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DECISION SCIENCE TECHNOLOGY

CASE STUDY

FLEET ASSET CAPACITY ANALYSIS AND REVENUE MANAGEMENT OPTIMIZATION USING ADVANCED PRESCRIPTIVE ANALYTICS

Keywords: Revenue Optimization - Asset and Capacity Management - Fleet Management - Rental Car - Demand Forecast - Learning Machines - Capacity Planning - Vehicle Scheduling

Abstract

Leading a highly dynamic business - in a competitive market, in our era of globalization and social consumers - is quite challenging. This challenge is also associated with high financial risks when the business requires intensive asset investments. This is the case for the multinational Europcar in the rental car business. This paper shows how advanced analytics can be properly combined and adapted in order to improve business management. The proper integration of these math-based software help companies to cut costs and gain market share in their complex and competitive market.

Insights: from the technical point of view, the paper shows the elements of an innovative Revenue Management combining predictive and prescriptive analytics.
The demand forecast is the backbone, providing a unique shared view to logistics and revenue decisionmakers, whose decisions are supported by math-optimization. From the business management perspective, the paper explores which conditions the top-management should create to achieve successful results by advanced analytics.

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THE RENTAL CAR BUSINESS CONTEXT

Services are delivered to customers by rental stations distributed in a certain territory, typically a whole country. A local rental car station is the physical place where a customer pick-ups a car and return it at the end of the service. Stations can be eventually grouped in zones while cars are divided by category based on their level and customers are split into segments (leisure, business, etc.).
The governance of the rental car business requires a combination of decisions over multiple time spans.
The goal of the decision-makers is to **"have the right cars at the right stations at the right time and sell it at the right price."**

The decisions impacting the revenue can be grouped in the following categories:

1. Asset management:
   a. long term (12 months): define contracts with car vendors establishing the number of cars to be acquired and dismissed (returned) as well as the economic conditions including penalties in case cars exceeds the maximum predefined mileage;
   b. midterm (few months): plan the in-fleet and de-fleet of cars to/from the right stations;
2. Logistic management – mid-short term: plan the cars transfers between stations to cover demand peaks, or limit low fleet utilization in certain zones;
3. Commercial management - mid-short terms:
   a. define the price for each car (group) and station based on rental duration and the expected market conditions;
   b. define promotions;
   c. block sales in case of expected excess-demand.

THE PROBLEM

The business is affected by variability, randomness, seasonality, special events (like fairs, holidays, unusual weather condition, like snow, etc.) and last but not least, competitor's actions. All these factors affect the final business results (thus profit). Consequently, any business decision, relevant to the fleet management as well as sales management expose the decision-makers to a certain risk of creating a low saturation (profit deterioration) or loss of business opportunity (the unavailability of cars in the correct station to catch a wave of demand). Each management action is associated with certain expected costs and expected results. For example, transferring some cars from one station to another to intercept some customers demand comes at a cost that has to be considered in the overall revenue balance.
Asset-capacity management is strongly connected with the commercial and marketing field, and vice versa. The decisions in one department can significantly affect other decisions elsewhere. Consequently, multiple decision-makers must share a global view and synchronize their actions to reach a common goal: **get the maximum profit from the available resources**. This is the goal of the Revenue Management.

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THE REVENUE MANAGEMENT PRACTICE & THE MAJOR COMPLEXITIES FOR THE RENTAL CAR BUSINESS

Revenue management in the Rental Car business has similarities to the airline and the hotel business. The Revenue Management in the rental car shares, with the airline and hotel cases, several elements: predictable demand, perishable inventory, appropriate cost and pricing structure and time-variable demand. On the other hand, one significant feature of car-rental Revenue Management context is the nature of the capacity (cars). The capacity is much more flexible than it is in either airline or hotel Revenue Management since the fleet dimension can vary over time. For these reasons, even if for the airline and the hotel Revenue Management there is a wide literature, for the rental car business the literature is less developed. The reader can find an exhaustive overview of the revenue management literature in "The Theory and Practice of Revenue Management" by K. T. Talluri and G. J. Van Ryziz.

The Europcar solution

The solution adapted supports multiple and interrelated decisions based on the forecast demand. The forecast becomes the backbone of the solution permitting the decision-maker to share a common future view. The term demand is referred to the number of cars picks up in a given time interval, related to a combination of station (or zone), a segment of customers and type of vehicle.

