Portuguese Study Groups' Reports

Report on "Revenue Management Pricing in Douro Hotels"

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Problem presented by: Marcelo Guedes (Douro Palace Hotel)

Study group contributors: Elisete Correira (UTAD), Sónia Dias (IPVC), Fernanda Ferreira (ESEIG), Ana Moura (ISEP), Paula Nunes (ESEIG), Teresa Pereira (ESEIG), Jorge Santos (ISEP), Carla Santos Pereira (UPT), Filomena Soares (ESEIG), João Soares (DMUC).

Report prepared by: All of the above.

Corresponding author:
João Soares (e-mail: `jsoares@mat.uc.pt`)

Executive summary

The Douro Palace Hotel management wants to develop a software that helps them with the dynamic pricing of the hotel rooms. Revenue Management software is widely used for data analysis of demand and prices. However the hotel barely follows the software recommendations for pricing decisions, mainly due to the lack of understanding of the rationale and the inherent difficulty in validating pricing decisions. The hotel would like to have a reliable model in order to give to the manager an overview of the business and how to act to improve the sales. The questions raised at the study group are related to this.

In this report, we present two distinct methodologies to address the hotel request. The first approach is excel based and more practically oriented towards to be an immediate help of the current pricing decisions. A second approach is more formal, mathematically speaking, but requires a more time consuming implementation. It is based on a recent operations management/operations research paper.

On short term plan, we propose the implementation of an automatic generation of excel files that will enable Douro Palace Hotel react more often/finely to the competition pricing. A thorough statistical analysis of the Demand function and the corresponding segmentation is also required - for simulation purposes or decision support. We think that Douro Palace Hotel should differentiate prices more often and promptly (both upwardly and downwardly) depending on the perception of the demand and the competitors prices.

On a long term plan, we propose the implementation of more sophisticated approaches, mathematically speaking, such as the one described in this report.

1 Introduction

Douro Palace is a 4 star hotel resort with views over the Douro River in place since 2009. The hotel has 60 similar rooms (including 4 suites), an exterior swimming pool with spa and it is surrounded by large vineyards and forests. The hotel is accessible by car, Baião is 13Km away, Peso da Régua, 31km and Porto, 80 Km; by boat, there is a pier within walking distance; and by train, the nearest train station is Aregos, 2Km away.

The Douro Palace Hotel management, single property, wants to develop a software framework that helps them with the dynamic pricing of the hotel rooms within their revenue management usual procedures. Ideally, the software should react whenever significant changes occur in the competition prices. The ultimate goal is to move towards price management automation. Revenue management (RM) is applicable to any business that has a relatively fixed capacity of perishable inventory (i.e., seats, rooms, *etc*), that inventories demand, that has a high fixed cost and low variable costs, and that has varying customer price sensitivity. Consequently, it is not surprising that RM are widely used in the hotel industry. RM pricing is based on two pricing constructs: price discrimination and demand-based pricing. A hotel that only charges one rate to all customers is not maximizing its revenue because some of its customers are probably willing to pay a higher price for the room, while other potential customers are either unable or unwilling to pay the one price offered. In order to successfully use price as a strategic weapon, hotels must study and understand both customer and competitive reaction to their use of revenue-management pricing.

Data are routinely gathered and analysed in hotels and other tourism units across the globe, through the application of adequate statistical techniques, to identify patterns of guests that do not repeat stays; booking cancelations; bookings in advance; expenditure patterns of "loyal" customers; consumption of food and beverages. In addition, it is also possible to identify the relationship between revenues and costs versus occupation / guest segmentation; to make forecasts of demand / occupancy and revenue of other departments depending on guests' segmentation. Revenue management is a mathematical framework that, taking all those elements in consideration, can help the firm sell the right inventory unit to the right type of customer, at the right time, and for the right price.

Douro Palace relies on its own information system to gather all these data and some subscribed revenue management software, such as REVGAIN, to obtain competitors' prices. REVGAIN also makes recommendations for hotel pricing decisions. However, the hotel barely follows them for the lack

of understanding of the rational the inherent difficulty in validating pricing decisions.

The strategy of the study group team was to identify and describe a set of techniques which may be used to carry out both a preliminary analysis which identifies possible groupings and relations between variables, and also some more sophisticated tools for the analysis and estimation of relations between these variables. As a result, we recommended some strategies for Douro Palace Hotel management to use.

In this report, we present two distinct methodologies to address the hotel request. The first approach is excel based and more practically oriented towards an immediate help to the current pricing decisions. A second approach is more formal, mathematically speaking, but requires a more time consuming implementation. It is based on a recent operations management/operations research paper.

In Section 2 we seek evidence of a booking, pricing or revenue problem through observation of anual revenue and monthly averages ocuppancy and price. Then, in Section 3 we roughly describe how Douro Hotel makes pricing decisions. In Section 4 we summarise the basic characteristics of the Douro Hotel main competitors. In Section 5 we quickly review Revenue management and explain why it is an adequate framework for the hotel industry. Finally, in Section 6 we propose two distinct methodologies. The first approach is excel based and more practically oriented. A second approach is more formal, mathematically speaking. It is based on the recent operations management/operations research paper [1].

2 Is there a problem?

Our first question was to seek evidence of a booking, pricing or revenue problem. Analyzing the available data from the last three years: 2013, 2014 and 2015, we observe a decreasing tendency on both total revenue (namely, 2.07, 1.73, and 1.39 million euros, respectively) and total revenue related with rooms sales exclusively (namely, 0.60, 1.10 and 0.75 million euros, respectively). We do not fully understand this behavior.

In Figure 1 we plot of average monthly occupancy at Douro Palace Hotel over the same three-year period. We observe an seasonal increase in the occupancy rate through the whole period with the exception of the last two months of 2015. In Figure 2 we plot the average monthly prices for the same period. In this plot there are two months that are unusual: February and November 2014. These two outliers may justify the "abnormal" higher rev-

enue observed in 2014. In Figure 3 we present the same plot without those outliers to better analyze the variation of mean prices along the years and along the months. With a couple of exceptions, around April and December, prices are roughly the same along the years and months, showing no significant variation. In our opinion, since room occupancy is higher in the summer months and december, prices should follow this tendency. As we will see later in this report, prices in other hotels are also affected by room demand that is higher on weekends and on "special" months. It seems that fixed prices along the year is an hotel policy!

