribution of each independent variable is expressed by the estimated coefficients, together with the respective p values, presented in Table 4. A very high p value

Table 3 - Multiple regression model data sheet to predict SAT, Aug/2005

Dia	Dia da semana	Feriado ?	Chegada (C)	V - 3	V - 2	V - 1	Vencimento (V)	V + 1	V + 2	TMA (seg)
01/08/2005	2a. feira	Não	-	2.142.215	-	-	2.136.197	-	-	145,50
02/08/2005	3a. feira	Não	1.918.920	-	2.142.215	-	-	2.136.197	-	144,00
03/08/2005	4a. feira	Não	2.177.552	-	-	2.142.215	-	-	2.136.197	144,00
04/08/2005	5a. feira	Não	-	1.918.920	-	-	2.142.215	-	-	147,00
05/08/2005	6a. feira	Não	218.438	-	1.918.920	-	-	2.142.215	-	144,75
06/08/2005	Sábado	Não	-	-	-	1.918.920	-	-	2.142.215	129,00
07/08/2005	Domingo	Não	-	-	-	-	1.918.920	-	-	113,25
08/08/2005	2a. feira	Não	-	2.177.552	-	-	-	1.918.920	-	146,25
09/08/2005	3a. feira	Não	2.036.848	-	2.177.552	-	-	-	1.918.920	148,50
10/08/2005	4a. feira	Não	801.143	798.630	-	2.177.552	-	-	-	149,25
11/08/2005	5a. feira	Não	-	-	798.630	-	2.177.552	-	-	147,00
12/08/2005	6a. feira	Não	-	1.456.656	-	798.630	-	2.177.552	-	141,75
13/08/2005	Sábado	Não	-	-	1.456.656	-	798.630	-	2.177.552	125,25
14/08/2005	Domingo	Não	-	801.143	-	1.456.656	-	798.630	-	110,25
15/08/2005	2a. feira	Não	-	-	801.143	-	1.456.656	-	798.630	138,75
16/08/2005	3a. feira	Não	296.642	-	-	801.143	-	1.456.656	-	142,50
17/08/2005	4a. feira	Não	246.901	296.642	-	-	801.143	-	1.456.656	143,25
18/08/2005	5a. feira	Não	-	-	296.642	-	-	801.143	-	142,50
19/08/2005	6a. feira	Não	-	-	-	296.642	-	-	801.143	142,50
20/08/2005	Sábado	Não	-	246.901	-	-	296.642	-	-	123,75
21/08/2005	Domingo	Não	-	-	246.901	-	-	296.642	-	109,50
22/08/2005	2a. feira	Não	-	-	-	246.901	-	-	296.642	139,50
23/08/2005	3a. feira	Não	-	-	-	-	246.901	-	-	139,50
24/08/2005	4a. feira	Não	2.136.197	-	-	-	-	246.901	-	139,50
25/08/2005	5a. feira	Não	-	-	-	-	-	-	246.901	139,50
26/08/2005	6a. feira	Não	-	-	-	-	-	-	-	133,50
27/08/2005	Sábado	Não	-	-	-	-	-	-	-	118,50
28/08/2005	Domingo	Não	-	-	-	-	-	-	-	100,50
29/08/2005	2a. feira	Não	-	2.136.197	-	-	-	-	-	139,50
30/08/2005	3a. feira	Não	2.181.734	-	2.136.197	-	-	-	-	139,50
31/08/2005	4a. feira	Não	1.879.401	-	-	2.136.197	-	-	-	145,50

Source: The authors

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

is observed for the variable arrival (A), indicating that the number of bills reaching the customer on that specific day cannot be seen as a good predictor for the SAT by the date in question. Although it is a critical variable, it must be removed from the analysis because its p-value is well above the limit normally used (0.05).