The forecast is required for more than twenty weeks and differentiates according to the following drivers:

1. Geography (stations and zone);
2. Type of Cars;
3. Segment of Customers;
4. Time (Historical Data)

Indeed, in the short term a daily forecast is required while, in the medium term, a weekly forecast may be appropriate to support most of the decisions.

To be also highlighted that the system needs to specifically model phenomenal like:

- Cancellation of existing reservations
- Upsell at the desk (the customer, for example, booked a Fiat Panda, but the seller at the desk sells an upgrade to the Mini)
- Possibility to extend an existing/open contract
- "One Way" (the check-in station is different from the check-out station).

The software automatically produces two different types of forecasts computed every day:

1. The unconstrained forecast: unlimited availability of resources (cars) is supposed;
2. The constrained forecast: capacity limitations are considered.

The forecast models are able to take into account influencing factors like holidays, special event (e.g exhibitions) and weather conditions.

Subsequently, a sophisticated simulation model elaborates the forecast in order to calculate the revenue and the utilization of the fleet over time.

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The performance indicators depend on other factors that the system must consider, such as the durations of the rental or the ancillaries included (GPS, insurances, etc). In particular, in order to integrate predictive and prescriptive analytics, every night the forecast is used to create a constrained and unconstrained "basic scenarios". The basic scenarios are used as inputs for math-optimization modules (prescriptive analytics), for example, the fleet optimizer provides suggestions on the fleet management over time. The fleet optimizer, considering all the cost components, identifies the optimal solution in terms of cars transfers between stations, cars in-fleet or dismissing, which minimizes the overall cost and maximizes the revenue fitting the demand at the best.
Using these basic scenarios as the starting point, the decision-makers can also evaluate, via what-if analysis the impact of any actions and compare scenarios. For example, it is possible to compare different alternatives in terms of cars transfers between stations.
Another important variable is the price. **The prices must be decided according to the demand,** the market position and the competitor responses. Choosing the optimal price level is another important feature in the rental car revenue management.

FORECAST BY MACHINE LEARNING VERSUS STATISTICAL LEARNING

A fundamental component of revenue management is the forecast. For many years, statistical methods such as ARIMA (AutoRegressive Integrated Moving Average) and Exponential Smoothing have been used to model and predict time series.

However, when the time series are influenced by many exogenous variables or have a very irregular trend the above methods may show difficulties during the forecast phase, although they are able to fit the series on the past. Recently, instruments with greater non-linear modelling capabilities have been proposed in the artificial intelligence field and they can be identified with the term "Learning Machine".

Starting from 1957 with the "Perceptron" (or formal neuron) introduced by Frank Rosenblatt, different models for supervised learning has been proposed and among them, there are Artificial Neural Networks (ANNs) and Support Vector Machines (SVMs).

Basically, these **two methods differ in the mathematical model underlying the learning phase.** During this phase, a set of examples is provided to the model which learn the relation between input features and the corresponding output. The procedure is accomplished by solving a non-linear optimization problem whose objective is the minimization of the difference between real and estimated outputs while preserving good generalization properties.

An additional benefit of these methodologies is that, unlike many statistical methods, they do not require a-priori information about the distribution of the phenomenon or its parameters and therefore they do not need any preliminary assumption.

On the other hand, to provide the best performances these tools need to be implemented properly.

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First, this means providing the Learning Machine with a significant set of examples (Data set). The term "significant" may have a slightly different meaning. For instance, if we have to forecast time series representing the demand for a product, too old examples could represent policies no longer applied, and therefore, they could mislead the machine.

Another important step is the identification of the features with a relevant relation with the output. Indeed feature selections are a very sensitive issue, and the reader can refer to "Feature selection algorithms: a survey and experimental evaluation" by for a survey of the topic.

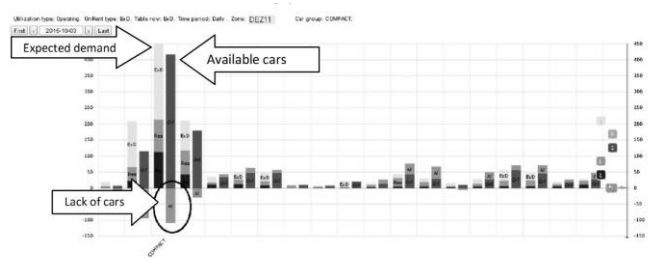
Remaining in the case of time series representing the demand for a product, in addition to the values assumed by the series itself in several previous moments, may be useful to add other features that can explain the demand dynamics. Finally, to obtain a good learning process, the use of techniques for the model validation is important. These techniques aim to avoid two possible contrasting phenomena known with the name of under-fitting or overfitting. Roughly speaking, under-fitting occurs when the relation between inputs and output is learned with inadequate accuracy. Conversely, the overfitting happens when it was learned too much from the examples of the Data Set, and the model is no longer able to generalize if a new example is processed.

