Application of a hotel pricing model to the munich hotel market

Antoine Thomas

2614919

Seminar Paper

Chair of Information Management
University of Würzburg

Supervisor: Prof. Dr. Christoph Flath
Assistant: Toni Greif

Würzburg, May 10, 2023

Contents

List of Figures

List of Tables

Acronyms

ADR Average daily rate. 1, 2, 7, 12, 14

MU Monetary unit. 3

OCC Occupancy. 1

OTA Online travel agency. 2

RevPAR Revenue per availably room. 2, 7, 12, 14

RM Revenue management. 2, 3

Abstract

In this work, data on the Munich hotel market has been applied to a hotel pricing model in order to define room rates for middle-class hotels that maximise profits. The Munich hotel market in particular has been very competitive for a long time, so it is important to obtain very accurate data. However, due to the lack of available information, assumptions have to be made about the situation in the Munich hotel market. It has been shown that, depending on the characteristics of a market and a hotel, setting higher or lower prices than the competition can lead to higher profits. It has also shown the importance of correctly determining variable costs and, in particular, the relationship between price and demand in a specific market. Hotel managers can use the results to gain valuable insights for effective pricing and straightforward risk management.

1 Introduction

Munich, the capital of Bavaria, is one of the most popular destinations for tourists and business people from all over the world. In recent years, Bavaria has hosted the most tourists in the whole of Germany. About one fifth of them visited the city of Munich[1]. With 18.29 million overnight stays in 2022, tourism in Munich had recovered somewhat from the pandemic[2]. Even before the pandemic, the city recorded 16.29 million overnight stays in 2019 (Colliers International Hotel GmbH, 2020b). Tourism turnover was 8.6 million in 2019 and, according to Clemens Baumgärtner, a German politician from the SPD party, is an important factor for the economic location of Munich[3].This attractiveness, which is associated with a high level of foreign demand, is mainly due to the high demand for trade fairs and events (Colliers International Hotel GmbH, 2020b), which is met in Munich.

The growth of the hotel industry has been particularly noticeable in recent years. In 2019, 20 hotels with a total of more than 8,000 beds were newly opened. Accordingly, at the end of 2019 there were around 470 accommodation establishments in Munich (Colliers International Hotel GmbH, 2020b). However, demand has hardly changed. Prices also remained largely unchanged. The hotel and restaurant association «Dehoga» has been critical of this development for years and fears the bursting of an existing «bubble»[4]. As a result, strategic pricing is of great importance for hotels, both in periods of high demand and in normal times.

In this work, a spreadsheet pricing model by Leong and Lee is applied to hotel room rates in the Munich hotel market for the year 2023 and corresponding aggregated historical data, differentiating between two demand phases, a normal demand phase and the period of the annual Oktoberfest as a high demand phase. The aim is to determine the optimal pricing in order to maximise profits. However, due to the lack of publicly available detailed data, the determination of the model's input factors can be complicated in some cases, so that various input variables have to be simplified and defined by appropriate assumptions in the course of data collection and analysis. On the one hand, hotel room rates have to be collected for the Munich hotel market in order to define average daily rates (ADR) for the above-mentioned demand phases. Similarly, the pricing model of Leong and Lee (2010) requires data on the occupancy rate (OCC) of hotel establishments and the demand for hotel rooms in the Munich market. Such data are not freely available and are approximated in our analysis using hotel market reports and articles dealing with the determination of price-demand relationships. Determining the costs of hotels and their structures is also

[1] https://stadt.muenchen.de/dam/jcr:6478ba7e-3f40-4c85-a22d-7d6c5abb41c8/mb190401.pdf

[2] https://www.muenchen.de/sehenswuerdigkeiten/muenchen-zahlen\-interessante-fakten-ueber-die-stadt#:~:text=The%20tourism%20in%20Munich%20has\%20recovered%20since%20the%20start%20of%20data%20collecting

[3] https://www.sueddeutsche.de/muenchen/muenchen-tourismus-bilanz-2019-1.4806519

[4] https://www.sueddeutsche.de/muenchen/muenchen-tourismus-bilanz-2019-1.4806519

complicated. Although a hotels revenue per available room (RevPAR) can be determined without taking costs into account, this is not the case for profits. In the first part of the work, the determination of these parameters is described in detail. With this information, an application of Leong and Lee's model can be made. In a corresponding part, the results obtained are presented and discussed. Finally, Leong and Lee's model and the data obtained for our application are critically questioned and evaluated in order to determine whether they correspond to reality and whether an application by a hotel company would be meaningful.

2 Literature review

Hotel managers take pricing decisions in the annual budget process, which usually takes place in the second half of the year. However, price decisions may need to be made at different times of the year for group bookings, contract negotiations or when new prices have to be set for short periods due to unplanned happenings (Steed and Gu, 2005). Therefore, hotels should *"have an effective pricing process in place at all times which takes into account customer needs, profit demands, brand integrity and macroeconomic factors"*(Steed and Gu, 2005). The financial impact of pricing decisions in hotels can be enormous. A decrease of 1€ in average daily rate (ADR) might can have a large impact on revenue in absolute terms. Thus, price decisions are very important, but they come with a lot of complexity due to the many factors that need to be taken into account (Steed and Gu, 2005).

In the 1980s and 1990s, hotel managers began to develop first awareness for revenue management (RM). According to Kimes (2016), hotel chains began to focus on RM with very small departments of around 2-3 employees. At the time, sales approaches were taken where potential guests were offered high prices in the sales process and lower prices if the guest declined. However, this approach was not particularly well regarded as it was considered unfair. After conflicts of interest arose between Sales and Marketing, which focused more on large bookings, and the Front Office, which dealt with transient customers, RM and pricing of hotels was moved into one separate department. According to a study by Kimes (2016), RM in hotel chains should by now be independent and centralised or reginonalised.

In the early stages of RM, room rates were mostly taken for granted. By 2010, RM was practiced with a much more sophisticated marketing approach, and the breakthrough of online travel agencies (OTA) in particular triggered the dynamic pricing approach (Kimes, 2016). *"Up until 2005, hotels charged the same rate for the entire length of a guest's stay. In contrast, Expedia was charging different rates for different days of a guests stay"*(Kimes, 2016).

Kim et al. (2020) showed in a study that various attributes of a hotel can have an impact on its room rates. These include the size of the property, its age, the quality of its services, and geographical attributes such as distance to airports, motorways or tourist attractions. There are several different approaches that hoteliers can take to determine the price of their rooms.

According to Steed and Gu (2005), hotel pricing can be approached in four main ways: cost-based pricing, market-based pricing, combined cost and market-based pricing and best practice pricing. Cost-based pricing focuses on the cost of building and maintaining hotels. Hotel managers have used two methods to price their rooms: The first was a rule of thumb, whereby the price of a hotel room increased by one monetary unit (MU) for every 100,000 MU required to build a hotel room. Another option was the Hubbart formula, a more complicated 8-step process that takes into account all of a hotel's costs and revenues for a given year. However, these cost-based pricing methods do not take into account the market and its conditions, as well as what customers want. As a result, this method is no longer used and has largely been replaced by market-based pricing strategies that take into account competition and other factors. (Steed and Gu, 2005)

The second method described by Steed and Gu (2005) is market-based pricing. This approach follows the economic principle of supply and demand to create an equilibrium price that results in an equal supply and demand for hotel rooms. *"In essence, prices rise when demand exceeds supply and prices fall when supply exceeds demand"* (Steed and Gu, 2005).

By combining these two previous methods, Steed and Gu (2005) describe the Combined Cost and Market-Based Pricing method, which is believed to be the closest to the approach of Leong and Lee (2010) used in this work. A hybrid pricing approach links room rates, demand and variable operating costs to determine the optimal room rate that maximises profits. As fixed costs are sunk costs in this context, they are not taken into account when identifying the optimal room rate. Research has shown that *"variable costs are important in pricing and that hotel demand can be influenced by other psychological and market factors"* (Steed and Gu, 2005).

According to Kimes (2016), hotel chains and RM specialists have expanded their pricing to include much more analytical approaches. Of particular interest are developments such as the integration of marketing analytics and especially data analytics by Marriott and Fairmont *"to better understand customer-spending behaviour, their propensity to stay at multiple properties and their long-term relationship with the chain"* (Kimes, 2016). However, Kimes (2016) still sees room for improvement in hotel pricing and management, and expects the integration of marketing analytics into RM and pricing to continue to grow. Among other things, she expects RM to be increasingly taken over by specialist companies in the future. One example is Swiss start-up RoomPriceGenie, which has raised $3.6 million from venture capital funds and angel investors in recent years.

3 Methodology

In this work, a business spreadsheet model developed by Leong and Lee (2010) is used to optimise prices. This model is designed to determine ideal prices for a hotel based on the hotel's own cost structure, occupancy rate and price elasticity of demand. Tools such as "Goal Seek" and "Solver" are used to maximise profit per room. The first step is to define the input variables to be used in the model. The fixed and variable costs per room need to be specified, as well as the prices charged and the occupancy rates in each demand period. At the same time, a percentage for other levies (e.g. additional tourist tax, which depends on the revenue and is paid by the hotel) can be specified, which is then added to the costs in the model. On this basis, a "basic price-profit model" can be created, providing information on revenue and profit as a function of input variables. However, the "basic price-profit model" does not allow realistic price optimisation because it assumes that the occupancy rate remains unchanged when prices change and does not include a price-demand relationship. In an extension, such a relationship is defined by assuming a linear relationship and specifying how much the occupancy rate changes in relative terms for a given relative change in price. For example, if during a normal demand phase a room is priced at €200, the hotel is 80% occupied and it is assumed that the occupancy rate of the hotel would decrease by 0.45% if the price increased by 1%, then an occupancy rate for a different price can be calculated using eq. 1.

$$occupancy_{new} = (1 - 0.45 \cdot \frac{price_{new} - price_{given}}{price_{given}}) \cdot occupancy_{given} \tag{1}$$

Using this formula and taking into account the figures mentioned above, one could determine an occupancy rate of 44% for a room rate of €400. Based on at least two room rates and the corresponding occupancy rates, a simple linear regression model is then set up for each demand phase, describing a specific price-demand relationship (see eq. 2 + 3 based on the example data above). Where OCC is the occupancy rate at a given price, α is the potential demand for rooms when the room rate is 0, β is a measure of the price sensitivity of demand.

$$OCC = \alpha + \beta \cdot price \tag{2}$$
$$OCC_{normal\_demand} = 1.16 - 0.0018 \cdot price \tag{3}$$

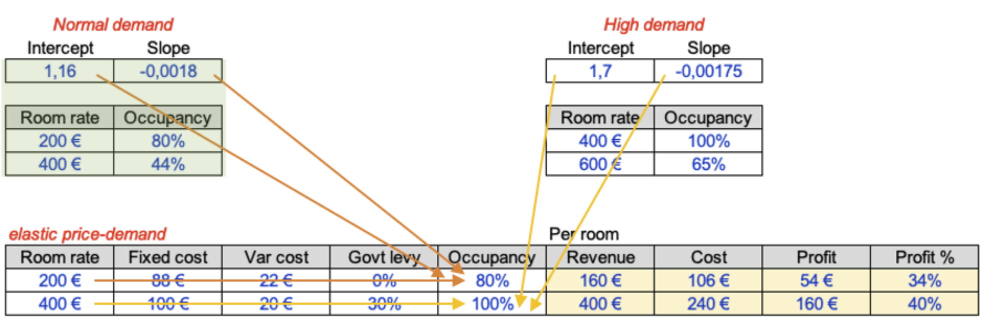


Figure 1: Price-demand elastic model - Model: Leong and Lee (2010)

In an adapted pricing model (see figure 1), the determined price-demand relationship is now incorporated. In the spreadsheet, the hotel occupancy is determined based on the regression and an actual price. By dynamically integrating this relationship, the room price can now be set using a "solver" to maximise profit.

