Research Article

Heterogeneity in demand for performances and seats in the theatre

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ABSTRACT Studying the heterogeneity of consumers allows to price the product differently for consumer segments or groups of a product. In this paper, we estimate a model of aggregate demand for Perm Opera and Ballet Theatre focusing on the heterogeneity in price effect on demand for tickets on different performances and seats. We estimate the parameters of demand function using censored quantile regression that accounts for the limited capacity of the theatre house. We reveal the price effect variation across different types of theatrical productions and seats with lower elastic demand on ballets and for seats of higher quality.

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INTRODUCTION

Revenue management (RM) is a common way of maximising profits in capacity-constrained industries. Revenue management practices rely on the understanding of consumer preferences that allows aligning the pricing policy to maximise the profit from customer segments. Since theatregoers demand for a ticket as a bundle of performance, play and seat characteristics, the producer may differentiate the price in these dimensions to manage a revenue. Then customers segment themselves into appropriate rate categories based on willingness-to-pay (WTP) for their preferences. Thus, the crucial assumption of RM is customer heterogeneity that states that the segments of customers are willing to pay differently for a product.

Customer heterogeneity is a subject of examination for decades. Most recent studies based on disaggregated consumer choice data employ the probabilistic models to segment population by observable (multinomial logit) or unobservable (latent class choice or mixed models) characteristics (Schlosser, 2015; Hetrakul and Cirillo, 2015; Vulcano *et al*, 2012). The convenience of using disaggregated individual choice data is determined by the existence of well-established models and their software realisation. It is well-known that the widely used discrete choice models require information of choice set for each sale act and an assumption on the choice of only one alternative. In the case of theatre revenue management there is a challenge with recovering choice set due to various sales starting dates for different performances and the heterogeneity of seats filling in time. The structure of consumer choice process may also vary for different consumers. There are some criteria that the spectators of theatre follow in decision-making process. They are usually guided by a particular theatre, the type of performance, the production, the particular performance (in the case of several performances of production), the price level of a ticket or seating area and the seat (or several seats) within the seating area in turn. Incorrect assumption on the structure of decision-making process or assumption on choice set leads to inconsistent estimates and errors in actual revenue optimisation.

Models of demand based on aggregated data do not require accomplishment of these assumptions and also allows controlling on consumer heterogeneity. In some earlier studies on aggregated data, authors divide population into the groups by observable characteristics of demand (Schimmelpfennig, 1997; Levy-Garboua and Montmarquette, 1996; Lange and Luksetich, 1984; Pommerehne and Kirchgassner, 1987; Throsby, 1994). In this article we model customer demand by quantile regressions using the data disaggregated to the level of seating area in a particular performance. This method accounts for demand heterogeneity without splitting the sample by observed characteristics. The method captures the effect of price and other characteristics for each marketed alternative depending on the level of quantile of demand distribution. This approach is more efficient compared to a priori dividing a sample into subsamples and estimating parameters separately for each subsample because quantile methods employ all available data in a regression model.

As we discussed above, the performance is a product differentiated in various dimensions. The customer segments have different preferences towards the production, performance and seat characteristics. Thus, the theatre management may charge prices depending on the production, performance and seat characteristics: this is known as price discrimination. Since RM practice is aimed at maximising profits, the issue of price elasticity is of particular importance when revealing customer behaviour. The topic of price elasticity is thoroughly studied in papers devoted to the economics of theatre (Seaman, 2006). Studies based on aggregated data show that demand is generally inelastic by price (Moore, 1966; Houthakker and Taylor, 1970; Touchstone, 1980). Some studies have found empirical evidence of negative elasticity (Throsby and Withers, 1979; Withers, 1980; Zieba, 2009). Studies based on disaggregated data demonstrate different elasticity estimates for the subgroups of the population (Levy-Garboua and Montmarquette, 1996; Lange and Luksetich, 1984). In our paper, the method of censored quantile regression allows to obtain specific estimate of price elasticity for each observation. Aggregated estimates of price elasticity by particular product characteristics and seating areas permit to revise the pricing policy.

Revenue management practice is effectively used in industries that are characterised by perishable goods, such as hotel, airline and railway industries. A particular play in a theatre may also be considered as a perishable good since tickets cannot be inventoried after a time of play. According to Hetrakul and Cirillo (2015) in order to apply RM effectively, the theatre needs to have heterogeneous customers, inflexible capacity, variable and uncertain demand, low marginal cost and high production cost. As discussed above, the attendees of theatre are heterogeneous in terms of preferences, customer experience, the purpose of attendance, time of purchase and socio-demographic characteristics, which allow to apply the revenue management strategy and differentiate the ticket price. The limited number of seats in a house permits to conclude about inflexible capacity. The attendance on a particular performance is variable and uncertain and depends on the day of week, the time of day and season as well as on the characteristics of production. The cost of the production creation is high due to significant fixed costs on decorations, costumes, director award. Whereas marginal cost of a particular performance is much lower as marginal cost of additional attendee. These properties make a demand for a theatre similar to demand for airline, train tickets and hotels.