Table 4 - Estimated coefficients of the independent variables of the multiple regression model to predict SAT on the date in question

	Coeficientes	*valor-P*
Interseção	**122,27**	**<0,00001**
Domingo	**-15,17**	**<0,00001**
2a. Feira	**15,37**	**<0,00001**
3a. Feira	**15,20**	**<0,00001**
4a. Feira	**17,70**	**<0,00001**
5a. Feira	**17,86**	**<0,00001**
6a. Feira	**15,11**	**<0,00001**
Feriado	**-29,20**	**<0,00001**
Chegada (C)	**-0,0000003**	**0,68355**
V - 3	**0,0000008**	**0,29973**
V - 2	**0,0000011**	**0,16894**
V - 1	**0,0000016**	**0,03437**
Vencimento (V)	**0,0000029**	**0,00009**
V + 1	**0,0000026**	**0,00116**
V + 2	**0,0000022**	**0,00362**

Source: The authors

Legend: Coeficientes = coefficients; Valor-P = P-Value; Interseção = Intersection; Domingo = Sunday; 2ª feira = Monday; 3ª feira = Tuesday; 4ª feira = Wednesday; 5ª feira = Thursday; 6ª feira = Friday; Feriado = Holiday; Chegada (C) = Arrival (A); Vencimento = Expiration date (E); V = E (expiration date)

Variables E - 3 and E - 2 also have high p-values, indicating that the number of accounts for which that specific day corresponds to 2 or 3 days before the due date cannot be seen as a good predictor for the SAT. The pre-expiration effect for the SAT then appears to start significantly only on the eve (E - 1). Therefore, like the Arrival variable (A), the variables E - 3 and E - 2 are not significantly influencing the SAT and should be removed from the analysis. Without them, a new regression model was generated, continuing with a good potential, since 79% of the data variation can be explained by it.

The estimated regression coefficients, together with the respective p values, are presented in Table 5. As can be observed, the p values of the other variables did not change much and, for this modified model, only one variable presents an angular coefficient with a higher p-value (but not much) at 0.05: E - 1; however, it will be kept in the model because the p-value of its coefficient is below 0.10. In this way, the removal of variables A, E - 3 and E - 2 was beneficial to the model, making it more parsimonious and allowing an interpretation of the coefficients obtained.

The first coefficient corresponds to the value of the dependent variable SAT when all the independent variables assume the value zero, that is, When Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Holiday, E - 1, E, E + 1 and E + 2 are zero - or when the day is Saturday, non-holiday and does not consist of any date within the 4 day interval around the expiration of some bill, the expected SAT is 122.64 seconds.

Table 5 - Estimated coefficients of the independent variables of the multiple regression model (without C; V-3; V-2) to predict SAT on the date in question

	Coeficientes	*valor-P*
Interseção	**122,64**	**<0,00001**
Domingo	**-15,15**	**<0,00001**
2a. Feira	**15,36**	**<0,00001**
3a. Feira	**14,96**	**<0,00001**
4a. Feira	**17,33**	**<0,00001**
5a. Feira	**17,84**	**<0,00001**
6a. Feira	**15,03**	**<0,00001**
Feriado	**-28,89**	**<0,00001**
V - 1	**0,0000012**	**0,06957**
Vencimento (V)	**0,0000031**	**<0,00001**
V + 1	**0,0000032**	**<0,00001**
V + 2	**0,0000024**	**0,00036**

Source: The authors

Legend: Coeficientes = coefficients; Valor-P = P-Value; Interseção = Intersection; Domingo = Sunday; 2ª feira = Monday; 3ª feira = Tuesday; 4ª feira = Wednesday; 5ª feira = Thursday; 6ª feira = Friday; Feriado = Holiday; Chegada (C) = Arrival (A); Vencimento = Expiration date (E); V = E (expiration date)

This number can be considered as a basic quantity, to which must be added the effects of the occurrence of the independent variables, quantified from their respective angular coefficients. Thus, the fact that the day is Sunday contributes to a decrease of 15.15 seconds in the predicted SAT in relation to the basic number; and so on, for the other days of the week. With this information, it is possible to elaborate a graph, presented in Figure 2, which allows a better visualization of the seasonality of the day of the week, referring to the whole sample period collected (July 2005 to March 2006).

The evolution of the demand for calls throughout the week, considering days without holidays and not near the due date, starts with a low value on Sunday, showing a certain increase on Monday; the demand remains steady throughout the week, dropping steadily on Saturday before returning to a still lower Sunday level.