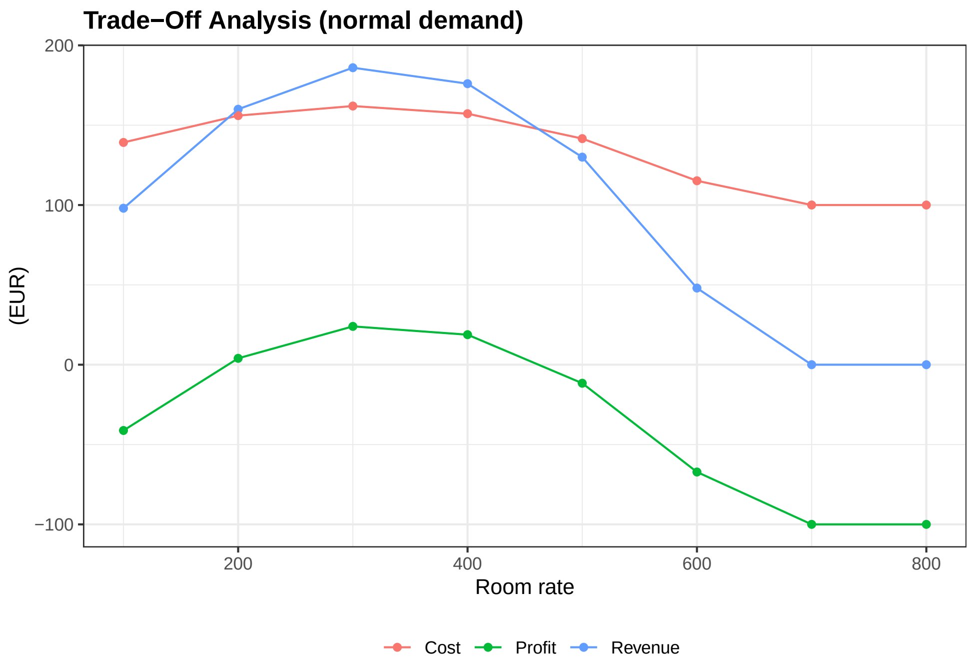


Figure 2: Trade-Off analysis for a normal demand - Model: Leong and Lee (2010)

A subsequent trade-off analysis (see figure 2) allows users to see how profit changes if the optimal room rates are not chosen. Furthermore, a sensitivity analysis (see figure 3 + 4) allows the user to determine the impact on profit of changes in uncontrollable external factors such as the price-demand relationship. Especially due to the fact that inputs such as the price-demand relationship are mostly determined by estimations based on little available historical data (Leong and Lee, 2010), a sensitivity analysis is of great advantage for early detection of the extent of possible consequences in case of a wrong estimation.

	Intercept	Slope
Occupancy Function	1,16	-0,0018

Room rate	Fixed cost	VarCost	Govt levy	Occupancy	Revenue	Cost	Profit	Profit %
200 €	100 €	10 €	0%	80%	160 €	108 €	52 €	33%

Profit	Occupancy Slope											
Room rate	-0,002	-0,0019	-0,0018	-0,0017	-0,0016	-0,0015	-0,0014	-0,0013	-0,0012	-0,0011	-0,001	-0,0009
100 €	-14 €	-13 €	-12 €	-11 €	-10 €	-10 €	-10 €	-10 €	-10 €	-10 €	-10 €	-10 €
200 €	44 €	48 €	52 €	56 €	60 €	63 €	67 €	71 €	75 €	79 €	82 €	86 €
300 €	62 €	71 €	80 €	89 €	97 €	106 €	115 €	123 €	132 €	141 €	149 €	158 €
400 €	40 €	56 €	72 €	87 €	103 €	118 €	134 €	150 €	165 €	181 €	196 €	212 €
500 €	-22 €	3 €	27 €	52 €	76 €	101 €	125 €	150 €	174 €	199 €	223 €	248 €
600 €	-124 €	-88 €	-53 €	-17 €	18 €	53 €	89 €	124 €	160 €	195 €	230 €	266 €
700 €	-266 €	-217 €	-169 €	-121 €	-72 €	-24 €	24 €	73 €	121 €	169 €	217 €	266 €
800 €	-448 €	-384 €	-321 €	-258 €	-195 €	-132 €	-68 €	-5 €	58 €	121 €	184 €	248 €
900 €	-670 €	-590 €	-509 €	-429 €	-349 €	-269 €	-189 €	-109 €	-29 €	51 €	131 €	212 €
1.000 €	-932 €	-833 €	-734 €	-635 €	-536 €	-437 €	-338 €	-239 €	-140 €	-41 €	58 €	157 €
1.100 €	-1.234 €	-1.114 €	-994 €	-874 €	-754 €	-634 €	-514 €	-394 €	-274 €	-155 €	-35 €	85 €
1.200 €	-1.576 €	-1.433 €	-1.290 €	-1.147 €	-1.004 €	-862 €	-719 €	-576 €	-433 €	-290 €	-148 €	-5 €
1.300 €	-1.958 €	-1.790 €	-1.622 €	-1.455 €	-1.287 €	-1.119 €	-951 €	-784 €	-616 €	-448 €	-281 €	-113 €

Figure 3: Sensitivity analysis data for a normal demand (Model: Leong and Lee (2010))

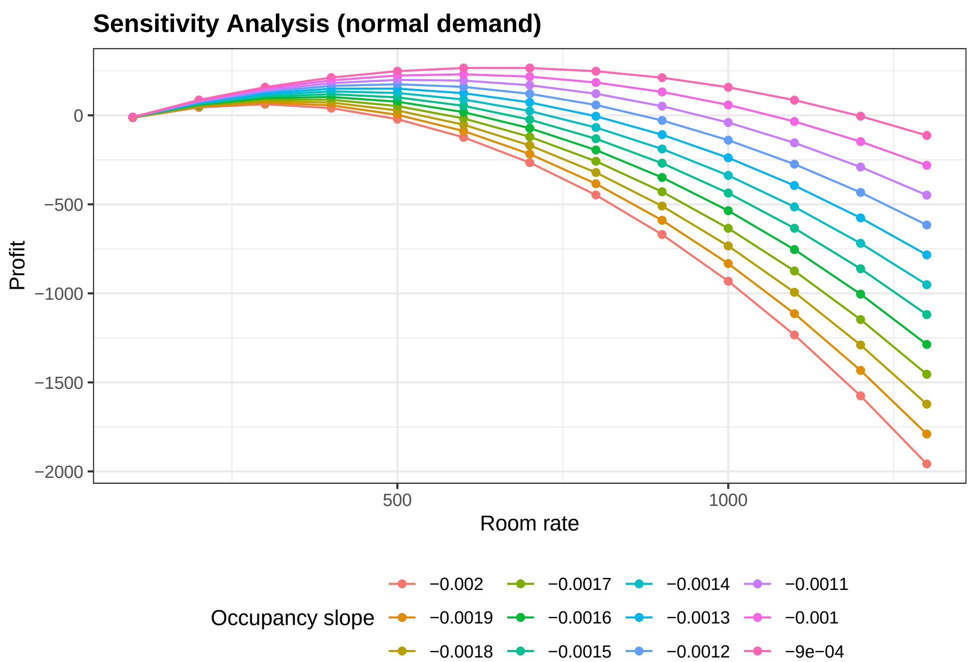


Figure 4: Sensitivity analysis plot for a normal demand (Model: Leong and Lee (2010))

Based on this example case in figure 3 and 4, it can be observed that changing the slope in the regression model related to our specific price-demand relationship (see eq. 3) has an impact on the whole optimisation model. If the slope is reduced, this implicitly means that the impact of a price increase on occupancy will be significantly lower. Conversely, if the slope is increased, the impact on occupancy will be significantly greater if the price is increased. Accordingly, the maximum profit will be higher or lower depending on the specific case. In the following sections, data from the Munich hotel market will be applied to this model as an application case with the aim of maximising profit. We will compare the period of the Munich Oktoberfest as a high demand period with a normal demand period.

For this purpose, data such as room rates, occupancy rates, price-demand relationships and cost structures have to be determined/assumed.

4 Data Collection

As a first step, the booking platform Booking.com was used to obtain data on hotels and their daily room rates in Munich. This platform was particularly suitable because a large proportion of German hotels are listed on it. In addition, the hotel data on the respective hotel pages is almost always structured in the same way. In order to make the analysis as consistent as possible, ten hotels were identified within a maximum radius of two kilometres of the Oktoberfest. These should all be in the medium price range. In a previous study by Enz and Canina (2010) on competitive pricing in European hotels, 91.94% of their sample of 273 German hotels were chain affiliated. Although their study shows that the relationship between the ADR and occupancy/RevPAR is slightly different when comparing chain and independent hotels, it was decided not to make a strict distinction between the two categories in this work. However, care was taken in the identification process to select mainly independent hotels.