However, there are some important issues that distinguish between airline and hotel industry, where the RM is implementing successfully, and theatre industry. These industries employ dynamic pricing mechanism that enables to discriminate consumers according to the time of ticket purchase. Currently, theatre industry mostly charges a price for a ticket independently from the time of sale, although it has a huge potential in applying the mechanism of dynamic pricing. It is also worth noting that the theatres are, in general, noncommercial and loss-making organisations and need the government or sponsor support. That is why along with the goal of maximising revenue, the theatre administration strives to maintain the level of attendance. However, this does not disseminate the RM employment in theatre but RM should account for more complex goals of theatre.

In the context of demand concerns, we should discuss the problem of censorship. The demand equation is a relation between the volume of tickets purchased and tickets prices and performance characteristics. Demand can be measured by the number of tickets sold per performance, per unit of time or by the percent of theatre occupancy. The majority of early studies based on aggregated data are not taking into account the censored character of demand. In this case, the number of tickets sold for the performance area is the only observed demand, while potential demand may exceed the capacity of a house. Dropping the distinction between potential and observed demand may affect the estimates of parameters and lead to estimates bias. In early papers, authors employ the simplest approaches dealing with censored data: to ignore the fact of data censorship or to exclude the censored observations from the sample. Some papers include house capacity as explanatory variable in the model in an attempt to take into account the demand censorship. The problem of censored theatre data is solved in Laamanen (2013). He estimates the demand equation through censored median regression using the method proposed by Powell (1986). However, this research does not account for the heterogeneity of price and characteristics effects that allows aligning the pricing policy more precisely. In our research, we extend the study by Laamanen (2013) and estimate the demand at various quantiles in order to capture the difference in price elasticity of demand for various performances and seats. The method employed for the estimation is the censored quantile regression proposed by Chernozhukov and Hong (2002) that is discussed in detail further.

This paper is organised as follows. In the next section, we discuss and analyse the available data on tickets sales. The preliminary analysis of the data motivates the method employed in the research. Section 3 works out the details of the censored quantile regression methodology. Section 4 presents the results and conclusions.

DATA

The data for research are taken from the Perm Opera and Ballet Theatre, which is considered as one the best regional opera theatre in Russia. It is famous for its modern musical productions, nonstandard classical performances and unconventional festival projects. It is also a major Russian centre for opera and ballet, where the quality of the musical performance is paramount. Every year the theatre performs forty regular productions and three to five new productions.

The Perm Opera and Ballet Theatre is a noncommercial organisation and as such is loss-making. Its main source of funding is a Perm state budget. As a noncommercial venture, the goal of the theatre is to make ballet and symphonic art available for Perm residents. The theatre does have to, at least partially, recoup the expenses with production revenue in order to produce new ones. Consequently, the theatre constantly tries to balance between being affordable and covering costs using pricing mechanism and charging different prices for different performances and seats.

The data collected cover all performances for four seasons between August 2011 and July 2015. There were 298 performances out of 36 repertoire productions at the main venue. The data include information on the name of production, the date and time of play (season, year, month, the day of week and time of day), the price of a ticket, time and date of ticket purchase and the location of a seat in a house. The house of the theatre is divided into sectors: loges, the stalls, tiered stalls, the circle and the upper circle. In the sectors, the seats are identified by row and place. Further, the house is divided into nine seating areas according to the distance from the stage (Figure 1). The seats in different seating areas vary by the quality of view and sound, prestige and price. However, the seats located in one seating area are considered as homogeneous in terms of price and quality. The theatre also has a system of discounts for special segments of the population (students, students of the ballet school, retired people). Thus, for every ticket purchased we have information on the basic price charged by the theatre and on the actual price of a sale with discount. We use only the basic price of the ticket as a measure of the price