Similarly to the days of the week, the fact that one day is a holiday reduces the expected SAT by 28.89 seconds. This large reduction in the average time of service, both for holidays and weekends is a bit strange when compared to working days. In principle, it was not possible to speculate the reasons that would lead to such a variation. The forecasting team was as-

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

ked about it and also could not justify the fact. Research into such motives may be an interesting object of future research. Similar interpretation must be carried out in relation to the days surrounding the due date: each bill expiring on the following day (that is, for which the date in question represents E - 1) increases by 0.0000012 according to the average time of service; and so on, for the other days around the due date.

Naturally, coefficients do not only have an isolated meaning but can and should be analyzed together: if the consequences of day-of-week effects, holiday occurrence, and critical date in relation to the bill's expiration date are incorporated into the predicted value for a basic day , it will be possible to establish an equation to predict the SAT on a given day depending on the characteristics of the date in question. In this way, the average service time can be predicted according to Equation 1.

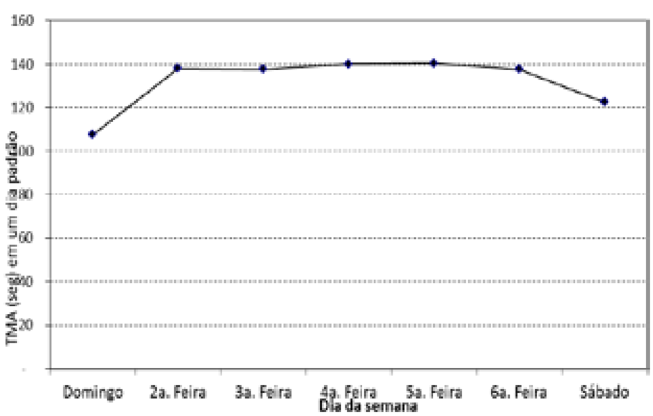

Figure 2 - Seasonal behavior of the day of the week - model without C, V-3 and V-2

Source: The authors

Legend: TMA (seg) em um dia padrão = SAT (seg) on a standard day; Domingo = Sunday; 2ª feira = Monday; 3ª feira = Tuesday; 4ª feira = Wednesday; 5ª feira = Thursday; 6ª feira = Friday; Sábado = Saturday; Dia da semana = Day oh the week

Equation 1: SAT (in seconds) = 122,64 – 15,15 x *Sunday* + 15,36 x *Monday* + 14,96 x Tuesday + 17,33 x Wednesday + 17,84 x Tuesday + 15,03 x Friday – 28,89 x *holiday* + 0,0000012 x *V-1* + 0,0000031 x *V* + 0,0000032 x *V+1* + 0,0000024 x *V+2*.

Among the variables in Equation 1 (highlighted in italics), the first seven are of the dummy type, assuming the value 0 (no) or 1 (yes). The last four represent, respectively: the number of bills whose due date is one day later; on the same day; one day before; And two days before.

4.3.3 Final considerations on the model obtained

Then, with Equation 1, it is possible to calculate how much the regression model would have predicted for the SAT in each of the days, about which the historic provides the real value of this magnitude. In this way, one can compare the values that would have been predicted with those that actually occurred, so that a forecast error can be measured. This comparison can be seen in Figure 3.

The difference between the actual values and those generated by the model is also known as residual or error. For a multiple regression model to be used, it is necessary to assume that the correlation among the residuals along the spectrum of the independent variables is zero, that is, that the residues are independent of each other, thus not presenting serial autocorrelation (Corrar et al., 2007). According to these authors, one way to verify the validity of this assumption is through the Durbin-Watson test. In the model being analyzed, the value 1,756 was found for DW Statistics.