To collect hotel room rate data, a web scraper was developed in Python to retrieve data for a given hotel for a given time period. The scraper extracts the source code from the respective booking pages and then retrieves the data relevant for our analysis. In order to call the developed function *scrape_prices*, several parameters need to be set. For *accomodation_url* the URL of the given hotel is passed, for *checkin_date* and *checkout_date* the corresponding information about the duration of the stay and for the parameters *adults* and *children* the number of guests has to be specified. *no_rooms* defines the number of rooms to be booked. The function then retrieves the requested booking page and processes the contents of the source code. During the scraping process, the hotel name, address, Booking.com hotel rating, room category and room rates are extracted. Finally, the retrieved and structured data is stored in comma-separated .csv files in the working directory.

For each of the ten selected hotels, all available room rates for a single night from 10 April to 31 December 2023 were extracted from Booking.com. Only rates for 2 adult guests sharing a double room were included.

Other data used in our study were mainly taken from market reports, books and articles. Data on the performance of the Munich hotel market was obtained from market reports for 2021, 2020 and 2019 by Colliers International, a Canadian service and investment management company. Data on the relationship between RevPAR/occupancy and the relative change in the average daily room rate was taken from the study by Enz and Canina (2010). In this study, the impact of a change in room rates was measured for each hotel according to its direct competitors. As cost structures tend to be different for each hotel business and depend on many factors, no universal valid values could be drawn in this work. However, a book by Henschel, Gruner, and Freyberg (2018) on all aspects of hotel management provides examples of cost structures for different types of hotels, which will be used for our application case. All of the above data will be analysed and summarised in the following analysis section.

5 Data Analysis

5.1 Hotel room rates

First, the scraped datasets containing room price information for selected hotels are imported. Then, the data set for each hotel is filtered to only contain price information for basic double rooms. Care is also taken to ensure that there is a maximum of one entry for each hotel per day. Therefore, the cheapest option is always selected. This is primarily done because more expensive prices usually include various extras, such as a more flexible cancellation policy or meals such as breakfast. In this way, all room rates cover a comparable range of services, regardless of the hotel. All data from each hotel is then combined into one large data set.

In the combined dataset, the Oktoberfest must now be labelled as the high demand period. In 2023 the event takes place from 16/09/2023 to 03/10/2023. To label the dataset, a function is created that takes a date as a parameter and checks whether this date is within the period of the Oktoberfest. A new attribute Oktoberfest is then added to our dataset, which uses the above function to indicate whether or not the Oktoberfest takes place on a particular date.

The price development over time from 10 April 2023 to 31 December 2023 is shown for the selected hotels (see figure 5). + 15). The vertical lines indicate the beginning and the end of the Oktoberfest period. These figures show that, on average, all hotels charge their highest room rates of the year during the period of the Oktoberfest. During the rest of the year, price fluctuations are clearly observed for some very brief periods, but these cannot be compared with the magnitude of the Oktoberfest period.

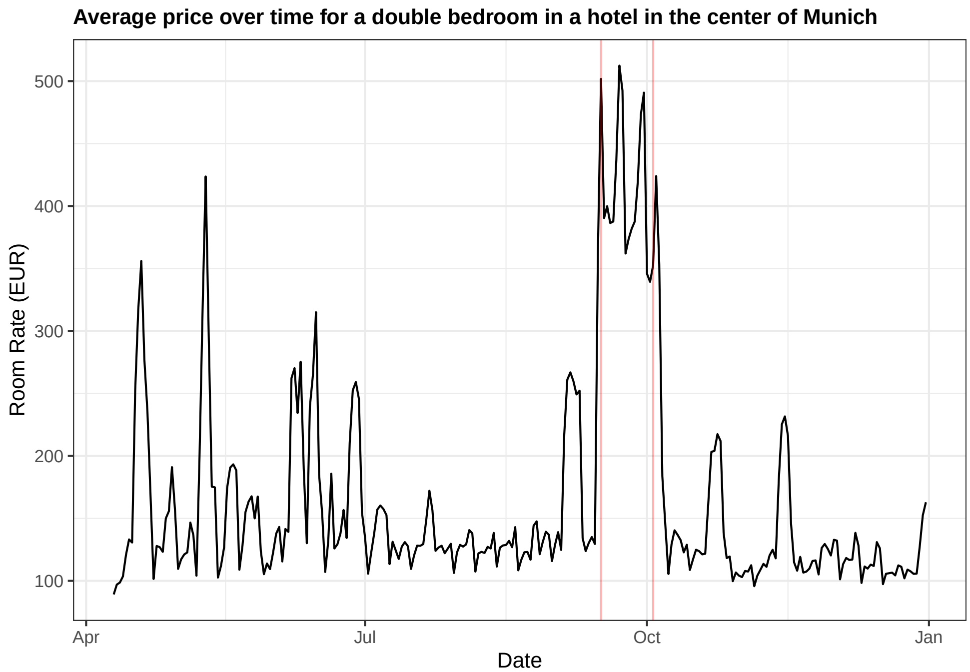


Figure 5: Average hotel room rate over time for a double room in the city center of Munich

In order to allow a separate analysis of both demand periods, the combined dataset is now split in two parts. One part contains only prices during the Oktoberfest (dataset 1) and the other part only prices during periods not related to the Oktoberfest (dataset 2). Looking at the average prices over time, one can clearly see that even in periods unrelated to the Oktoberfest, above-average prices can occur for very short periods. A boxplot (see figure 6) illustrates this characteristic by showing observable outliers. These outliers range from approximately 240 to 580 Euros and represent about 12.5% of all observations. An initial assumption that these prices are charged on weekends in order to profit from weekend tourism was investigated in more detail. This was done by filtering out all outliers in "dataset 2". The day of the week was then added to each observation. However, in a diagram (see figure 7), which visualises the number of outliers for each day of the week, no higher price tendency can be observed on weekends. As these outliers could not be accurately linked to clear events or causes, it was decided to exclude them from the data set and not to consider them as prices related to a normal demand period.

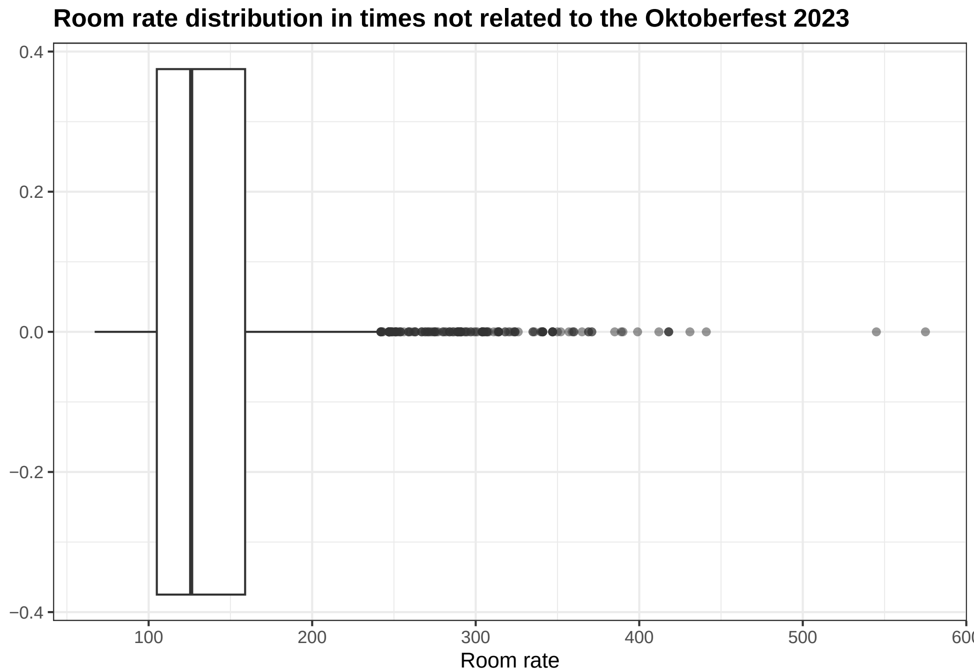


Figure 6: Room rate distribution in times not related to the Oktoberfest 2023

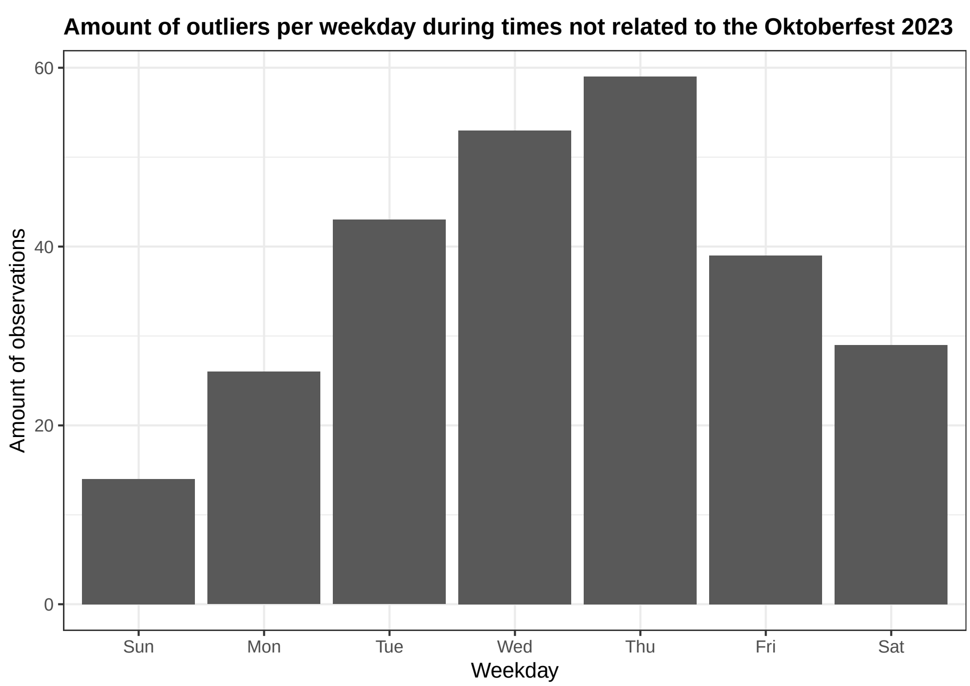


Figure 7: Amount of outliers per weekday during times not related to the Oktoberfest

After removing the outliers (12.5% highest price-related observations) in the non-Oktoberfest periods from the data set, adjusted average prices could be calculated. In 2023, the average price of a single double room in a mid-range hotel during normal demand periods is around €129. During the Oktoberfest period, a room costs around €413 per night. Looking at the whole period recorded in 2023, without differentiating between events, the average price of a room is €166 per night. The median price is around €129.