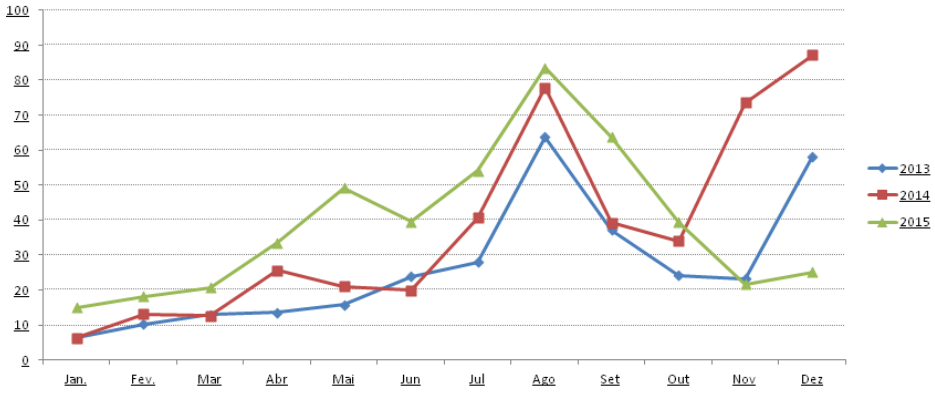

Figure 1: Occupancy 2013-2015

Some authors claim that, rather than measuring capacity utilization (occupancy, in this case) service firms should measure capacity efficiency, such as revenue per available room [4]. In any case, from the data given to us we understood decaying revenues.

3 Current Practice

In this section we roughly describe how Douro Hotel makes pricing decisions. Initial prices are set up across several channels (*e.g.*, Booking, Xpedia, Trivago) for a large time horizon that can go up to one year by using a Channel Manager software. In Figure 4 we present the prices for a basic room throughout the month of November of 2016 (considered a distant future), taken at the week of the workshop (last week of June).

Daily, the sales manager receives extensive report files output from the revenue management software (currently, REVGAIN) about the competitors'

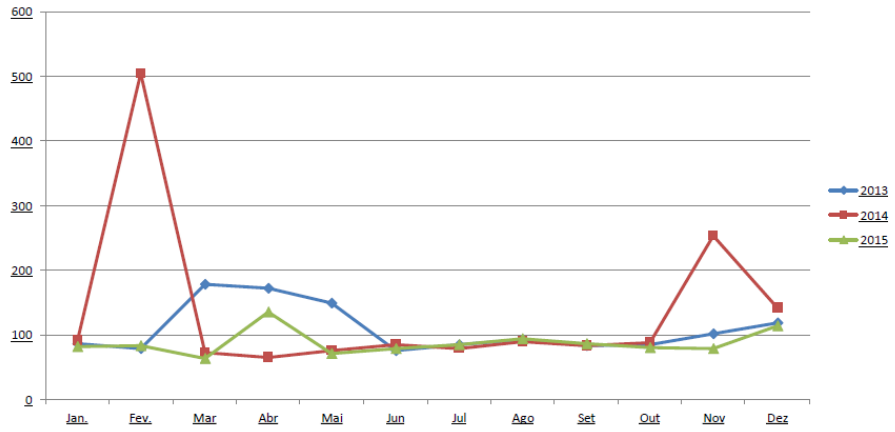

Figure 2: Average monthly prices 2013-2015

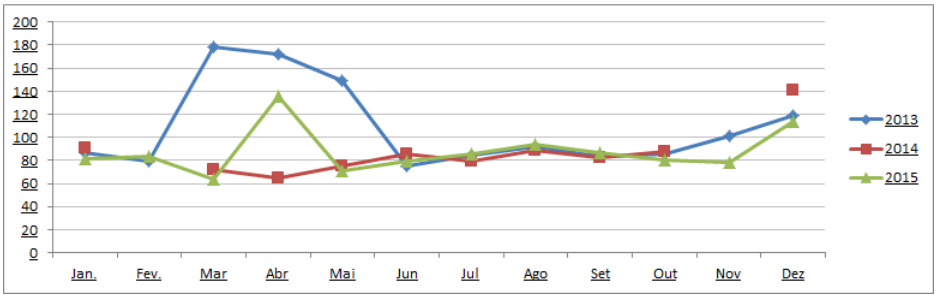

Figure 3: Average monthly prices 2013-2015 (Feb. and Nov. 2014 not considered)

prices on every channel throughout a relevant time horizon. Periodically, if so desired, the sales manager runs the Channel Manager software to update (change) Douro Hotel prices. If not, and in any case, an automatic decision rule drives the prices upward as the hotel occupation reaches certain thresholds. The following table illustrates this rule, daily prices are in euros,

Ocupation	Vista Jardim	Vista Rio	Suite
Up to 50%	91	98	155
Up to 66%	107	114	178
Up to 80%	126	133	204
Up to 100%	143	150	224

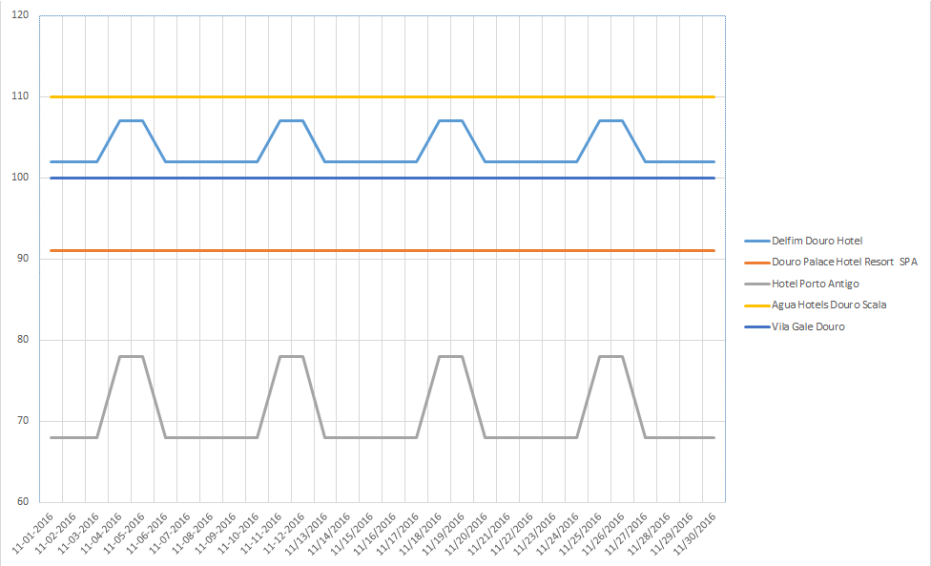

Figure 4: Prices for a basic room throughout November 2016

We have not seen evidence that the hotel makes any price adjustment downwardly.