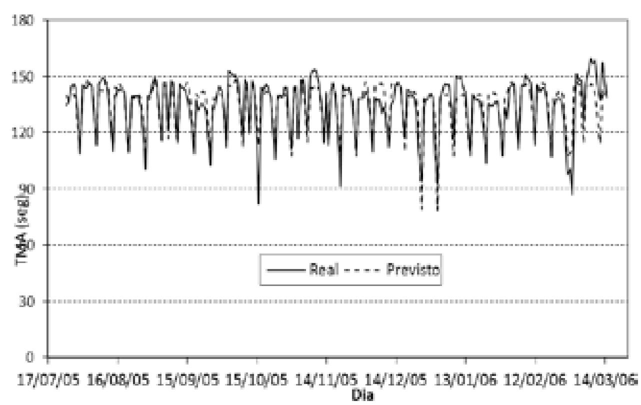

Figure 3 - Actual values multiplied by a constant and predicted by the model for the SAT per day, July 2005 to March 2006

Source: The authors

Legend: TMA (seg) = SAT (seg); Real = Real; Previsto = Predicted; Dia = Date

For a sample of 234 data, with 11 independent variables, this value found for the test statistics (1,756) does not reveal evidence, at 0.05 of significance, of dependence among the residues. The erratic aspect of these residues can be visualized in Figures 4 and 5 below, which relate them to the actual SAT values predicted by the model, respectively.

Regarding the predictive quality of the model, the magnitude of the residues can be observed in Figure 6. This histogram reveals that most of the residues present a low magnitude, around 0,0, and that there was a low frequency of occurrence of waste with absolute magnitude greater than 10 seconds.

Figure 3 above corroborates the perception of low magnitude of the residues since it is possible to perceive a good visual adhesion of the predicted values in relation to the real data. This adherence was formalized here through MAPE, the Mean Absolute Percentual Error or absolute percentage

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

error. Figure 7 below presents these average forecast errors for each month, from July 2005 to February 2006.

On average, the model is incurring a forecast error of the order of 3.61%, a reasonably low value. Before comparing it with the error obtained by the standard forecast process, it is worth remembering, for example, that during this process, analysts receive the values predicted by TotalView and add to them the expected impacts by events and premises, such as bill cycle behavior and the occurrence of holidays, as well as other special events related to the product, such as the minutes plan, media campaigns and other potentially impacting aspects.

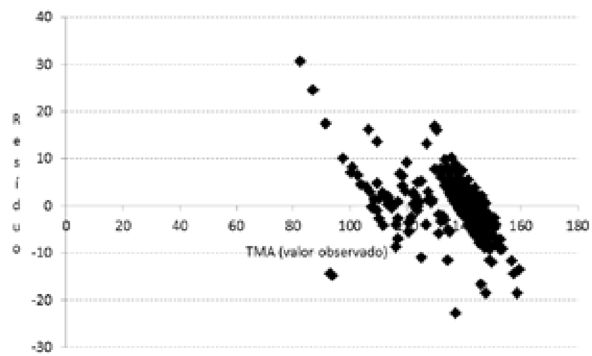

Figure 4 - Model residuals versus observed SAT value, July 2005 to March 2006

Source: The authors

Legend: Resíduo = residue; TMA (valor observado) = SAT (observed value)

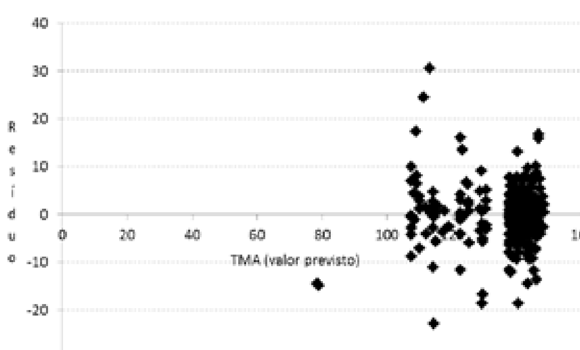

Figure 5 - Residuals of the model versus predicted value for the SAT, July 2005 to March 2006

Source: The authors

Legend: Resíduo = residue; TMA (valor previsto) = SAT (predicted value)

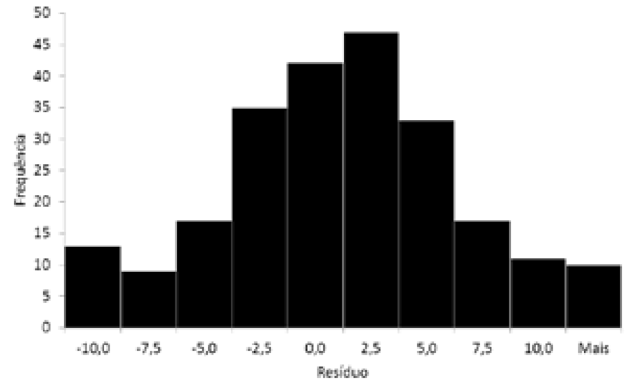

Figure 5 - Residuals of the model versus predicted value for the SAT, July 2005 to March 2006