Whole year	Room rate
Mean	166,66€
Median	129,25€

Demand phase	Room rate (mean)
Normal demand	128,89€
Oktoberfest	412,98€

Table 1: Average/Median room rates during normal, high demand phases and over the whole caputured time

Looking at individual hotels, the average room rates in both demand phases and their relative difference were calculated for each hotel (see table 9). An average relative price increase of about 320% can be observed for the Oktoberfest period compared to the normal demand periods. However, there is considerable variation between hotels. The lowest price difference between the two periods in our hotel sample is 283%, while the highest goes up to 389%. The standard deviation is about 32%. In the course of the further analysis, room rates had to be assumed for the high demand phase, the Oktoberfest, as well as for the normal demand phases. For this purpose, the corresponding average values (413€/night during Oktoberfest, 128€/night during normal demand periods) were used.

5.2 Hotel market performance in Munich

To obtain general data on the performance of hotels in Munich, the 2019 hotel market report was used as part of the analysis. Due to the unusual situation in 2020 and 2021 caused by the covid pandemic, the use of more recent data had to be examined. According to the Munich Hotel Market Report, prices on the Munich hotel market fell by an average of 22.8% in 2020. The massive drop in prices is also linked to the cancellation of the Munich Oktoberfest and other events, as well as the lack of demand from international guests (Colliers International Hotel GmbH, 2021). Although the situation improved somewhat in the following year's report (Colliers International Hotel GmbH, 2022), many events, including the Oktoberfest, did not take place that year either. As the event did not take place in these two years and the Munich hotel industry was in an exceptional situation, using data from 2020 and 2021 does not make sense in our analysis.

In the Colliers International hotel market report, hotel performance KPIs from 2009 to 2019 were taken from a chart. Its data were extracted to create a reproduction. According to the report, a positive development of the Munich market could be observed in 2019. Although room occupancy fell by around 1.3% that year, this was offset by a slight increase in room rates. As a result, revenue per available room also increased slightly (Colliers International Hotel GmbH, 2020b).

The following graph shows the average annual values of ADR, RevPAR and occupancy for each year from 2009 to 2019 in Munich.

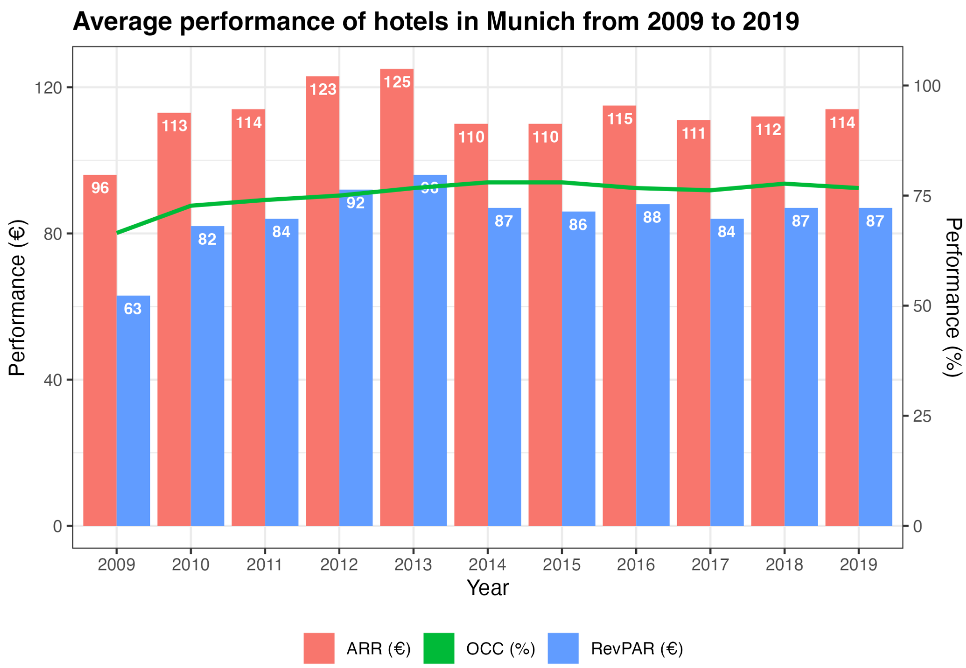


Figure 8: Market performance of hotels in Munich from 2009 to 2019 - Source: Colliers International Hotel GmbH (2020b)

In order to apply the model of Leong and Lee (2010), a room rate and a corresponding occupancy rate have to be specified for each demand phase. As the average room rates for high and normal demand were determined in the first part of the analysis, occupancy rates had to be estimated for the Munich hotel market. According to an article in the Süddeutsche Zeitung on hotel bookings during the Oktoberfest, almost all hotels were fully booked in 2019, not only in Munich but also outside the city (Katharina Haase, 2022). As the sample consists of mid-range hotels in the immediate vicinity of the Oktoberfest, it was assumed in the further analysis that these were always fully booked at the time of the event. Given an average price of €413, it was therefore assumed that a hotel in our sample would have an occupancy rate of 100% at the time of the event.

To estimate the occupancy rate during a normal demand period, data from the market report Colliers International Hotel GmbH (2020b) were used. For this purpose, the average of the occupancy rates for 2019 and 2018 was first calculated. However, as this is an average for the whole year and does not take into account the fact that the 17 days of the Oktoberfest are assumed to be 100% occupied, it has to be adjusted accordingly (see eq. 4).

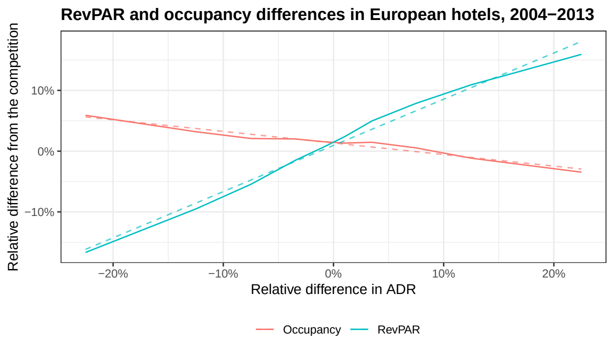
$$
\begin{aligned}
occupancy_{avg} &= \frac{occupancy_{adj} \cdot (365 - 17) + occupancy_{oktoberfest} * 17}{365} \\
\iff occupancy_{adj} &= \frac{occupancy_{avg} * 365 - occupancy_{oktoberfest} \cdot 17}{365 - 17}
\end{aligned}
\tag{4}
$$

	Occupancy
Average	77.2%
Normal demand phase	76.1%
Oktoberfest	100.0%

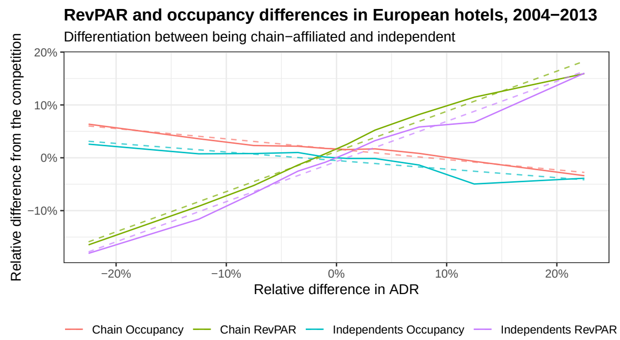
Table 2: Hotel occupancy for different time periods in Munich

5.3 Price-demand relationship

If hotels set their prices higher than their competitors and market demand remains the same, they are likely to experience higher revenues. Conversely, if prices are set lower than those of competitors, hotels are likely to experience higher occupancy rates (Leong and Lee, 2010). In the study of Enz and Canina (2010), the impact on hotel revenues and occupancy rates was determined on the basis of price differences between direct competitors within a local market. They found that price differences in the average room rate relative to competitors had an impact on revenues and occupancy rates. However, the impact of price differentials on occupancy rates was generally found to be small across Europe. On average, a 15-30% higher room rate relative to competitors results in only a 3.46% lower occupancy rate. A 15-30% lower room rate results in a 5.9% increase in occupancy. The differences between chain and independent hotels are significant. It is clear that, on average, independent hotels have lower revenues and occupancy rates than chain hotels (Enz and Canina, 2010). Figures for the European market were not considered fully representative of the Munich market for the purposes of this work and had to be adjusted. The treatment of this data and the definition of a price-demand relationship is discussed in more detail below.



(a) Average differences



(b) Differences differentiating chain-affiliated and independend hotels

Figure 9: RevPAR and occupancy differences in European hotels, 2004-2013 - Source: Enz and Canina (2010)

It can be observed that hotels can see a difference in occupancy and RevPAR compared to their competitors (see figure 9) for an unchanged price. This is most likely due to the fact that the data collected by Enz and Canina (2010) includes competitive sets for each hotel, defined by each hotel itself. Each hotel has named at least 4 direct competitors according to its own conscience and the basic specifications set by STR Global, an organisation that provides market data on the hotel industry worldwide (Enz and Canina, 2010). Since the illustrated price and occupancy/RevPAR relationships were determined by comparing each hotel's performance with its own and self-declared direct competitors, it is reasonable to assume that hotels may have named direct competitors that perform worse on average than themselves. This would be a plausible explanation for the fact that the regression lines do not intersect the y-axis at zero. This phenomenon is mainly observed for chain affiliated hotels (see figure 9b). As chain-affiliated hotels clearly predominate in the sample of Enz and Canina (2010) (74%), this may also explain why, when looking at the average difference values (see figure 9a), both lines intersect the y-axis well above the origin. Since any hotel can define both independent and chain hotels as direct competitors, it would be a realistic assumption to say that chain hotels charging the same room rate as directly competing independent hotels represent a higher value to customers.

However, since our sample represents only hotels with very similar characteristics, and for simplicity's sake we have to assume that a consumer is indifferent between all these hotels at a given price, the regression lines in our case must cross the origin. Accordingly, the relationship between ADR and occupancy/RevPAR has been adjusted (see figure 10). At the same time, as only average values are available for the relationship between ADR and occupancy/RevPAR, it is not possible to determine how these factors correlate specifically during periods of high or low demand. As only average values are available for the European market as a whole, further adjustments need to be made before they can be applied to individual hotel markets. After Berlin, Munich is the German city with the highest demand for accommodation. With 18.3 million overnight stays and 87,993 beds in 2019 (bed occupancy rate of 56.98%), the hotel market in Munich is highly competitive (Colliers International Hotel GmbH, 2020a). Particularly in the mid-range segment, it can be assumed that individual hotels probably have little power over the pricing of their rooms due to the wide range of offerings and the high level of competition. A price increase would most likely result in a much higher decline in occupancy rates than the European average indicated by Enz and Canina (2010). Therefore, depending on how competitive a hotel's local market is, the price-demand relationship, which is represented by a linear regression as in eq. 2, needs to be adjusted. For this purpose, a fixed multiplier, defined according to a market and its competitive situation, has been added to our linear regression model (see eq. 5). A multiplier of 1 represents a market that corresponds to the European average (see figure 10). A multiplier lower than 1 indicates that the market is less competitive than the European average. A multiplier higher than 1 represents a market with above-average competition. As competition in the Munich hotel market is particularly high (Colliers International Hotel GmbH, 2020a), a multiplier of 3.5 was hypothetically assumed for our use case (see eq. 6). A relative change in the price of 1% therefore results in a change of the occupancy rate of $19.05\% \cdot 3.5$.