4 Competitors Characterization

The Douro area is considered world heritage by UNESCO and, therefore, enjoys world wide reputation. There is a large hospitality offer, hotels and wine firms. The hotel assumes that wine firms are not a direct competitors. Based on information from the `booking.com` channel, the hotel believes that competitors are few, such as Régua Douro, Delfim Douro, Hotel Porto Antigo, Vila Galé and Agua Hotels Douro Scala (this two last ones being part of hotels chains). Figure 5 summarises in portuguese the basic characteristics of the competitors.

5 Revenue Management

Revenue management, a method for managing capacity profitably, has gained widespread acceptance in the airline and hotel industries in the last 20 years. Revenue management is a method which can help a firm sell the right inventory unit to the right type of customer, at the right time, and for the

Análise da Concorrência

Hotéis concorrents Localização	Review score Booking.com			Comentários negativos	Dimensão (capacidade)	Cama extra para crianças (paga?)	Vista Rio	Piscina Exterior/Interior e SPA	Nº de atividades disponíveis	Acesso a localidade mais próxima
	Total Score	V/M	Loc							
Douro Palace **(Santa Cruz do Douro, Baião)**	8,6	**7,8**	8,5	- Piscina interior paga - Restaurante lento - Pequeno almoço básico	60	Sim (<12anos 35€; > 45€)	Sim, mas distante	Sim/sim (pago)	9	Carro (12Km Baião ou 30Km Peso da Régua ou comboio (26 min a Peso da Régua
Agua Hotels Douro Scala **(Mesão Frio)** **CADEIA**	8,3	8	8,5	- Deveria ser 4* e não 5* Localização com difícil acesso -Falta de acessibilidade para mobilidade condicionada	43	Não (só berço)	Não	Sim/sim	11	Carro
Delfim Douro **(Samodães, Lamego)**	9,1	8,2	9,4	-Estacionamento difícil -Falta SPA e piscina interior -Restaurante lento	41	Sim (4 aos 16 anos 35€)	Sim	Sim/não	9	Carro
Hotel Porto Antigo **(Oliveira do Douro, Cinfães)**	8,7	8,2	9,3	-Wifi e ar condicionado -Restaurante – preço/qualidade - Precisa de remodelação	20	Sim (<10anos 19€; >10 38€;)	Sim	Sim/não	9	Carro ou comboio
Vila Galé Douro **(Cambres, Lamego)** **CADEIA**	8,7	7,7	8,8	- Estacionamento pago - Mobilidade reduzida - Restaurante caro - Falta de quartos com chuveiro	38	Sim, grátis até 12 anos	Sim	Não/sim	Sem Informação	Pé Carro
Régua **Douro (Peso da Régua)**	8,4	8	9,2	- Mau acesso do parque de estacionamento para a receção - Wifi - Cama estreita - Falta de piscina interior - Precisa de remodelação	77	Não (só berço)	Sim	Sim/não	8	Pé Carro Comboio

*V/M – relação qualidade/preço

Figure 5: Competitors' characteristics

right price. Revenue management guides the decision of how to allocate undifferentiated units of capacity to available demand in such a way as to maximize profit or revenue. The problem then becomes one of determining how much to sell at what price and to which market segment [7]. The subject is part of the curricula of several operations management master's and doctoral programs [5, 6].

The airline industry is considered the birthplace of Revenue management. After deregulation in the late 1970s, airline competition increased, and the airlines tried to operate their pricing schemes as efficiently as possible. Revenue management was one of the methods developed as a way of increasing competitive advantage and increasing revenue. In airlines, Revenue management is concerned with selling the right seat to the right customer at the right price so as to maximize revenue.

The airline and hotel industries have several characteristics in common that make them ideal candidates for Revenue-management systems. As a start, both have relatively fixed capacities. Once an airplane has been purchased or a hotel has been built, it is rather difficult and expensive to increase capacity. The idea, then, is to use the capacity in the best (most profitable) way possible. According to Kimes [3], see also [2], Revenue Management techniques are appropriate when:

the firm has relatively fixed capacity - if all rooms in a hotel are occupied, another room cannot easily be added, although the customer may be accommodated in a sister hotel. For airlines, if all seats on a flight are occupied, the plane cannot be enlarged, but it may be possible to put the passenger on a later flight. Essentially, capacity is fixed, although there may be some limited flexibility.

the firm has the ability to segment demand - the firm can segment its market into different types of customers. For example, business and pleasure travelers (further split into couples/singles and families) can be split easily into separate groups. The basic idea is that hotel managers not only have different marketing plans for the different types of customers but also, because of the large number of competitors, prices are perceived differently. Hoteliers would like to be able to sell these segments rooms that best fit their needs. In the case of pleasure travelers, lower-priced rooms that must be booked a certain length of time ahead may be most appropriate. With business travelers, higher-priced rooms that have no time penalty may work best. Basically, the business must know which customers are most likely to use variously-priced

classes of service, and must develop different marketing strategies for each market segment.

the inventory is perishable - If the room is not sold one night, that room-night is lost forever, and the hotel manager cannot put it into inventory for use at some other time. Airlines and rental-car firms face similar problems.

product is sold in advance - Some hotels sell most of their rooms a few days in advance, but in some situations, reservations are made well in advance of the day desired. In the case of group sales, reservations may be made several years in advance. When the product is sold in advance, the manager is faced with uncertainty. Should a group that wants to pay a low rate be accepted, or should the manager wait to see if higher-paying customers will appear? How many super-saver (using airline terminology) rooms should be sold? Might someone who would pay a higher rate want to reserve those same rooms? With a good revenue management system, these types of questions can be answered.

Fluctuating demand - Hotels face widely fluctuating demand patterns. Demand varies by season of the year, by day of the month, and by time of the week. Revenue management can be used to help temper some of the demand fluctuations by helping to increase occupancy during slow times (by decreasing price) and by increasing revenue during busy times (by increasing price). If a manager knows when demand peaks and valleys are going to occur, he or she will be better able to plan for them.

there are low marginal costs/high marginal change costs - Low marginal sales costs. Once a certain number of rooms are sold, it does not cost much more to sell another room. The hotel and staff are already in place, and one more room does not make much of a difference in terms of cost. Conversely, hotels face high marginal production costs. For example, if a property is full and a customer wants a room, another room cannot easily be added onto the property because of the large fixed cost. Hotels add capacity only in large chunks and only after demand patterns have been carefully studied.