Source: The authors

Legend: Frequência = frequency; Resíduo = residue; Mais = more

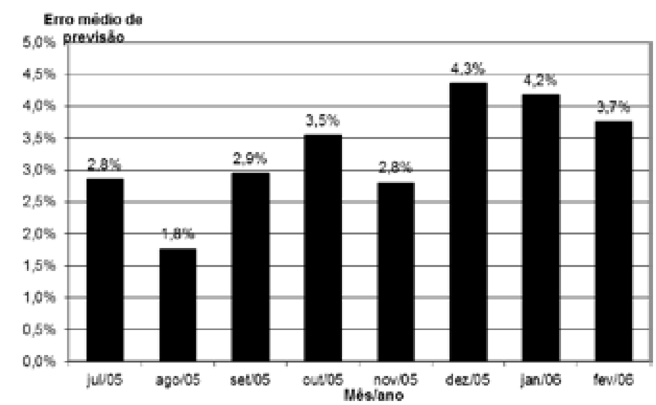

Figure 7 - Average monthly error of the multiple regression model to predict the SAT, July 2005 to February 2006

Source: The authors

Legend: Erro médio de previsão = Average error in forecast; Mês/ano = Month/year

However, the values obtained through the proposed regression model are intended to replace only the forecasts suggested by TotalView, plus the influence of the holidays and the behavior of the bill cycles. The idea is not to replace the role of the analyst in charge of forecasting, with all his valuable experience and subjectivity, but to provide him with a supplementary allowance for decision-making. Thus, since the analyst will be able to add to the values suggested by the regression model the impacts that he deems relevant, it seems more reasonable to compare the prediction errors of the model proposed here with the errors from the TotalView prediction module, with the intention to verify the occurrence or not of improvements in the process.

Thus, the MAPE obtained by TotalView for the same analyzed period was 5.58%; therefore reasonably higher than the 3.61% of the regression model, which are even

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

more impressive when compared to MAPEs found by forecasting models available in the literature, such as those analyzed by Veiga et al. (2012) in their comparative study between models, which experienced prediction errors of the order of 10%.

In addition, a more detailed analysis of the prediction errors of the proposed model reveals that some of the most difficult days to predict, and therefore with potentially larger forecast errors, consist of holidays or dates that behave almost like a holiday. For example, on 12/24/2005 and 12/31/2005, they were not classified as holidays, but certainly are not common days and therefore should generate a SAT that is different to a standard day. But the regression model did not consider this fact, since it was possible to classify a day only as being holiday or not; And since these days were not really holidays, they were treated by the model as ordinary days.

Similar problems, but perhaps on a smaller scale, certainly occurred on some days of the year which consisted of local, but not national, holidays. As the model proposes a consolidated SAT forecast, it was only possible to consider national holidays. For example, on January 20, 2006, a local holiday in the city of Rio de Janeiro, had a change in the national SAT caused by the change in the SAT in the city but, when treated as a normal day by the model, it had its SAT badly estimated. This problem is also seen in prolonged holidays and in the days between a holiday and the weekend, where the SAT does not follow the pattern of behavior.

A more serious problem occurred on December 25, 2005. its prediction error was very high because the day in question had two SAT reducing effects, which were added by the additive nature model: being Sunday and being a holiday. But, in reality, the effect of a day being a holiday is certainly reduced if it is a Sunday or a Saturday; and the model did not consider this aspect, because it is only possible to consider a day as a holiday or not, and not as a kind of moderate holiday.

In fact, these problems have caused forecasting errors to increase, but not necessarily the future forecasting process will have to incur such large-scale errors when days with different behaviors occur. In practice, when forecasting analysts are using the model proposed here, they can manipulate the values of the dummy variable **holiday** for days other than the standard. For example, the day December 24 can manually receive the value 0.7 for its holiday variable, instead of being treated as a normal day (value 0 for this variable); The day January 4 can receive the value 0,4; A holiday on a Sunday may have its holiday variable value reduced from 1 to 0.6.