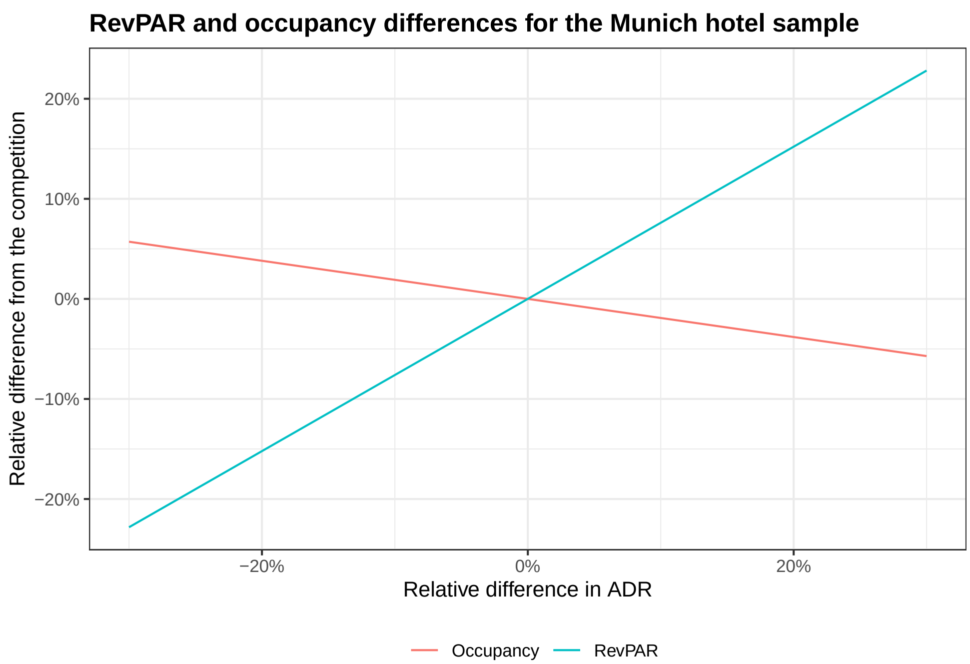


Figure 10: Adjusted RevPAR and occupancy differences for the Munich hotel sample

$$relative\_diff_{occupancy} = 0.00 - 0.1905 \cdot multiplier_{competition} \cdot relative\_diff_{ADR} \quad (5)$$

$$relative\_diff_{occupancy} = 0.00 - 0.1905 \cdot 3.5 \cdot relative\_diff_{ADR} \quad (6)$$

It was now possible to determine how much a relative change in price affects the relative change in occupancy in the Munich market. As we have a price for both demand phases for which occupancy values are available, we could now determine the occupancy to be expected for any given relative price change. It is already known that in our sample an average price of €128.89 is set during a normal demand phase and hotels can expect an occupancy of 76.09%. Accordingly, using the linear regression models determined above (see eq. 6), a 30% price increase (167.56€), for example, would result in a 20.00% decrease in occupancy. Therefore, in a normal demand phase, an occupancy of 60.87% can be expected at a price of 167.56€. The same applies to prices during periods of high demand. During the Oktoberfest, hotels charge an average rate of €412.98 and are assumed to be fully booked. Accordingly, a price increase of 50% (€619.47) would result in a decrease in occupancy of 30.34%. According to this calculation, an occupancy rate of 66.66% should be expected during the Oktoberfest period at a room rate of €619.47.

Once at least two room prices and their corresponding occupancy rates have been determined for each demand phase, linear regression models can be used to calculate a price-demand relationship for each of these demand phases, which allows the immediate determination of a specific occupancy rate for any given room price (see figure 11 and 7 + 8). These formulas follow the same logic as eq. 2. For a normal demand phase, 1.268163 would be the occupancy in case of a room price of 0, while -0.003936 represents the price sensitivity of demand.

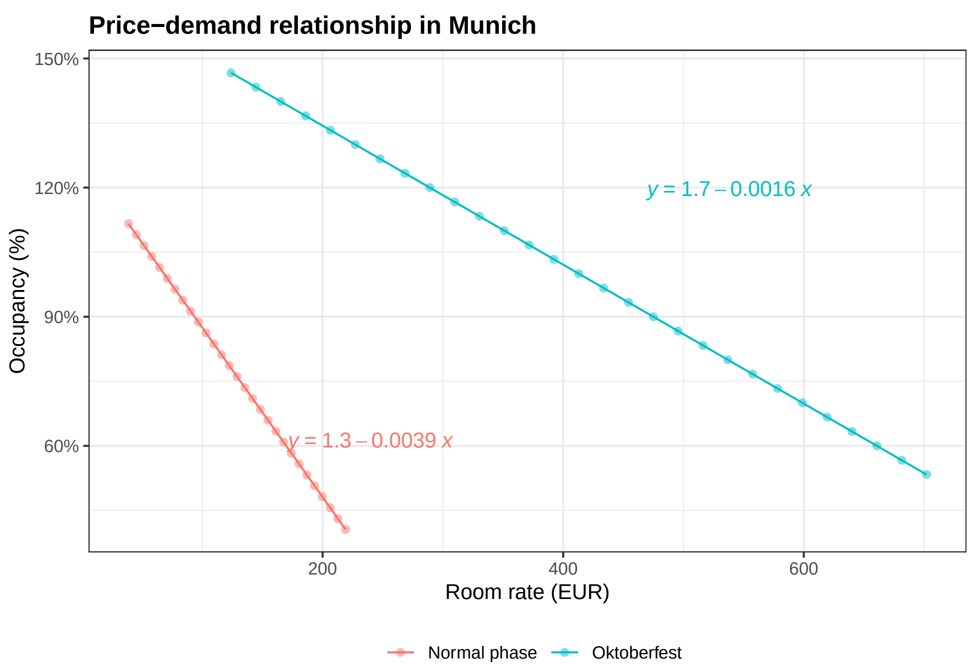


Figure 11: Price-demand relationship for the specific Munich hotel sample

$$occupancy_{normal} = 1.268163 - 0.003936 * room\_rate \tag{7}$$

$$occupancy_{oktoberfest} = 1.666745 - 0.001614 * room\_rate \tag{8}$$

5.4 Cost Structure

The level and structure of hotel costs depend on a number of factors. These include the volatility of demand, the range and quality of services offered, the size of the hotel, its location and the terms of ownership (owned or leased). In addition, expenses of around 90-95% of revenues are quite common. In particular, personnel and material costs are the most important factors in the cost structure of hotels. In addition, the majority of expenses are fixed costs. In general, and also for our application case, it is necessary to distinguish between fixed and variable costs.(Henschel, Gruner, and Freyberg, 2018, p. 203+204) According to (Henschel, Gruner, and Freyberg, 2018), the cost structure in hotels also depends on the occupancy rate. The higher the occupancy rate, the lower the fixed costs. At the same time, variable costs increase.

In the context of our application case, due to the lack of specific figures on the cost structure of hotels in Munich, data available in literature has to be used. For this purpose, two convenient tables can be taken from the book by Henschel, Gruner, and Freyberg (2018). The expenses are calculated on the basis of the hotel's revenues (see table 3). A distinction can be made between owned and rented facilities.

The cost structure depending on the service provided (see table 4) allows the breakdown of expenses into fixed and variable costs. This cost structure depends on both the type of hotel and the average occupancy rate of a given hotel. Although a classification of fixed and variable costs usually takes a lot of time and effort, fixed costs are usually caused by "capacity costs" and "on-call" costs based on the specific service process in the hotel. "Operating costs" represent the variable costs of hotel facilities.(Henschel, Gruner, and Freyberg, 2018, p. 203)

Expenses	Proportion of operating income	
Operating expenses		
Cost of goods	22,30%	
Personnel expenses	32,40%	
Energy consumption	5,90%	
Taxes/fees/contributions/insurances	3,80%	
Other operating and administrative expenses	11,70%	
Investment-related expenses	*Owned business*	*Leased business*
Rent and lease expenses	0,20%	12,60%
Leasing	0,10%	0,80%
Depreciation	6,60%	2,90%
Interest on debt	1,90%	0,50%
Maintenance	6,90%	3,80%
TOTAL	91,80%	96,70%

Table 3: Example of a Structure of operating and investment-related expenses for a city hotel with normal facilities (Henschel, Gruner, and Freyberg, 2018, p. 203).

Hotel type	Occupancy in %	Capacity costs	On-call costs	Operating costs	Total costs
Single-season operation	50	34,8	40,4	16,8	92,0
	70	30,3	49,3	20,4	100,0
	100	26,1	48,6	25,3	100,0
Two-season operation	50	21,3	58,1	20,6	100,0
	70	18,0	57,6	24,4	100,0
	100	15,2	55,5	29,3	100,0
Holiday hotel	50	16,6	59,8	23,6	100,0
	70	13,7	58,9	27,4	100,0
	100	11,3	56,4	32,6	100,3
Hotel garni	50	22,7	64,2	13,1	100,0
	70	18,7	62,3	15,0	96,0
	100	16,3	65,0	18,7	100,0

Table 4: Raw costs structure of hotels depending on the service provision (in %) (Henschel, Gruner, and Freyberg, 2018, p. 204).

To determine a cost structure, some of the data in table 4 had to be adjusted slightly for our use case due to unexplained inconsistencies (see table 5). It was found that for certain occupancy rates and hotel types, the relative amounts of "capacity costs", "on-call costs" and "operating costs" did not add up to 100%. At the same time, the sum of these three cost categories should represent the total costs of a hotel (Henschel, Gruner, and Freyberg, 2018, p. 50). To ensure that the three cost categories always add up to 100%, the cost categories were adjusted as follows.

$$Capacity\_costs_{adj} = \frac{100\%}{Total\_costs} * Capacity\_costs \tag{9}$$

$$Oncall\_costs_{adj} = \frac{100\%}{Total\_costs} * Oncall\_costs \tag{10}$$

$$Operating\_costs_{adj} = \frac{100\%}{Total\_costs} * Operating\_costs \tag{11}$$

For the remainder of our analysis, the "hotel garni" was chosen as the type of hotel that most closely matched our sample. A "hotel garni" is an establishment that offers accommodation, breakfast, drinks and at most small meals (Colliers International Hotel GmbH, 2022). The corresponding cost structure was then simplified and reduced to fixed and variable costs (see table 5+ 6).

