PRICE ELASTICITY OF DEMAND FOR ACCOMODATION SERVICES – EMPIRICAL APPLICATION IN PRAGUE

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Abstract: The paper focuses on the issue of measuring price elasticity of demand. Research has available a significant data sample on a daily basis in the segment of accommodation services since 2005 in the Czech Republic. The aim of the paper is to evaluate the development of consumer behaviour (measured by price elasticity) in the monitored segment from 2005 to the year 2017. For the calculation of price elasticity log-log regression analysis is used. The data is available daily, and therefore the resulting elasticity in the article is compared to several levels (working days, weekdays, summer months). One of the primary outputs in the research is that price elasticity is relatively stable in the monitored levels over time but has changed significantly over the long-term period.

Keywords: Price Elasticity, Demand, Price Optimization, Consumer Behavior.

1 Introduction

The presented paper focuses on the issue of measuring the price elasticity of demand in the accommodation services market in Prague. The motivation to resolve this issue is mainly the need to know the price elasticity as a critical input element at price optimization. Given that in the sector of services, price with work is generally an essential element, and it is also important to know the price elasticity. The log-log regression analysis resolved using OLS model has been chosen as the critical method for measuring the elasticity. This method is more accurate and versatile than the traditional measuring of the price elasticity at a point using the derivation of the demand function. In particular, the objective of this contribution is to measure the price elasticity of demand for accommodation services in Prague in different periods and different years, and based upon this to point out the differences that arose in the consumer's behaviour between 2005 and 2017. The paper presents a literature review, where studies related to the issue are commented, and then the methodology and also the work with analyzed data. Due to the focus of the contribution, this chapter is significant. There are also described the starting points for further research; primarily there are defined the investigated periods (the price elasticity of demand is measured yearly, on the weekend, during summer months and working days). Based on the described methodology, the research itself is then carried out, the key findings of which are presented in the next section entitled results. The results are described not only in the individual monitored periods, but there is also made comparison over time - therefore, the comparison is also presented graphically. Due to the uniqueness of the outputs, there is presented the discussion on the presented results and summarizing conclusion.

2 Literature Review

Literature review focus on the issue of measuring the elasticity in general first, and consequently on the application of this issue in economic reality and on its importance for market analysis and the functioning of the business. The issue of measuring the elasticity is generally described in several sources (e.g. Mankiw, 2011), generally understood as measuring of the percentage change of one variable (usually quantity) in a percentage change of another variable (usually price). The term elasticity concerning demand was defined by A. Marshall, a representative of the Cambridge Economic School (Marshall, 1997). Generally described approach on measuring of the elasticity is used, for example, by Kirschen et al. (2000); Kanjilal & Ghosh (2017), but it is used in the energy sector. In another concept (which is also used in the presented contribution), the elasticity is calculated using statistical tools, usually using regression analysis. This approach is used, for example, by Houthakker and Magee (1969, pp. 111-125) – but this approach is used here using data obtained through 224 enterprises and consumer behaviour monitoring. In the presented paper, elasticity is calculated on the basis of daily data directly from the market, which makes it significantly different. A study focusing specifically on a single city in the tourism sector and the price elasticity of such demand is laborious to find. The closest one is an article focusing on the whole of South Korea (see Ahn et al., 2018, pp. 768-778).

The presented paper uses the log-log regression model to measure the price elasticity. Regression analysis is used quite often in the issue of tourism in relation to the price, in particular, to find out the effect of one quantity on another. We can also find similar application related to one specific event (see Barreda et al., 2017) or product (see Andreyeva et al., 2010; Colchero et al., 2015). The question is the importance of measuring the price elasticity of demand in the given sector. Tourism (or service sector) is a sector in which proper pricing plays a significant role. Compared to industry (where businesses often optimize costs), the service sector is different because the business has to work much more with the price and understand how its demand works - and for this purpose is created this contribution. The price and knowledge of its elasticity is then the input element for a revenue management tool, respectively, for revenue and yield management. The importance of price elasticity is described by Vives et al. (2018); Melis & Piga (2017) or Hung et al. (2010). The price elasticity of demand is one of the most important input factors in the optimization process focused on price. We can use some other approaches to predict the price for accommodation (see e. g. Tang et al., 2016) with the public data. That approach is commonly used by the firms in the hotel industry but is not directly related to the consumer behaviour in a particular time – such the approach via price elasticity method. Consumer behaviour is related to the different situation on the market, and therefore there is some trade-off for price optimization. Situations like that are described e. g. by Boz et al. (2017) or Smeral (2018). Based on the previous text, this paper measure price elasticity of demand that can be used for several different analysis or price optimization process in the company.