Revenue Management consists of two separate but related parts: room-inventory management and pricing. The inventory-management process

deals with how different types of rooms are to be allocated to demand. The pricing procedure is more concerned with the best prices to charge in different situations.

A method that is frequently used in revenue management systems is the threshold curve. Essentially, data on past booking behavior over time (usually 60 to 90 days) are collected, curves based on historical aggregate demand patterns are constructed, and actual booking patterns are plotted against the forecast. Generally, different threshold curves are built for different days of the week and seasons of the year for particular blocks of inventory (room types). Given that some fluctuations in demand are likely to occur, an acceptable range of variation is calculated using standard deviations of demand (see Figure 6). If demand is higher than expected, one or more rate classes may be closed, while if demand is lower than expected, one or more rate classes may be opened. A simple threshold curve can be built using historical mean and standard deviations of demand, although many of the commercial applications of this methodology are fitted using cubic spline methodology. Despite this limitation, the threshold curve methodology is fairly simple to use and appears to give good results. In addition, aggregate demand, rather than demand for different rate classes, is used to develop the threshold curve. As with other methods, the most critical problem is obtaining timely and accurate information.

6 Our methodological proposals

Here, we present two distinct methodologies to address the hotel request. The first approach is excel based and more practically oriented towards an immediate help to the current pricing decisions. A second approach is more formal, mathematically speaking, but requires a more time consuming implementation. It is based on the recent operations management/operations research paper [1].

6.1 An excel based methodology

Our first methodological proposal is not too difficult to implement but it requires a more indepth knowledge of the overall demand and its segments (e.g, families, couples, *etc*). It seems that the hotel already have some data that would enable a first attempt to fully characterize the demand. Then, we propose the implementation of the following steps:

1. Use PRICEGAIN to obtain a report of the (available) prices of com-

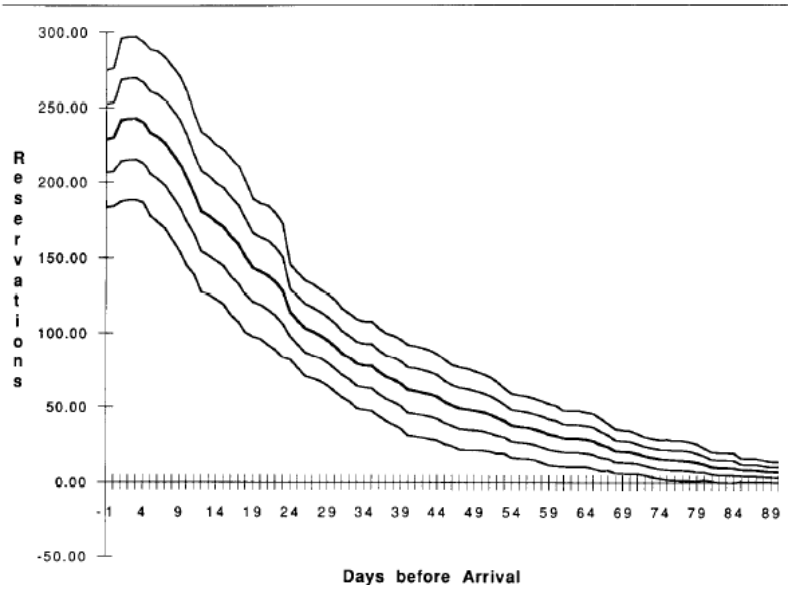

Figure 6: Exemplification of threshold curve

petition over a significant time horizon (e.g., 3 months) for different types of rooms.

2. For each room type and for each demand segment (e.g., *basic room* ≡ Twin or Double Room ~~Balcony~~ ~~Half/Full Board~~ ~~Luxurious View~~ ~~Family~~, etc) prepare an EXCEL file with **normalized** prices. Each demand segment perceives the prices over different hotels in different way: a 100 euros for a basic room is valued differently across different hotels.

3. Based on the graphs produced, the sales manager decides upon price changes. For example, Figure 7 presents the prices (non normalized) for a basic room at six similar hotels (Douro Hotel and its competitors) for the whole month of July of 2016 taken on June 28th. In the same figure, the bars mean number of hotels that are sold out for a basic room in that particular day (a red bar means Douro Hotel). Figure 8 presents the same information taken two days after - in this figure only variations from Figure 7 are plotted.

4. Implement the above in a *rolling horizon* manner every day/week/2 days/etc. Keep records of competition prices for further analysis.

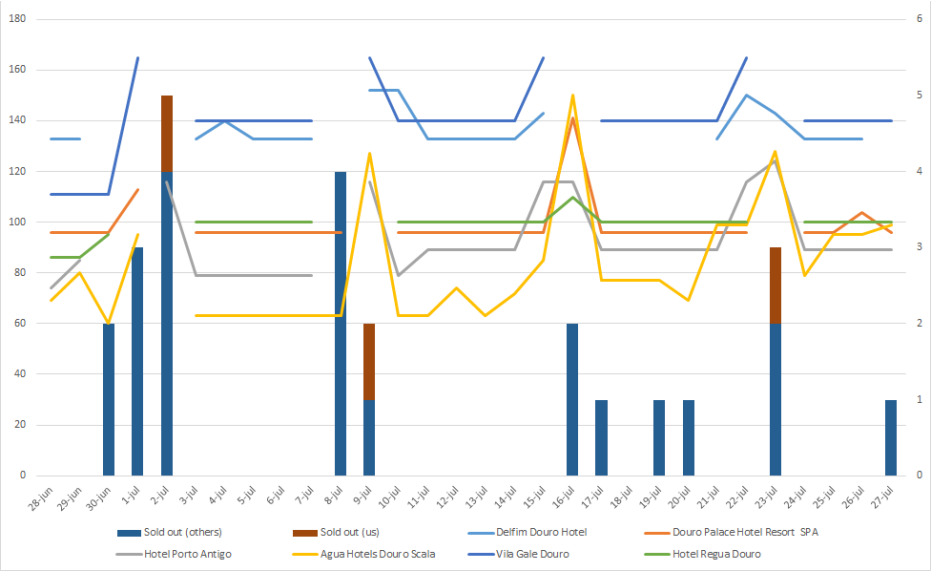

Figure 7: Prices for july (taken in June 28th)

An immediate observation from Figures 7 and 8 is that (some) other hotels change prices more frequently - maybe forcing cancelations in others. The Excel graphs also allows for the identification of *red signs* - moments where Demand is likely to be absorbed by others. This is to be judged with care because how a particular demand segment values a similar basic room across different hotels needs a better understanding. Therefore, the need for a *same unit* measurement - the normalized prices

The automatic generation of these Excel files is not problematic. What is not so straightforward is the quantification (forecast) of the Demand function and the corresponding segmentation - which needs to be done anyway.