Occupancy	**Capacity costs**	**On-call costs**	**Operating costs**	**Total costs**
50,00%	22,70%	64,20%	13,10%	100,00%
70,00%	19,48%	64,90%	15,63%	100,00%
100,00%	16,30%	65,00%	18,70%	100,00%

Table 5: Adjusted cost structure (Hotel garni)

Occupancy	**Fixed costs**	**Variable costs**	**Total costs**
50,00%	86,90%	13,10%	100,00%
70,00%	84,38%	15,63%	100,00%
100,00%	81,30%	18,70%	100,00%

Table 6: Adjusted fixed and variable cost structure (Hotel garni)

Using the data in table 6, the following linear regression models were created for both fixed and variable costs.

$$Y_{fix.costs} = 0.9235 - 0.11125 * X_{occupancy} \tag{12}$$

$$Y_{var.costs} = 0.0765 + 0.11125 * X_{occupancy} \tag{13}$$

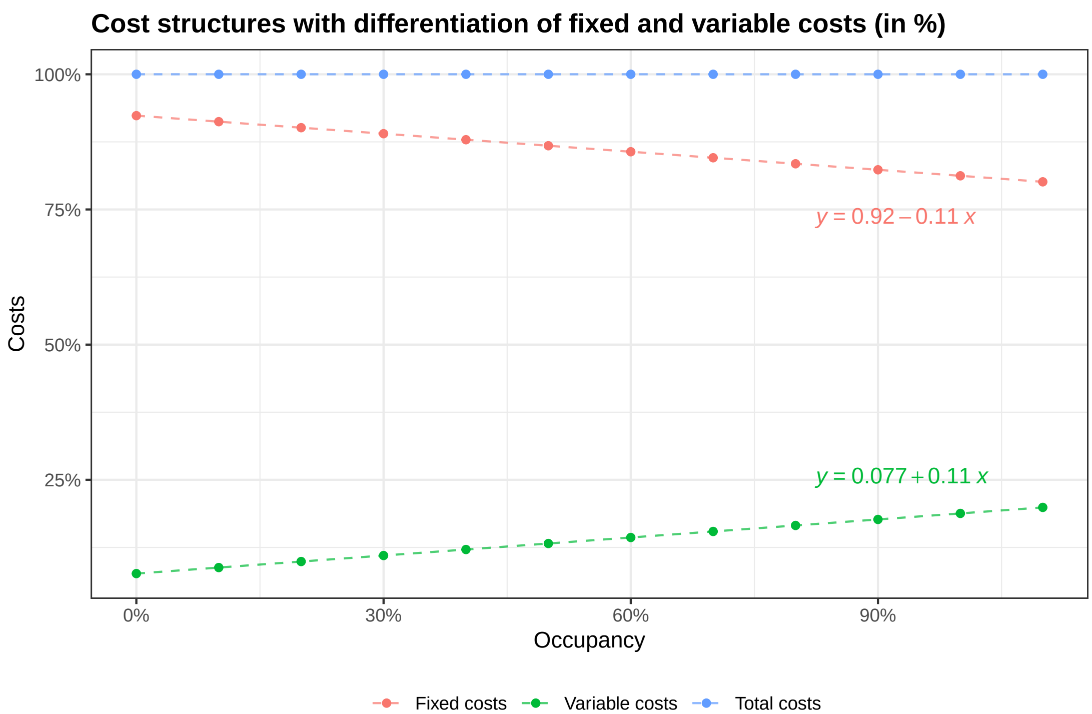


Figure 12: Cost structures with differentiation between fixed and variable costs (in %)

In the first part of the analysis, an median room rate of €129.25 was determined for the entire period represented by our sample. Here, the use of the median value was preferred to the mean value due to the high number of outliers. In addition, the average occupancy rate of hotels in Munich (2018-2019) was assumed to be 77.2%, based on data from hotel market reports. First, the proportions of fixed and variable costs were calculated using the linear regression models (see eq. 12+ 13) and the average occupancy rate of our sample. The specific fixed and variable costs (in % of operating income) were then calculated for both owning and renting. This was done by multiplying total expenditure (in % of operating income) by the proportion of fixed or variable costs. The specific fixed and variable costs were then calculated using the following formulae.

$$\textit{Avg. fixed costs/room/night} = \textit{Avg. room rate} * \textit{Rel. fixed costs rate} * \textit{Avg. occupancy} \quad (14)$$

$$\textit{Avg. variable costs/occupied room/night} = \textit{Avg. room rate} * \textit{Rel. variable costs rate} \quad (15)$$

For our case, fixed costs of €76.72 / €80.82 (owner/leased business) and variable costs of €19.27 / €20.30 were calculated (see table 10). The entire cost management was integrated as an extension to the spreadsheet model of Leong and Lee (2010).

6 Results

Once the necessary data and information were identified, they could be applied to the model of Leong and Lee (2010). The spreadsheet model described in the paper of Leong and Lee (2010) was slightly adapted and extended for our application. The spreadsheet can be downloaded from the work's GitHub repository.

6.1 Room price optimization

Based on the proposed cost structures according to the book "Hotelmanagement" (Henschel, Gruner, and Freyberg, 2018, p.203+204), the structure of operating and investment costs, as well as the cost structures depending on the hotel category and the stage of activity are listed in the sheet "Expenses & Cost Structure". In the sheets "specific cost structure" and "specific cost determination" the costs are determined as in the last part of the chapter 5.4. As already mentioned, fixed and variable cost rates are determined for a whole year to be applied to both demand phases. With a room rate of €129.25 and an assumed average occupancy rate of 77.2%, fixed costs of €76.72 per room and variable costs of €19.27 per occupied room can be calculated for both demand phases in the case of an owner-occupied business. In the context of our application, only the case of an owner-occupied establishment is taken into account because of the marginal differences in the final result when comparing the case of an owner-occupied establishment with that of a rented establishment.

In the sheet "Price Demand Relationship" the corresponding values from the formulas 6, 7 and 8 were replicated. Linear regressions could then be integrated into the extended model in the sheet "Model wPrice-demand rel" to include the price-demand relationship. From this point, the occupancy was defined according to the formulas 7 and 8 according to the price set in the model. The following formulae were used to calculate revenue, total costs and profit per room.

$$revenue = room\_rate \cdot occupancy \tag{16}$$

$$total\_costs = fixed\_costs + variable\_costs \cdot occupancy + other\_levy \cdot revenue \tag{17}$$

$$profit = revenue - total\_costs \tag{18}$$

$$profit(\%) = profit/revenue \tag{19}$$

For the average prices of €128.89 in a normal demand phase and €412.98 in the Oktoberfest phase determined in chapter 5.1, corresponding revenues, costs and profits were calculated in the model. Assuming that the cost structure is accurate, hotels in Munich can make a profit of €6.70/room (6.83%) at these prices in a normal demand period. During the Oktoberfest period, however, the profit is €316.99/room (76.76%) (see table 7). To maximise the profit, an Excel "solver" must be used. The profit must be selected as the value to maximise in the solver parameters. To maximise profit we change controllable variables, in our case the room rate. Accordingly, the cell containing the room rate is selected as the variable to be changed in the selection mask. We could also select constraints, such as a certain price, a certain occupancy rate or a certain total cost that must not be exceeded or undercut. However, this option was not used in our case. The 'solving method' selected was 'GRC Nonlinear'. After an appropriate calculation by the solver, it can be seen that in our case higher prices and lower occupancy rates have to be accepted in order to maximize profit. During a normal demand phase, the room rate after price optimisation is €172.22. Profit can be increased to €13.58 or 13.36% per room. During the Oktoberfest, however, the profit can only be increased by approximately €19 to €335.53 per room with a new room rate of €561.19. During this period, profit can be increased by about 2% to 78.59% (see table 8).

Demand phase	Room rate	Fixed costs	Variable costs	Other levy	Occupancy	Revenue/room	Total costs/room	Profit/room	Profit (%)
Normal demand	128.89€	76.72€	19.27€	0%	76%	98.09€	91.39€	6.70€	6.83%
Oktoberfest	412.98€	76.72€	19.27€	0%	100%	412.98€	95.99€	316.99€	76.76%

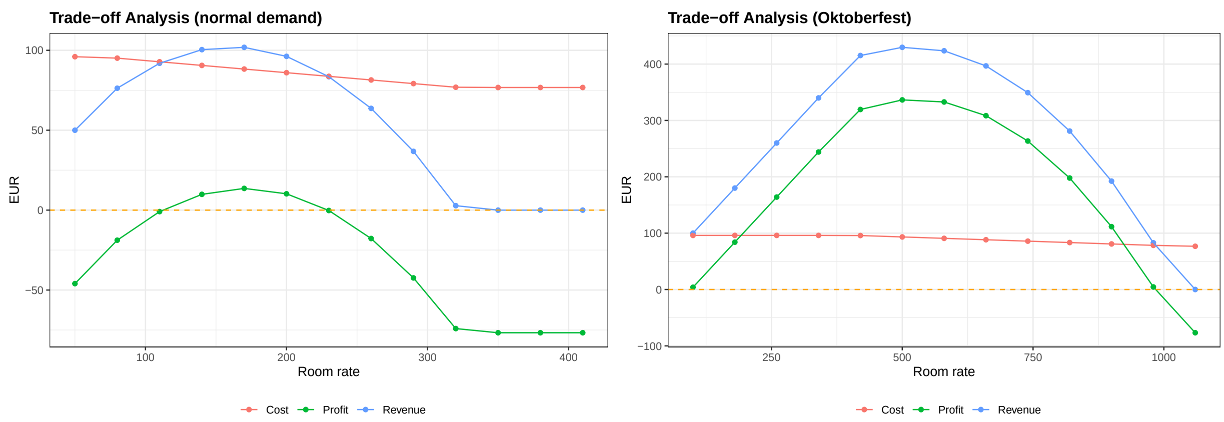
Table 7: Pricing model with actual prices in both demand phases

Demand phase	Room rate	Fixed costs	Variable costs	Other levy	Occupancy	Revenue/room	Total costs/room	Profit/room	Profit (%)
Normal demand	172,22€	76,72€	19,27€	0%	59%	101,68€	88,10€	13,58€	13,36%
Oktoberfest	561,19€	76,72€	19,27€	0%	76%	426,91€	91,38€	335,53€	78,59%

Table 8: Pricing model with prices maximizing profit in both demand phases

6.2 Trade-off analysis

A trade-off analysis (see figure 13) shows the revenue, costs and profit as a function of the room price for both demand phases. Especially in the case of normal demand, it is clear that the range in which a room can be sold at a profit is quite small. In a normal demand phase, profit can only be made by pricing rooms between approximately €110 and €230. Revenue can be generated up to a room price of around €230. This is due to the fact that above this price and the applying price-demand relationship, the occupancy rate becomes 0%. On the other hand, during the Oktoberfest period, a hotel is profitable from around 110€ to around €980. The maximum profit is around a room rate of €550. Revenue can be made in this high demand phase up to a room rate of around €1050. In both phases, the total cost decreases as the room rate increases. This is due to the fact that as the room rate increases, the occupancy rate decreases and therefore the variable costs decrease as well.