3 Research Methodology

Measuring the price elasticity is generally an issue that has several possible ways to be resolved from a methodological point of view. In addition to traditional measurement using the midpoint method or the elasticity of the measurement at point using a partial derivative, it is possible to use the methods using regression analysis. The midpoint method is too general for measurement and is not appropriate for use with a large volume of data. Measurement of elasticity at a point is, on the other hand, much more accurate, but inappropriate for general determination of price elasticity. For these reasons, it is more appropriate to use the method using regression analysis. A simple log-log regression analysis method will be used to determine the coefficient of price elasticity of demand. In this logic, theoretical regression function is defined as:

$$\log Q_i = \beta_0 + \beta_1 * \log P_i + \varepsilon_i \quad (1)$$

where Q_i is the quantity demanded, P_i is the corresponding average price of the quantity demanded *i*. Values β_0 and β_1 are parameters of the theoretical regression function and ε is a random error. Thus, the demand function will be expressed as a function of quantity. We will estimate this theoretical regression function in order to obtain an empirical regression function:

$$\log Q_i = b_0 + b_1 * \log P_i + e_i\,, \quad (2)$$

where the estimate of parameter β_1, i.e. b_1 is the slope of the estimated regression empirical function, i.e. the coefficient of price elasticity of demand. For the solution, the OLS method will be used, and it can be mentioned that there is a *B* function

$$B = \sum_{i=1}^{n} (\log Q_i - b_0 - b_1 * \log P_i)^2 \,, \tag{3}$$

whose solution is under conditions (4)

$$\sum_{i=1}^{n} e_i^{\,2} = \sum_{i=1}^{n} (\log Q_i - b_0 - b_1 \log P_i)^2 \,\mathrm{K}\, \min, \tag{4}$$

which corresponds to the following solution:

$$\frac{\partial B}{\partial b_0} = 2\sum_{i=1}^{n} (\log Q_i - b_0 - b_1 * \log P_{1i}) * (-1) = 0 \,, \tag{5}$$

$$\frac{\partial B}{\partial b_1} = 2\sum_{i=1}^{n} (\log Q_i - b_0 - b_1 * \log P_{1i}) * (-x_i) = 0 \tag{6}$$

For measured parameters b_0 and b_1 apply (7) and (8)

$$b_1 = \frac{\frac{1}{n-1}\sum_{i=1}^{n} (\log P_i - \overline{\log P}) * (\log Q_i - \overline{\log Q})}{\frac{1}{n-1}\sum_{i=1}^{n} (\log P_i - \overline{\log P})^2} \tag{7}$$

$$b_0 = \overline{\log Q} - b_1 \overline{\log P} \,. \tag{8}$$

Although the objective is not to estimate the entire regression function only it's coefficient b_1; complex outputs will be presented, especially for the purpose of evaluating the whole model. Its evaluation will be done using the coefficient of determination r^2.

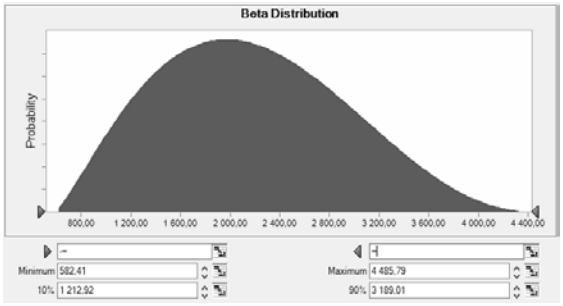
There are available data between 2005 and 2017. These data contain data on the quantity demanded, quantity offered, and average price in the segment of accommodation services in Prague. Only traditional accommodation facilities (so-called collective accommodation facilities), i.e. data out of the so-called sharing economy, are included in these data. The uniqueness of this data lies in the fact that data is available on a daily basis. This data was obtained and adjusted in cooperation with STR Global Inc. This paper works with more than 4500 values. However, in order to measure the price elasticity using the method described above (log-log regression analysis), it would be first necessary to adjust the data obtained in such a way as to be appropriate for the analysis. It is essential to realize the fact that the data (especially the average price) reflects the decision-making of the companies in the current market situation. If we want to measure the price elasticity of demand, we need to work with such data that is not affected by the extremes at that moment (such as data at the end of the calendar year or major events that are organized at that moment). There are two ways to make this adjustment.