Based on the work developed through the week, we propose that Douro Palace Hotel:

- Install such an excel based framework.
- React more often/finely to the competition pricing - e.g., downward on week days and upward on weekends.
- Differentiate prices depending on perceived demand - e.g., price weekends differently.

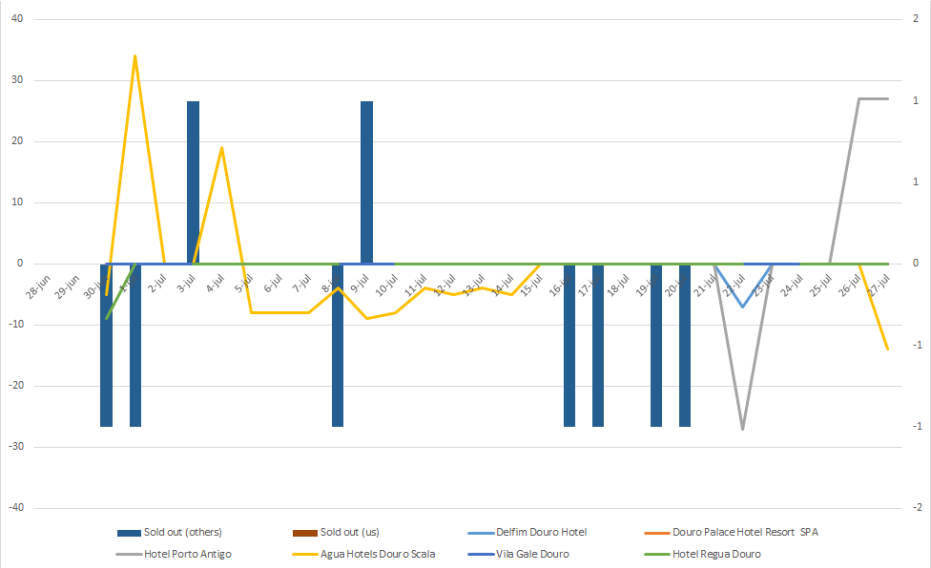

Figure 8: Price changes for july (taken in June 30th) - see Figure 7

6.2 A Dynamic Pricing approach

Dynamic Pricing is one of the strategies of revenue management and consists on setting flexible prices for products or services based on current market demands. Using algorithms that take into account competitors pricing, supply, demand, and other external factors in the market, business will be able to change prices to maximize revenue.

Since one of the goals of this study group is to understand the criteria used by the RATEGAIN software when these softwares "suggest" the prices, we studied the algorithms of the work of Bayoumi et al' 2013 [1] and based on them, it was possible to simulate the prices for the hotel with knowledge of the variables that influenced these values. So, in this section, using some real data provided by Douro Hotels, we present a simple simulation of the Price Multipliers Approach, based on the work referred above.

Prices for a night stay at Douro Palace Hotel are available at all internet booking channels one year in advance. Until three/four months of the night's stay, prices do not change. Only during the previous three months of the night's stay, they look for the information and prices' recommendations given all days by the RATEGAIN software. With the software *Channel Manager*, hotel could resend new prices whenever they want for all internet channels.

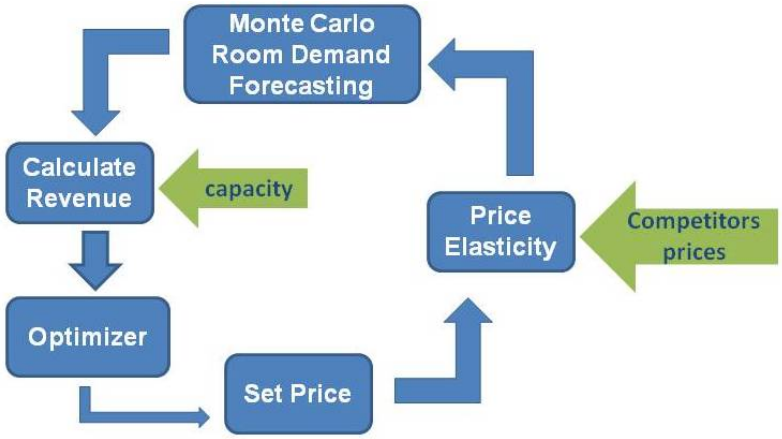

Figure 9: The pricing algorithm of Bayoumi et al.

They ask us to explain what is the mathematical reasoning behind these type of programs for the prices' suggestions.

The Price Multipliers Approach is an intricate algorithm (see Figure 9) that uses a Monte Carlo simulator to simulate all hotel's processes, and make a room demand forecasting, calculates the revenue, and then uses an optimizer to optimize the estimated revenue. The optimization consists on determining the values of price multipliers (the variables) of the formula that defines the price of a night stay.

Naturally, a price change will influence demand. Using a price elasticity function estimated from hotel's historical data and also from competitors' prices, a new demand is obtained. The algorithm iterates again until it obtains the hopefully best parameters selection that lead to a maximum total revenue.

We did not implement such algorithm due to the short duration of the study group and also because the available data was not sufficient. Nevertheless, we will explain the behavior of the multipliers in the price model. Therefore, what we will present in the following subsections is not the model that optimizes the price, but the function that explains how some external factors are used to obtain the iterative prices. We do not take into account the demand forecasting relative to the change of prices.

6.2.1 The Price Multipliers Approach

The price for a night stay on a given day, with n days in advance, will be determined using the following factors: first, it will be based on a reference price given by the hotel manager, that is determined by his experience or based in the historical data; then, a few multipliers of certain influencing variables will be added. These multipliers vary around 1, meaning that some discount (if the multiplier is less than 1), or some premium (if the multiplier is greater that 1), will be implemented; finally, another function is applied that takes into account the competitors' prices and produces a smooth change on the suggested price.