(a) Normal demand period

(b) Oktoberfest period

Figure 13: Trade-off analysis for both demand phases

6.3 Sensitivity analysis

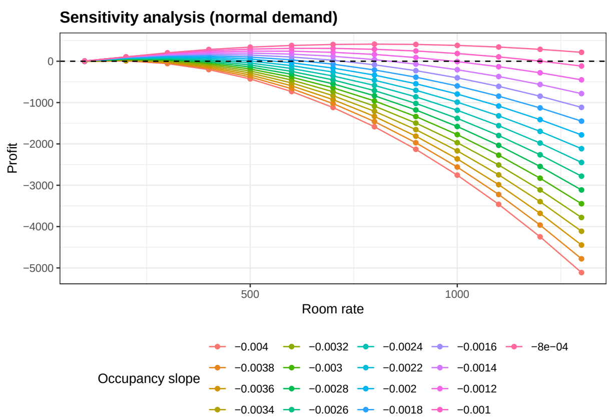
Looking at the formula to determine revenue (see Appendix D), it is clear that the revenue-maximising room rate depends solely on the price-demand relationship. A decrease in demand in a market would cause the price sensitivity of demand/slope of the linear regression model of the price-demand relationship (see eq. 7 + 8) to increase. This will also cause the room rate that maximises revenue to decrease. In this situation, the highest room rate that still generates revenue (the upper zero point of the revenue function) would also fall. This is because as demand falls, the maximum price a customer is willing to pay for a room falls. Above this critical price, the occupancy rate would be 0% and no revenue would be generated.

This is similar to the profit function (see Appendix E). Here the profit-maximising room rate depends on the price-demand relationship as well as variable costs. If demand falls, the profit-maximising room rate would also fall, assuming that the variable cost rate remained unchanged. The gap between the two zero points of the profit function also decreases in this scenario. By setting a room rate between these two points, a hotel can make a profit.

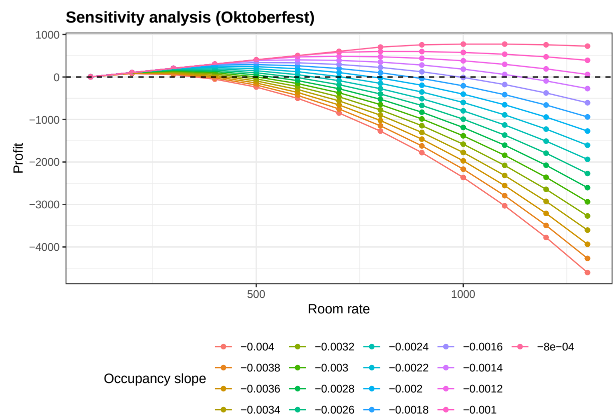
In contrast, for both the revenue and profit functions, an increase in demand leads to higher profit-maximising room rates and the distance between the two zero points of both functions increases.

In a sensitivity analysis for both demand phases (see figure 14), these patterns can be confirmed and illustrated by changing the slope of the price-demand relationship of the profit function. A decrease in the "occupancy slope", which describes a decrease in demand, leads to an increase in the profit-maximising room rate. At the same time, it is easy to see from the sensitivity analysis that the profit curve is correspondingly less curved and the distance between the two zero points is reduced. The sensitivity analysis revealed insignificant differences between the two phases, which can be attributed to variable costs and the limitations of the spreadsheet model. Furthermore, curves for the same values of demand sensitivity were plotted in both figures.

Comparing the normal demand period with the Oktoberfest period, the curve shwoing the relationship between price and demand is almost 2.5 times steeper in the normal demand period (-0.0039) than in the Oktoberfest period (-0.0016) (see eq. 7+ 8). As demand is correspondingly high during the Oktoberfest period, hotels have a wider pricing range. Conversely, during periods of normal demand, the price range is much narrower as demand is not as high.



(a) Normal demand period



(b) Oktoberfest period

Figure 14: Sensitivity analysis for both demand phases

7 Discussion

As part of the analysis, room prices were scraped at the beginning of April 2023. Prices up to the end of 2023 were obtained from Booking.com. However, our analysis and the model used do not take into account when prices apply, when hotel stays are booked and whether prices for a given date would be different at a later booking date. "In recent years, the revenue management field in hotel industry has witnessed an increased adoption of existing dynamic pricing policies" (Aziz et al., 2011). Moreover, according to Aziz et al. (2011), a reservation scenario consists of parameters such as arrival date and room type, as well as reservation date and length of stay. However, these last two factors are not considered in our use case. Furthermore, according to interviews led by Aziz et al. (2011), hotel managers prefer to use multi-category pricing systems that allow dynamic price changes after new reservations have been made. With this in mind, it can be assumed that the room rates of hotels in our sample would be different at a later point in time of data collection, and therefore the results from our model would not be fully accurate. In addition, at the time of scraping room rates, it was found that some hotels were already fully booked on certain days, especially during the Oktoberfest. As a result, it was not possible to obtain room rates for these days. It cannot be assumed with certainty that the prices we recorded are representative for this period. It is therefore likely that the prices generated by the optimisation model are biased.

Another question is the appropriateness of assuming an average hotel occupancy rate of 77.2% in Munich. This was based on the performance of 2018 and 2019. In 2021, Munich's hotel industry suffered severely from the consequences of the Covid pandemic and the cancellation of the Oktoberfest. In that year, the average hotel occupancy rate was around 26% (Colliers International Hotel GmbH, 2022). According to a hotel market report by the German Hotel Association (IHA), the German hotel market has managed to recover to around 91% of its 2019 performance by 2022, but the Ukraine and energy crises, as well as the associated inflation, are causing a great need for readjustment and a certain degree of uncertainty in the hotel industry[5]. It is therefore possible that the occupancy rate assumed for 2023 in our use case is too optimistic.

Also with regard to the price elasticity of demand, we had to make strong assumptions in our use case due to the lack of data, which would probably have led to fatal consequences in practice. "Price elasticity of demand is one of the key inputs for optimization processes connected to price setting and revenue management" (Petricek, Chalupa, and Chadt, 2020). The sensitivity analysis also showed that setting the wrong price elasticity of demand can have a huge impact on the model used. In particular, the fact that a value was used that would be valid for every demand phase of the year in Munich would be particularly questionable in a real case. A study by Petricek, Chalupa, and Chadt (2020), in which the price elasticity of demand is determined using a mathematical model, shows that the price elasticity of demand can vary depending on the day of the week, the season or the service offered. Enz and Canina (2010) also showed differences in price elasticity of demand when differentiating between chain and independent hotels. In our model, profit- and revenue-maximising prices depend mainly on price-demand relationships (see Appendix D + E). In the practical application of this model, it is all the more important to ensure that these values are determined with the highest possible accuracy and using the most appropriate mathematical procedures.

For hotel managers in particular, it can be helpful to look at the relationship between profit, revenue and costs as a function of room rate in a trade-off analysis before setting a room rate. This makes it easy to see what price range a business needs in order to be profitable. However, not all hotels want to maximise profit all the time. As Leong and Lee (2010) point out, non-monetary objectives can also influence how a hotel sets a room rate. While a hotel may not make as much profit by lowering room rates, it will increase bookings. Especially for new hotels entering a market or running a marketing campaign to attract customers, it may make sense to sacrifice some profit by lowering room rates. On the other hand, it can also be advantageous to choose higher prices relative to the profit-maximising room rate. For example, during periods of high demand, a hotel can prevent its own staff from being overwhelmed and unable to perform their duties properly (Leong and Lee, 2010). At the

[5] https://gastgewerbe-magazin.de/branchenreport-hotelmarkt-deutschland-2023-45257

same time, guests would have a calmer and more service-oriented stay. In this context, a trade-off analysis for better stakeholder management should also be very useful in practice.

8 Conclusion

Through the analysis and application of the model of Leong and Lee (2010), it became clear that the use of accurate data can provide valuable insights into the pricing of hotel rooms. By using appropriate goal seekers and solvers in the spreadsheet model, room prices that maximise profit or revenue can be determined depending on the variables fed to the model. At the same time, trade-off analysis provides big-picture insights that allow hotel managers to make decisions about room rates that are not motivated by purely monetary considerations. Similarly, sensitivity analysis allows users to determine the impact of changes in exogenous, uncontrollable factors on room rates, enabling simple risk management. However, it also became clear that effective practical application of this model, especially for the Munich market, requires very precise data, which is not always freely available. In our case, we had to make strong assumptions in some cases where no data was available. Cost structures are individual for each company and can only be determined in a hypothetical application under certain assumptions. It has been shown that variable costs in particular should be determined as accurately as possible by the hotels' accounting systems (see appendix E, eq. 30). The results of this work show that an accurate determination of the price-demand relationships is probably the most important step for a successful application of the model, and that even slight miscalculations can have serious negative consequences. Furthermore, it seems that the parameters used in the model of Leong and Lee (2010) are not sufficient for a practical application. For example, an effective inclusion of the time difference between the reservation date and the arrival date, the length of stay or the number of bookings already received for a given day could lead to a significantly improved pricing for respective hotels.

References

Aziz, Heba Abdel, Mohamed Saleh, Mohamed H Rasmy, and Hisham ElShishiny (2011). "Dynamic room pricing model for hotel revenue management systems". In: *Egyptian Informatics Journal* 12.3, pp. 177–183.