In both cases, there is a loss of forecast precision. To get the best forecasts, our solution (called Opticar) tries to integrate statistical techniques and machine learning procedures, taking every precaution that the specific approach requires.

HOW OUR SOLUTION WORKS: A CAPACITY MANAGEMENT EXAMPLE

Our solution gives the users a clear view of how the business will evolve in the next four six months. In the following, an example will show how our solution (called Opticar) affects Europcar's business and how the users can interact with it by a simple "what-if analysis" to manage the resource capacity (in this example, we do not consider the price and fleet optimization).

In the figure below, it is shown the result of the unconstrained forecast scenario, in which there is a significant lack of COMPACT cars respect to the demand (negative value).



	COMPACT			
Date	Total fleet	On rent	Util %	Avail fleet
2015-10-03 SAT	417	526	126.1%	-109

Unconstrained forecast scenario – Zone DEZ11

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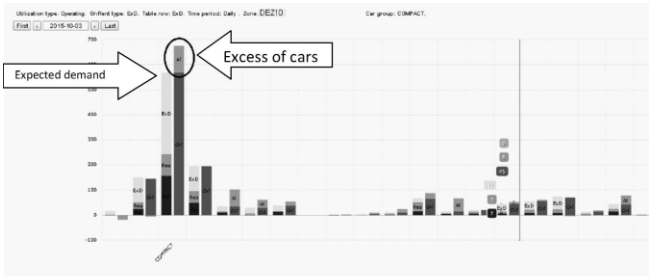
In particular, the demand for COMPACT cars in the zone DEZ11 exceeds the availability of cars for 109 vehicles. In this situation, the user can either launch the optimization procedure that manages the fleet movements or act manually, via what-if analysis, to avoid this situation and maximize the business results. For example, in the zone DEZ10, which is geographically close to DEZ11, it is expected to have an extra capacity of 108 COMPACT cars for that day.



	COMPACT			
Date	Total fleet	On rent	Util %	Avail fleet
2015-10-03 SAT	676	568	84.0%	108

Unconstrained forecast scenario – zone DEZ 10

Then a movement of cars from zone DEZ10 to DEZ11 can be evaluated to increase the revenue but also in terms of cost impact. Opticar allows creating scenarios that consider one or more transfers of cars between zones and manual scenarios can also be compared with the optimized scenario.

THE IMPORTANCE OF THE CHANGE MANAGEMENT

Technologies and technical competencies, including computational efficiency and hardware architecture, are surely important ingredients to applied Predictive and Prescriptive Analytics but, of no less importance are the change management processes and the top-management commitment to do a project like this successful.

The Europcar experience highlights the importance of such aspect. Europcar top-management followed all the project phases, of including the process re-engineering, pushing for a collaborative decision-making approach based on objective data and methods.

Moreover, the qualified time has been dedicated to designing internal trainings and lead operative managers in all the country-offices so that they and their teams can adapt to this new approach. The constant sharing of experience and best practice between revenue managers is also part of the continuous training program.

The effort has paid back in terms of business, as Europcar sees increases in volumes, especially in low seasons, but also in high seasons, and improved average rates (Revenue per Day). In addition, time savings as manual reports cease to exist, and teams can then concentrate on the revenue-enhancing tasks rather than manual reporting.

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Distribution of cars has improved, which leads to better utilization of fleet, and cost reductions. Overall the development and implementation of OptiCar has been very successful and still leaves many revenue opportunities to be explored in the future.

CONCLUSIONS

The case represents a modern application of advanced analytics, the extensive use of data by sophisticated models to drive decisions. This fact implies to introducing a culture permeating the company that goes beyond the traditional management culture. Products and services can often be copied by competitors, pushing the competition at the price level. Changing the decision-making culture, introducing the intensive use of predictive analytics and math-optimization enables, the improvement of the performances and the scientific management of the risk factors. This state is more difficult to be copied, is not only a question to buy a software, but it is also a powerful lever to win in the market.

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