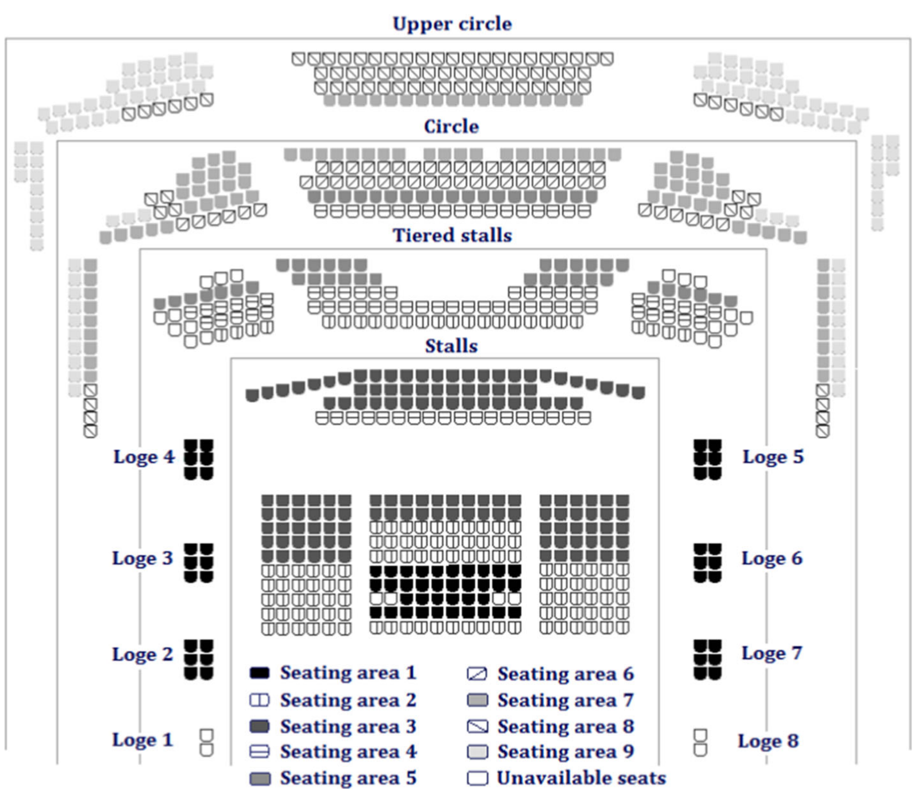

Figure 1: The scheme of an house.

considering that the administration of the theatre manages the basic price and remains the system of discounts.

In addition to the information provided by the theatre, we collected information on performance characteristics which explains the demand according to previous research (Seaman, 2006; Corning and Levy, 2002; Throsby and Withers, 1983).We classified productions into operas and ballets, into classical (written before 1900) and modern (written after 1900) ones. We collect information on the author and construct dummy responsible for the nationality of the author (Russian/foreign) and the dummy on whether the production is a premiere one (Laamanen, 2013). We classified performances according to the age recommended for attendance: children (without restriction), family (12+) and adult (16+). Information on conductors allows estimating the contribution of a particular person. Among conductors, we identified two persons that are especially successful and in-demand (Urrutiaguer, 2002; Willis and Snowball, 2009). Perm Opera and Ballet Theatre has been regularly nominated for the prestigious Russian theatre award "Golden Mask". For each production, we collect information on the number of nominations and awards won. In order to measure the world popularity of musical composition, we collect the data on various ratings (Felton, 1989). We use data from the worldwide rating of operas and their composers (operabase.com) and of ballets (listverse.com). Descriptive statistics of performances characteristics are presented in Table 1.

To estimate the model of demand, we aggregate data on sales and prices by seating areas. For each seating area, we calculate the attendance rate as a number of sold tickets to the total number of seats in the area and assign the basic price in accordance with one of the 8 theatre pricing schemes. The pricing scheme is the set of prices for 9 seating areas. Prices for the most expensive tickets (the first seating area) vary from 300 to 2000 rubles, while the cheapest tickets (the ninth seating area) are always sold for 100 rubles (Table 2).

Apart from the seats in the house, the productions may also be heterogeneous. Figure 2 shows that half of the observations are filled over 80 per cent. The remaining seating areas show lower demand which tells us about the heterogeneity of productions. To analyse the patterns of attendance we divide performances according to the level of attendance. If the attendance rate exceeds the mean level (80 per cent) then the production is attributed to "popular", otherwise to "unpopular". According to the price in the first seating area, the observations may be divided into "expensive", when the price exceeds its median (700 rubles) and "cheap", if less. We also classified the seating areas into "prestigious" (the first three zones) and "of no prestige" (the last three zones) (Figure 3).

The attendance of "popular" and "expensive" performances is as high for the first three as for the last three seating areas. If the performance is "popular" and "cheap", then the attendance is high in both groups of seats but in the case of "cheap" performance, the demand for "prestigious" seats is slightly higher compared to "expensive" performances. This effect holds for "unpopular" performances also. In the case of falling prices, customers switch from the last seats to the first, more prestigious ones. This suggests the existence of price effect in more prestigious seating areas. If we analyse only "expensive" performances, we notice that the fall in popularity leads to a decrease in the attendance, especially in the last seating areas. This is also true for "cheap" performances. The preliminary data analysis points out that there is an effect of price on the demand but this effect may vary for different performances and for different seating areas depending on their quality. In the next section, we discuss the methodology of the study that helps to capture the heterogeneity of price effect.