Colliers International Hotel GmbH (Jan. 1, 2020a). *Deutschland: Hotelmarkt 2019 Q1-Q4*. URL: https://www.colliers.de/wp-content/uploads/2020/05/Colliers_Hotelmarktbericht_Deutschland_2020.pdf (visited on 04/29/2023).

— (Jan. 1, 2020b). *München: Hotelmarkt 2019 Q1-Q4*. URL: https://www.colliers.de/wp-content/uploads/2020/05/Hotelmarktbericht_M%C3%BCnchen_2020_Colliers.pdf (visited on 04/15/2023).

— (Jan. 1, 2021). *München: Hotelmarkt 2020 Q1-Q4*. URL: https://www.colliers.de/wp-content/uploads/2022/01/JAN_PDF_Hotelmarktbericht_M%C3%BCnchen_2021_Colliers_Bild.pdf (visited on 04/15/2023).

— (Jan. 1, 2022). *München: Hotelmarkt 2021 Q1-Q4*. URL: https://www.colliers.de/wp-content/uploads/2022/12/Hotelmarktbericht_M%C3%BCnchen_2022_Colliers.pdf (visited on 04/15/2023).

Enz, Cathy A and Linda Canina (2010). "Competitive pricing in European hotels". In: *Advances in hospitality and leisure*. Vol. 6. Emerald Group Publishing Limited, pp. 3–25.

Henschel, U. Karla, Axel Gruner, and Burkhard von Freyberg (2018). *Hotelmanagement*. Berlin, Boston: De Gruyter Oldenbourg. ISBN: 9783110524079. DOI: doi:10.1515/9783110524079. URL: https://doi.org/10.1515/9783110524079.

Katharina Haase, SZ (July 20, 2022). *Hoteliers zu möglicher Wiesn-Absage: "Es gibt keinen Plan B!"* URL: https://www.sueddeutsche.de/muenchen/oktoberfest-2022-muenchen-hotels-buchungen-1.5623836 (visited on 04/15/2023).

Kim, Jinwon, Seongsoo Jang, Sanghoon Kang, and SeungHyun James Kim (2020). "Why are hotel room prices different? Exploring spatially varying relationships between room price and hotel attributes". In: *Journal of Business Research* 107, pp. 118–129.

Kimes, Sheryl E (2016). "The evolution of hotel revenue management". In: *Journal of Revenue and Pricing Management* 15, pp. 247–251.

Leong, Thin Yin and Wee Leong Lee (Sept. 2010). "Teaching Note —Spreadsheet Modeling to Determine the Optimum Hotel Room Rate for a Short High-Demand Period". In: *INFORMS Transactions on Education* 11. DOI: 10.1287/ited.1100.0053.

Petricek, Martin, Stepan Chalupa, and Karel Chadt (2020). "Identification of consumer behavior based on price elasticity: A case study of the Prague market of accommodation services". In: *Sustainability* 12.22, p. 9452.

Steed, Emmett and Zheng Gu (2005). "An examination of hotel room pricing methods: Practised and proposed". In: *Journal of Revenue and Pricing Management* 3, pp. 369–379.

A Appendix A

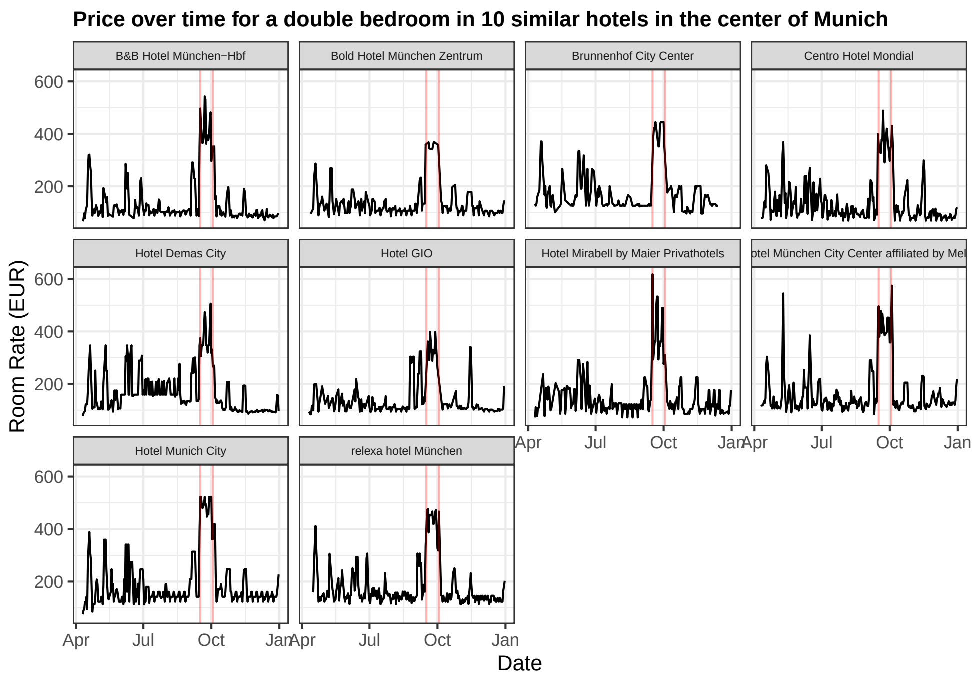


Figure 15: Average hotel room rate over time for a double room in 10 ten similar hotels in the city center of Munich

B Appendix B

	Hotel name	Room rate normal demand	Room rate Oktoberfest	Rel. difference
1	Hotel GIO	116.34	330.00	2.84
2	Hotel Demas City	126.54	364.29	2.88
3	Brunnenhof City Center	138.50	409.36	2.96
4	Bold Hotel München Zentrum	118.60	358.00	3.02
5	relexa hotel München	142.09	432.07	3.04
6	Hotel Mirabell by Maier Privathotels	123.33	395.72	3.21
7	Hotel Munich City	144.65	481.67	3.33
8	Hotel München City Center affiliated by Meliá	126.06	422.08	3.35
9	Centro Hotel Mondial	105.45	362.64	3.44
10	B&B Hotel München-Hbf	105.09	408.44	3.89

Table 9: Average room rates during different demand phases and relative price differences between those

C Appendix C

Hotel category	Hotel garni	
Average occupancy	77,20%	
Average room rate	129,25 €	
Cost structure		
Fixed costs	83,76%	
Variable costs	16,24%	
Specific cost determination	**Owned facilities**	**Leased facilities**
Proportion of costs		
Proportion of costs of operating income	91,80%	96,70%
Proportion of fixed costs of operating income	76,89%	81,00%
Proportion of variable costs of operating income	14,91%	15,70%
Specific costs		
Fixed costs/room	**76,72 €**	**80,82 €**
Variable costs/occupied room	**19,27 €**	**20,30 €**

Table 10: Specific cost calculation for the Munich hotel sample

D Appendix D

The linear regression model $OCC(x)$ describes the price-demand relationship and occupancy rate in dependency of a given room rate x (see eq. 7 + 8).

The **revenue per room function** $R(x)$ describes the revenue per room as the product of the occupancy rate OCC and the dependent room rate x.

The zero points of the revenue function $R(x)$ define the break-even points, which represent the minimum and maximum room rates to be in a range which generates revenue.

The zero point of the derivative $R(x)'$ describes the maximum possible revenue per room.

$$OCC(x) = Intercept + Slope \cdot x \tag{20}$$

$$\begin{aligned} R(x) &= OCC(x) \cdot x \\ R(x) &= (Intercept + Slope \cdot x) \cdot x \\ R(x) &= Intercept \cdot x + Slope \cdot x^2 \end{aligned} \tag{21}$$

$$
\begin{aligned}
0 &= R(x) \\
0 &= (Intercept + Slope \cdot x) \cdot x \\
x_0 &= -\frac{Intercept}{Slope}
\end{aligned}
\tag{22}
$$

$$
\frac{dR}{dx} = R(x)' = Intercept + 2x \cdot Slope \tag{23}
$$

$$
\begin{aligned}
0 &= R(x)' \\
0 &= Intercept + 2x \cdot Slope \\
x_{max} &= \frac{Intercept}{-2 \cdot Slope}
\end{aligned}
\tag{24}
$$

E Appendix E

The variable cost per room function $V(x)$ is described as the product of the variable cost per occupied room v and the occupancy rate (see Appendix D)

The total cost per room function $C(x)$ describes the total costs as the sum of the fixed costs f and the variable costs $V(x)$ and in dependence of the room rate.

The **profit per room function** $P(x)$ describes the profit as the difference between revenue $R(x)$ (see Appendix D) and total costs $C(x)$ in dependence of the room rate.

The zero points of the profit $P(x)$ function define the break-even points, which represent the minimum and maximum room rates to be in a profitable range.

The zero point of the derivative $P(x)'$ represents the room rate, which maximizes the profit.

$$
\begin{aligned}
V(x) &= v \cdot OCC(x) \\
V(x) &= v \cdot (Intercept + Slope \cdot x)
\end{aligned}
\tag{25}
$$

$$
\begin{aligned}
C(x) &= f + V(x) \\
C(x) &= f + v \cdot (Intercept + Slope \cdot x)
\end{aligned}
\tag{26}
$$

$$
\begin{aligned}
P(x) &= R(x) - C(x) \\
P(x) &= (Intercept + Slope \cdot x) \cdot x - (f + v \cdot (Intercept + Slope \cdot x))
\end{aligned}
\tag{27}
$$

$$\begin{aligned}
0 &= P(x) \\
0 &= (Intercept + Slope \cdot x) \cdot x - (f + v \cdot (Intercept + Slope \cdot x)) \\
x_0 &= \frac{\pm(\sqrt{Slope^2 \cdot v^2 + 2 \cdot Slope \cdot (Intercept \cdot v + 2 \cdot f) + Intercept^2} - Slope \cdot v + Intercept)}{2 \cdot Slope}
\end{aligned} \tag{28}$$

$$\frac{dP}{dx} = P(x)' = 2x \cdot Slope - Slope \cdot v + Intercept \tag{29}$$

$$\begin{aligned}
0 &= P(x)' \\
0 &= 2x \cdot Slope - Slope \cdot v + Intercept \\
x_{max} &= \frac{Slope \cdot v - Intercept}{2 \cdot Slope}
\end{aligned} \tag{30}$$

Hiermit versichere ich, die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt sowie die Zitate deutlich kenntlich gemacht zu haben.
Ich erkläre weiterhin, dass die vorliegende Arbeit in gleicher oder ähnlicher Form noch nicht im Rahmen eines anderen Prüfungsverfahrens eingereicht wurde.

Würzburg, 08.05.2023 Antoine Thomas