One option is to remove extremes from the mentioned values, for example, using the Grubbs' test. These statistical elements are particularly useful when we do not know more detailed information about the statistical set (we know only its division). Due to the fact that we know the analyzed market, this data will be adjusted under a different logic. Data adjustment is based on the assumption that, in extremely high or extremely low added value (profitability) of services sold to traditional collective accommodation, decision-making on price is influenced by a number of other factors than only the quantity demanded. It is the same decision-making logic of enterprise that is described in the enterprise's behaviour in duopoly or cartel (for more information see Kaplow, 2013; Escobar & Llanes, 2018). At first, it is necessary to find an index that evaluates the profitability of the service sold on the market. For these purposes, based on the obtained values was calculated the *RevPAR* (Revenue per Available Room) index for each day, which was defined as (9)

$$\mathrm{Re}vPAR = Occ * ADR \,, \tag{9}$$

where *Occ* is the average daily occupancy, and the *ADR* is the average daily rate. In order to make a final adjustment to the above-mentioned extreme values, it is useful to know the exact distribution function of the variable (in our case, *RevPAR*). In order to accurately estimate the progress of this distribution function, an extension to MS Excel software was used, namely CrystalBall from Oracle. In this software was used the function, allowing to estimate the best distribution of random variables. For every single year, beta distribution (modified to indexed numbers) has always been recommended. An example of such a distribution in 2005 is presented in Figure 1.

Figure 1. Beta distribution of RevPAR in the year 2005



Source: own calculations

In order to eliminate high and low values, only such RevPAR values were chosen that are higher than 10% percentile and less than 90% percentile. The adjustments described above are carried out for each year and consequently are used only those data that achieve the RevPAR values between specified percentiles. These values better reflect the real market situation and are more appropriate to achieve the objective of the contribution. A similar procedure as the one described above was also applied to occupancy - but there was no link between occupancy and price, which may distort output data. However, it should be noted that the outputs (i.e. adjusted data) were very similar. Such adjusted data can already be used to determine the coefficient of the price elasticity of demand for different periods. These periods can be set up very individually. For the purposes of this contribution, the price elasticity of demand for each year was measured under four different periods. Firstly, there was a measurement of the price elasticity throughout the whole year (YE_{pd}). Secondly, there was a measurement of the price elasticity throughout the weekend (WE_{pd}). The reason was to find out differences in consumer's behaviour during these days. It is necessary to be aware of the fact that within the accommodation services, it is not possible to define the weekend traditionally, since the price for which the service is sold, is related to the price for a night from one day to another. That is why the price and demand carried out on Friday or Saturday are considered as the weekend. Thirdly, price elasticity was measured throughout working days (OE_{pd}). Fourth, price elasticity was measured throughout the summer months (July and August, SE_{pd}). The reason was to find out whether partial differences in consumer's behaviour could be observed during summer months, which traditionally represent a unique situation in terms of demand for accommodation services. All of the elasticity described above was measured over the years 2005 to 2017 and then was carried out a comparison.

Based on the research conducted, there were found out the following strengths and weaknesses of the methodology described above. The versatility of a given method, which can be applied to the whole market as well as to partial market players, must be considered a strength. However, it is necessary to work with appropriate data, and at the same time, it is necessary to have sufficient amount of this data, which can be considered as a weakness of the given method. At the same time, it is necessary to draw attention to the fact that there was used a regression function that is linear in parameters and may not be applied to demand (or supply) that do not show a linear relation. However, this contribution were found relatively high determination coefficients in each year, indicating that the selected regression function is appropriate for resolving the problem.

4 Results

Based on the method described above, the following regression functions were made for all years. Only regression features for yearly price elasticity of demand (YE_{pd}) are presented for the monitored years. Simultaneously are added determination coefficients, which represent the evaluation of given regression model. This output is shown in Table 1.