Let $P_{\text{Multipliers}}$ be the price to be obtained. It will be the product of a seasonal reference price P_{SR} suggested by the hotel manager by the following four variables (called *multipliers*):

M1: time remaining until the arrival date;

M2: current occupancy rate for the target date;

M3: length of the stay;

M4: group reservation size.

Although the last two variables influence pricing, Douro Hotel does not want to consider them. For that reason, the price multipliers formula to be considered is the one that follows:

$$P_{\text{Multipliers}} = P_{\text{SR}} \times M_1 \times M_2$$

where $M_i \sim 1$, for all i, and setting $0,8 \leq M_1 \times M_2 \leq 1,5$, for example, to guarantee that the pricing is under control. Note that this range was defined by the hotel manager, who wants to have prices between some previously defined limits.

We used some data provided by the hotel relative to June 2016. For this month, the seasonal reference price is €97, not distinguishing between week days and weekends. For the example that we will present, we distinguish them and we used €97 and €121 as the June seasonal reference price for week days and weekends, respectively.

6.2.2 Time multiplier

Up to three months before the date of stay, the price of the room to be launched for all the channels will be the reference price, and it will increase

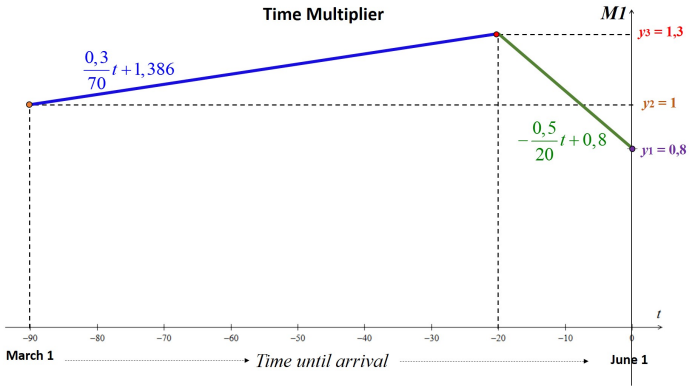

Figure 10: The *time multiplier function.*

as we approach the date of stay and also until the day observed by the hotel's manager experience or by the data history to be the moment when there is more demand and customer availability to book a room at a higher price. Currently, hotel suggested us 20 days before the date of the stay. A few days before the date of stay there is no longer expectations to book available rooms, so, the value decreases until the minimum value set by the hotel, which in this case will be €78.

The behavior of this multiplier is modeled by a two lines function (see Figure 10): the first one is increasing, and the second one is decreasing; the domain is the interval consisting on the three months before the date of stay, and the images of the extremes of the domain are fixed by the hotel manager, by defining the seasonal reference price and the minimum price, respectively, €97 and €78 for June week days. So, multipliers y_1 and y_2 are already defined, and multiplier y_3 is chosen such that the area of the region below the graph of the function is 1.

We observe that, in Bayoumi et al's Algorithm, multipliers y_1 and y_2 are some of the variables that we want to optimize and, therefore, the iterations of the algorithm will produce smooth changes on the graph of the *time multiplier function.*

6.2.3 Capacity multiplier

While the occupancy rate of the hotel for a given night stay is low, we have to create incentives to try to reach an occupancy rate to obtain revenue, say 50% of occupancy rate. When the occupancy is close to full capacity, we

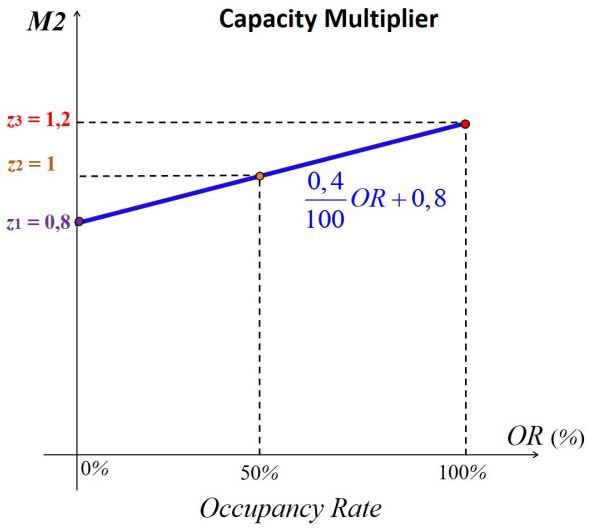

Figure 11: The *capacity multiplier function*.

can increase prices to improve revenue. This is why we model the *capacity multiplier* as an increasing line (see Figure 11) such that the maximum price value given by this multiplier should not be higher than $1,5$ times the reference price and the minimum value is chosen such that the area of the region below the graph of the function is 1. In our example, we set the maximum value of the multiplier to be $1,2$, meaning a maximum price of €116, and a minimum price of €78 for a night stay in a week day of June 2016.

The hotel provided the data of all the reservations for June 2016. We constructed two occupancy rates' graphics during the three months before a night stay, respectively, for week days and for weekends. Instead of showing all days of the month, Figure 12 shows the mean of the occupancy rate in a week and in a weekend, respectively. The values are the measures, respectively, before February, in February, March, and weekly in April, May, and the weeks of June before each night stay.

6.2.4 Effect of the Competitors' Prices

Business should always be alert with competitors' prices. If, at some moment, they start to offer best prices, the demand in our business could decrease a lot in a few days. This is why it is important to look at the current directly competitors' prices when we are finding the best price for our

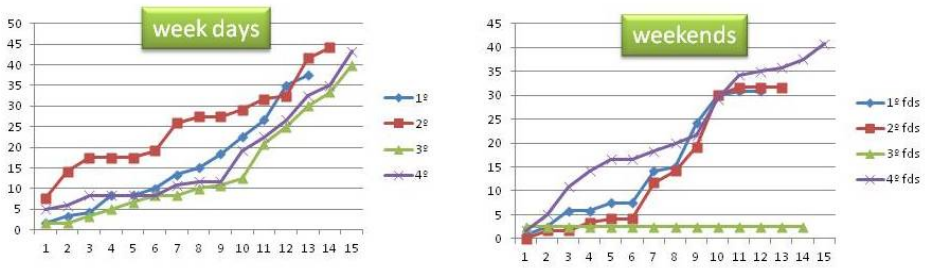

Figure 12: The growth of the *occupancy rate* for June 2016, before February, in February, March, and weekly in April, May, and the weeks of June before each night stay.

product. In the study group week, we made a simple approach taking into account competitors' prices by adding a new multiplier and by improving the previous model.