After this manipulation, the forecasting team can consider Telemar's billing sector information on bill cycles and use Equation 1 to predict the SAT for product 103, each day. Once the outputs of the equation are generated, analysts can incorporate the expected impacts by the special events, such as new service deployment, service routing changes, and so on, thus reducing forecast errors.

5. CONCLUSIONS

Parallel to the growth that the call center industry has presented in Brazil and in the world, this type of business has been experiencing a great increase in the complexity of its operations, making it difficult to manage it without the use of adequate quantitative tools.

It was verified that the forecast tool (TotalView) used by the company studied - Contax - does not consider some information that could refine the forecasting process. Thus, in the specific case of product 103, which concerns fixed-line services and problems with the telephone bill, failure to include the occurrence of holidays and expiration dates of customers' bills results in the waste of useful and easily accessible information that is capable of reducing forecast errors. Taking these effects into account, a multiple regression model with dummy variables to predict the average call time (SAT) of calls was developed. It is worth remembering that this model was built with the objective of complementing the experience and the intuition of the specialists of the company.

The predictions provided by the regression model were compared to the actual data and showed an accuracy higher than that obtained by TotalView alone. In addition, the way the model was developed allows its easy incorporation into the company's forecasting process. From the methodological point of view, it was possible to verify that the absolute quality of a consecrated tool is less important than the adequacy of the tool to the problems of the company and that, if such tool does not use information available and indispensable for the decision making process, its adequacy becomes highly questionable.

Some limitations regarding search results need to be highlighted. Firstly, the proposed forecast tool considers only information regarding the intrinsic characteristics of the dates considered in the analysis (such as day of the week, holidays and proximity to the expiration of telephone bills). Other special events related to specific dates, but not intrinsic - such as media campaigns, base growth, and other potentially shocking aspects of demand - still need to be considered "outside" by analysts and manually entered into the tool.

In addition, the tool in question treated the days considered in the analysis in a binary form (yes or no) regarding

Electronic Journal of Management & System
Volume 11, Number 4, 2016, pp. 367-379
DOI: 10.20985/1980-5160.2016.v11n4.650

whether or not they consist of holidays, that is, it was not considered a half term for this issue, making it impossible to have “less intense holidays”, which can usually occur with local holidays or “sandwiched” days between the holidays and the weekend.

Another limitation is the difficulty in obtaining - together with Contax - the latest data on demand history (volume of calls and SAT) of product 103. In view of this, it was not possible to verify the quality of the forecast model from data that was not used for its construction. It was only possible to measure its functionality relative to the past (period of data used as input), but not whether the model will work well in relation to the future (which would have been achieved if the model could have been applied to a data period different of those used for its design). In other words, the model may have been well suited to a specific set of data (dates), but it was not possible to generalize such suitability.

Still with regard to the proposed forecast tool, it is not reasonable to overlook the failure to consider a possible seasonality of demand throughout the year. Because the available demand history for its elaboration consists of only a few months, it was not possible for the tool to try to capture this seasonal effect. But it is not wise to say that it does not exist. Finally, some topics not addressed in the present work represent potential opportunities for future studies, such as:

- The consideration of regionalities would be an interesting aspect to be addressed in future studies, preventing the SAT from being approached in a consolidated manner nationally;
- The elaboration of a forecast model capable of capturing, understanding and predicting the effects of a possible seasonality throughout the year, in addition to the already captured seasonality throughout the week;
- Information regarding telephone bill values could, if available, be incorporated into the model, since it seems reasonable to assume that customers with higher amounts due have a more time-consuming service;
- The reasons that reduce SAT on holidays and weekends in up to 30 seconds compared to working days were not discovered and deserved to be investigated through a more thorough and more qualitative research;
- An analogous suggestion is to investigate the surprising absence of dependence of the SAT in relation to the arrival of the telephone bills to the residence of the clients, found in this research;
- One last idea points to the possibility of trying to develop a model for the intraday SAT forecast.

Therefore, due to its growing importance in the current business environment and the diversity of problems it presents, efficient call center management represents a fertile area for the application of quantitative tools for its best operation and planning.

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