Tab. 1. Regression functions and coefficients of determination

Year	Regression function	r^2
2005	logQ = 5.616719102 – 0.362903643 * logP + e	0.86
2006	logQ = 5.58355147 – 0.354651246 * logP + e	0.82
2007	logQ = 5.791506919 – 0.415405081 * logP + e	0.93
2008	logQ = 6.102048541 – 0.53260554 * logP + e	0.89
2009	logQ = 6.955174752 – 0.813366093 * logP + e	0.84
2010	logQ = 6.094051824 – 0.542514621 * logP + e	0.91
2011	logQ = 6.118644965 – 0.537013766 * logP + e	0.79
2012	logQ = 5.588298508 – 0.36789955 * logP + e	0.93
2013	logQ = 6.147395448 – 0.534920875 * logP + e	0.87
2014	logQ = 5.586308141 – 0.357170905 * logP + e	0.86
2015	logQ = 5.132899811 – 0.204763496 * logP + e	0.87
2016	logQ = 4.831771571 – 0.111720684 * logP + e	0.91
2017	logQ = 4.82509913 – 0.103602176 * logP + e	0.89

Source: own calculations

The thirteen regression functions mentioned above represent only the necessary procedure to determine the yearly price elasticity of demand (YE_{pd}) in individual years. Regression functions were also estimated for the remaining three periods in which elasticity was monitored. Furthermore, the total output of all measured price elasticity of demand in individual years is presented in the article, as shown in Table 2.

Tab. 2. Price elasticities of demand

Year	YE_{pd}	WE_{pd}	OE_{pd}	SE_{pd}
2005	-0.363	-0.312	-0.356	-0.248
2006	-0.355	-0.128	-0.432	-0.402
2007	-0.415	-0.362	-0.437	-0.459
2008	-0.533	-0.341	-0.597	-0.375
2009	-0.813	-0.717	-0.825	-0.807
2010	-0.543	-0.470	-0.546	-0.577
2011	-0.537	-0.281	-0.546	-0.222
2012	-0.368	-0.286	-0.378	-0.324
2013	-0.535	-0.361	-0.556	0.150
2014	-0.357	-0.174	-0.330	0.476
2015	-0.205	-0.064	-0.258	0.788
2016	-0.112	-0.020	-0.151	0.482
2017	-0.104	0.223	-0.192	0.330

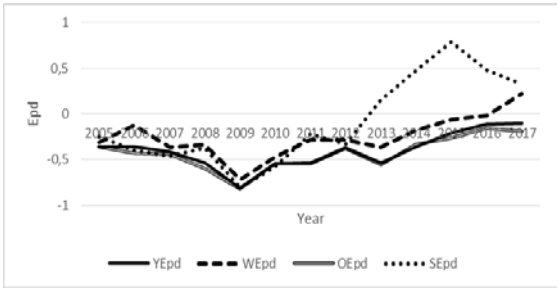
Source: own calculations

First of all, it should be noted that the price elasticity of demand is traditionally negative (reflecting the negative relationship between price and quantity demanded), although sometimes the outputs of the price elasticity of demand are presented in absolute value, this presentation does not make sense, because we omit the situation where demand itself can take on something other than a traditional relationship. Several key conclusions result from the above-mentioned values and regression functions. First, it is necessary to point out the fact that yearly elasticity indexes YE_{pd} are always in the interval <-1, 0> and it can be judged that the demand for accommodation services in Prague in the monitored years is price inelastic; thus, the change in the price of 1% (e.g. increase) results in a lower than one-percent change (decrease) in quantity demanded. It should be noted that these are the total average values that cannot yet be used to optimize the price, but they only give a general overview of the behaviour of consumers buying accommodation services in Prague. On the one hand, the inelasticity of demand for price services is related to the location. Prague is a key destination for tourism, which encourages lower elasticity values. The average price elasticity of demand in Prague between 2005 and 2017 is -0.4031.

If we focus on the values of the price elasticity during the weekends, it is obvious that this value is lower in absolute value each year (although the numerical value is higher, the higher elasticity in the negative values reflects the lower elasticity; hence the interpretation is made different) than the total yearly elasticity. Consumers are less sensitive to the change in price during the weekends, and they will buy a given service even at higher prices. The WE_{pd} values are also on average in the absolute value lower by 0.1498 points. However, it is necessary to draw attention to the value of the index in 2017, which reach positive values. This fact will be commented on further.