There are five hotels in the Douro Valley that Douro Palace Hotel takes as its directly competitors: Agua Hotels Douro Scala, Delfim Douro, Hotel Porto Antigo, Vila Galé Douro, and Régua Douro. The *competitors multiplier* will be determined as follows (see Figure 13). We use the hotels rate on the Booking.com channel to obtain a weight for each hotel (the mean of the five hotels weights is 1). Then, we obtain the proportional weight of our hotel. Hotels with higher weights (when offering the same product) will be firstly chosen by the clients.

	DOURO PALACE	Agua Hotels Douro Scala	Delfim Douro	Hotel Porto Antigo	Vila Gale Douro	Régua Douro
Rate	8,6	8,3	9,1	8,7	8,7	8,4
Weight	0,995	0,961	1,053	1,007	1,007	0,972

Figure 13: The *hotel's weight* based on Booking.com clients' rate.

We define the *competitors multiplier* M_c as

$$M_c = w_0 \times \left[1 + \frac{1}{5}\Sigma_i\left(w_i \cdot \frac{P_{i,\text{Today}} - P_{i,\text{LastWeek}}}{P_{i,\text{LastWeek}}}\right)\right]$$

where w_0 is the weight of Douro Palace Hotel, and, for $i = 1, \ldots, 5$, w_i is the weight of competitor i, and $P_{i,\text{LastWeek}}$and $P_{i,\text{Today}}$ are, respectively,

the prices for the fixed night stay of competitor i launched on the internet booking channels in the previous and in the current week. Factor w_0 will cause an increase/decrease of this variation with respect to the hotel's rate when compared with its competitors. The second factor, when multiplied by the current price, will increase/decrease such price with the same variation of its competitors, in average.

Now, we may correct the price obtained from the previous model using the variation of the competitors prices. We consider the following model:

$$P_{\text{Corrected}} = p_1 \times P_{\text{Multipliers}} + p_2 \times M_c \times P_{\text{LastWeek}}$$

where $P_{\text{Multipliers}}$ is the one obtained previously, P_{LastWeek} is the current price on the internet channels that we want to improve, and p_1 and p_2 are weights, i.e., $p_1 + p_2 = 1$. We suggest that $0,5 \leq p_1 \leq 1$, which means that the price given by the multipliers model should make a greater contribution in the calculation of the corrected price than the variation of the competitors prices.

To make a simulation with this model for June 2016, we need the historical data of the prices launched on the internet channels during the three months until the date of each June's night stay. Unfortunately, hotel does not have these data. So, we made a forecast in the way that follows. We considered that a night stay in the months of July, August, and September has the same hotel's price as in June. Then, to obtain the price for a night stay n months before such fixed night stay, for $n = 1, 2, 3$, and 12 (one year in advance), we check the price for a night stay n months after the study group week (last week of June). We obtain the four graphics of Figure 14.

6.2.5 A simple simulation

Now, we are able to make a simple simulation for the variation of prices for June night stays, over the three months preceding June. We suppose that from one year in advance till four months ago the prices launched for the internet channels did not changed and they are equal to the seasonal reference prices €97 and €121 for week days and weekends, respectively.

We implemented the formula of Subsection 6.2.4 using the time multiplier, the capacity multiplier with the data of Figure 12 and the forecast of the competitors prices for each month. The obtained prices are presented in Figure 15. The weights p_1 and p_2 considered in the formula were $0,7$ and $0,3$, respectively.

In Figure 15 we may compare the forecast prices, obtained as described in the end of the Subsection 6.2.4, with the simulated prices from the model

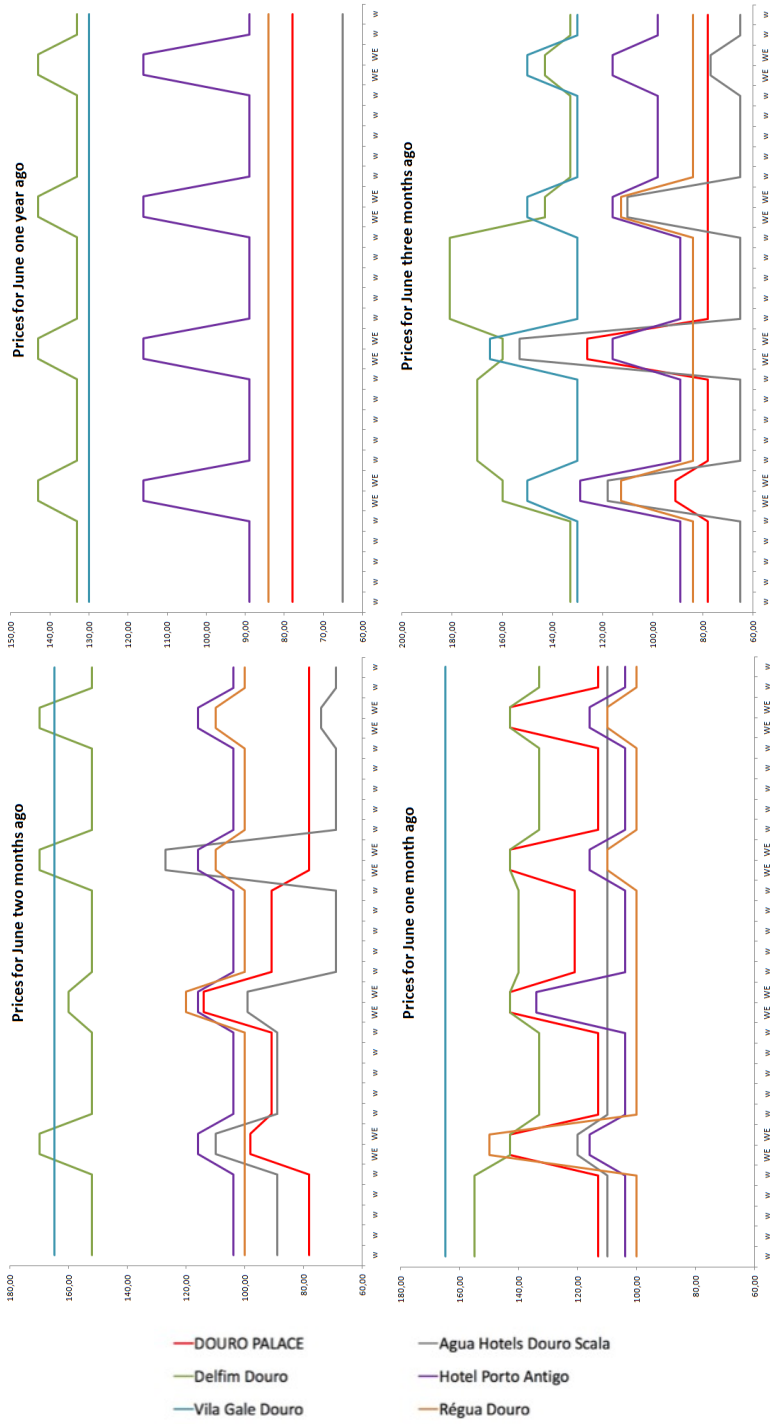

Figure 14: A forecast of the *competitors prices* for June 2016 one year ago, and three, two and one month ago, respectively.

proposed.

The line of the simulated prices show that in general, the prices predicted for the Douro Hotel with the model proposed are higher than the forecast. The prices predicted are always higher in the weekends, which is not a previous practice of the hotel but is in accordance with the tendency of the other hotels. The increase of the prices until 20 days before the date of the stay is influenced by the prices of the competitors hotels. Twenty days before the date of the stay, the simulated prices decrease because, according to the information in Figure 12, the occupancy rate for June 2016 is low.

As we observe in the graphs, the Douro Hotel will have advantages in using the model suggested in this section. The prices will be in general higher but still lower than the prices of the competitors hotels that are better classified by the clients (see Table 13) and because of this we expect that this different price policy would not influence the clients decision.

As a conclusion, we consider that the application of the model proposed will be easy to understand for the sales manager and allow the increase of the revenue.

To implement an algorithm to optimize revenue, it is necessary to analyze and evaluate big data sets about our hotel and its business environment. Due to the restrictions of duration of the study group week and the amount of lacking data, we opted for exemplify a behavior of prices that leads to the growth of revenue. We presented a price model based on the work of [1]. This could be part of an algorithm to optimize revenue. In our work, we did not calculated revenue, and we did not simulated demand forecasting. Even to simulate the behavior of prices, there was some lacking data: we did not have the historical data of real prices for June 2016 of Douro Palace Hotel and its competitors. Note that, in future, if we want to implement such algorithm, this type of data will be collected in real time.

We heavily recommend the hotel to use these types of techniques of revenue management. Besides the growth of revenue, the mathematical study of all hotel data will help in understanding of some current misunderstood decaying revenues.

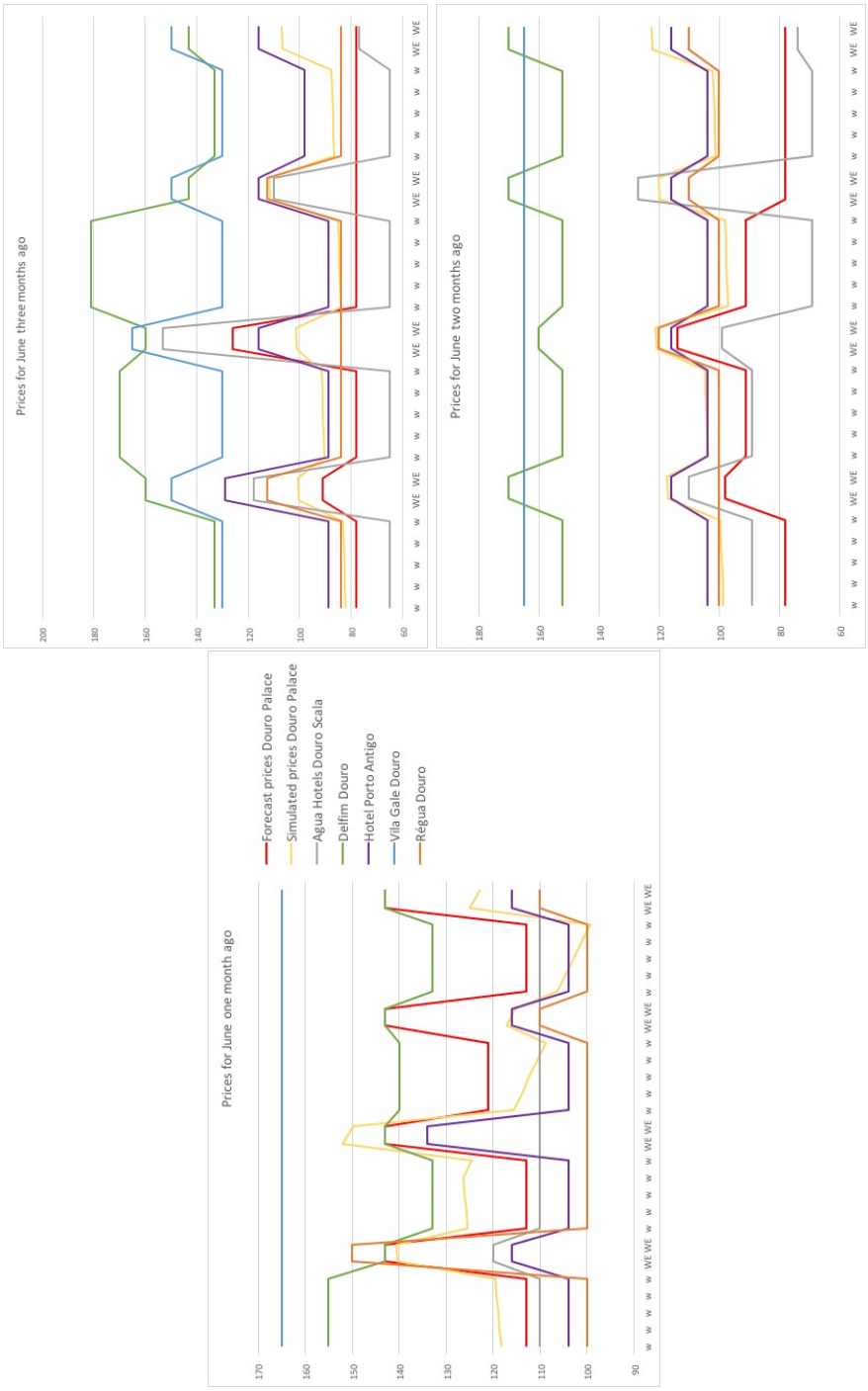

Figure 15: A simulation of the prices of the Douro Hotel for June 2016 three, two and one month ago, respectively.

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