The situation during working days (OE_{pd} index) corresponds very closely to the overall yearly elasticity, but in some years, it shows values that correspond to a higher sensitivity of the consumer to the change in price. This is not surprising and only corresponds to what has already been described above. The last index focuses on elasticity values during the summer months (July, August) in the monitored years. Until 2012, the values do not show excessive deviations from the average elasticities in the industry, but consequently, the value of the coefficient begins to grow significantly and reaches positive values (similar to the WE_{pd} value in 2017). Based on the methodology used, these positive values mean that the basic relationship between the quantity demanded and the price is disrupted, and in the short term, there is a Giffen's good. In the previous text, the individual elastic values were described separately; subsequently we will focus more on their development over time. In order to better orient ourselves in development, the given values are presented graphically. The output can be seen in Figure 2.

Figure 2. Development of price elasticities between 2005 and 2017



Source: own calculations

As shown in Figure 2, the index of yearly price elasticity of demand (YE_{pd}) has an inconsistent trend over time. This is the first decreasing and subsequently increasing tendency of the curve with a breakthrough in 2009. By this year, it can be stated that the elasticity index has become more negative (thus constantly decreasing), reflecting the fact that consumers were becoming more sensitive to the change in price. The highest values (in absolute value) of the index was 0.813, bringing closer to the unit elasticity of demand. The question is what caused this breakthrough. One of the possible explanations may be the financial crisis in 2008, which also affected the tourism market. Since this year, on the other hand, we monitor the growth of the given curve and its approach to zero values, reflecting the fact that in recent years, the consumers are less sensitive to the change in the price of accommodation services in Prague. The other curves are commented in the previous text or show no significant deviations.

5 Conclusion

This paper presents the measurement of the price elasticity of demand in the area of providing accommodation services in

Prague. It is unique by its focus, and a similar study on the price elasticity of given demand in one city is difficult to find. The outputs presented in this contribution point out to inelastic demand in terms of price. This output corresponds to a study focusing on South Korea, where the elasticity in individual years is not mentioned, or their deeper investigation is not carried out. In some articles, we find the measurement of other types of elasticity (for example, a number of studies focusing on macroeconomic theory measure the income elasticity). In general, the above-mentioned research is not only unique but also actual and can serve not only for a deeper understanding of consumer's behaviour but also as a methodical material that presents the possibility of measuring the price elasticity in a given location (due to its endless potential of use). The statistical analysis that was carried out may have shortcomings in the form of use of regression analysis based on functions that are linear in their parameters. At the same time, only a simple regression analysis was used, and thus no further impacts were investigated - but this would make it unclear to determine the price elasticity. The presented outputs can be used both in terms of consumer's behaviour analysis and in terms of the enterprise's possible optimization of price management, respectively yield and revenue management in the accommodation facility. Knowledge of price elasticity of demand is crucial for this optimization.

Knowledge of price elasticity of demand is an important area not only needed to understand consumer's behaviour but also to manage the enterprise effectively. The price elasticity index reflects a number of variables that need to be taken into account when deciding on pricing and other business planning. Similarly, it is an indicator that clearly describes the consumer's behaviour in terms of market performance in the change in price. This paper presents two key outputs. The first is the application of log-log regression analysis to market data so that we can determine the value of price elasticity of demand. From a methodological point of view, this is a universal use that can be applied (under conditions described) to any industry. The second key output is an overview of price elasticity of demand for accommodation services in Prague between 2005 and 2017. Price elasticity was measured under four different criteria (price elasticity of demand for the year, working days, weekends and summer months). The measured outputs were then compared over time. Several conclusions can be drawn from the above calculations. Firstly, it is obvious that the demand for accommodation services is price-inelastic - its value has long been on average at -0.4031. The inelasticity of demand in this segment reflects the fact that the percentage change in the quantity demanded that was triggered by a one-percent change in price is lower, and that is on the value of price elasticity. Another conclusion resulting from the research is interesting in terms of time development. Price elasticity of demand is not constant and has seen significant differences since 2005. Until 2009, the values of price elasticity in absolute value were increasing and then again returned to zero. This development can be attributed to the financial crisis that occurred in 2008. The last key conclusion from the research is related to the effect of Giffen's good, which is manifested mainly in recent years in monitoring the values of elasticity during the summer months. This is only a basic overview of the outputs, but the contribution provides possibilities for further investigation of the issue.

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