One more issue to be discussed is a potentially different quality of seats for different types

Table 1: Descriptive statistics for performances characteristics

Variable	*Obs.*	*Share*
Seasons	2682	
2011/2012	828	30.9
2012/2013	819	30.5
2013/2014	711	26.5
2014/2015	324	12.1
Day of week	2682	
Working days	1440	46.3
Weekend	1242	53.7
Time of day	2682	
Before 2 a.m.	342	12.8
After 2 a.m.	2340	87.2
Type of performance	2682	
Ballet	954	35.6
Without world rating	468	17.4
With world rating	486	18.2
Opera	1728	64.4
Without world rating	1197	44.6
With world rating	531	19.8
Date of creation	2682	
Before 1990	2304	54.1
1990 and later	1953	48.9
Language of opera	2682	
Foreign	378	14.1
Russian	2304	85.9
Recommended age	2682	
Without restrictions	1107	41.3
From 12 y.o.	1170	43.6
From 16 y.o.	405	15.1
Awards in "Golden Mask"	2682	
Presence	144	5.4
Absence	2538	94.6
The nationality of author	2682	
Russian	1521	56.7
Foreign	1161	43.3
Band director	2682	
Valery Platonov	1494	55.7
Teodor Currentzis	279	10.4
Others	909	33.9

of productions. Seats are heterogeneous in terms of view and sound quality which are not ordered strictly according to seating area number (and price of a ticket). Thus, seats closer to stage are not the best to watch a ballet since the level of stalls is lower than a level of the stage. Theatre experts' opinion is that the best seats for watching a ballet are located in the centre of circle which corresponds to fourth to sixth seating areas. This is supported by the data on attendance of performances and seats disaggregated by production type (Table 3). The most filled areas at ballets are areas 4–7 while for operas the most filled areas

Table 2: Descriptive statistics for price and attendance

Variable	*Obs.*	*Mean*	*SD*	*Min*	*Max*
Basic price (rubles)	2682	387.1	366.9	100	2000
Seating area 1	298	868.1	496.6	300	2000
Seating area 2	298	578.4	380.2	250	1400
Seating area 3	298	486.5	351.6	210	1300
Seating area 4	298	427.7	323.5	180	1200
Seating area 5	298	349.6	265.8	160	1000
Seating area 6	298	277.5	211.3	140	800
Seating area 7	298	224.4	151.1	120	600
Seating area 8	298	171.4	89.9	110	400
Seating area 9	298	100	0	100	100
Attendance rate	2682	0.80	0.26	0.01	1
Seating area 1	298	0.86	0.15	0.24	1
Seating area 2	298	0.90	0.13	0.35	1
Seating area 3	298	0.89	0.14	0.35	1
Seating area 4	298	0.90	0.15	0.11	1
Seating area 5	298	0.84	0.22	0.11	1
Seating area 6	298	0.8	0.26	0.06	1
Seating area 7	298	0.67	0.34	0.02	1
Seating area 8	298	0.63	0.35	0.02	1
Seating area 9	298	0.72	0.31	0.01	1

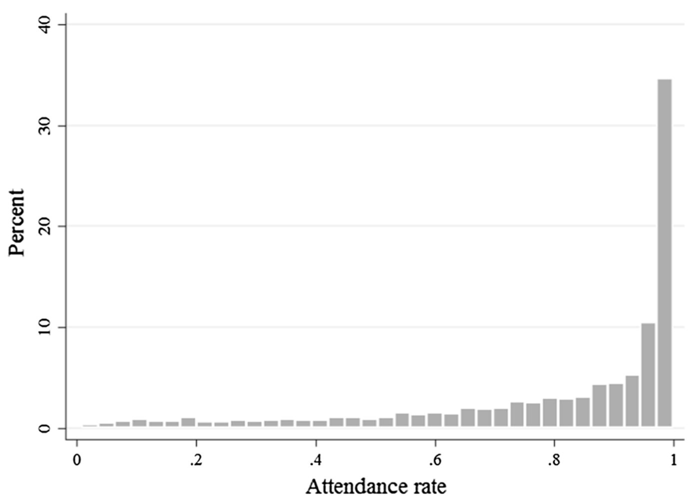

Figure 2: Distribution of attendance rate.

are 2–4. This corresponds to a higher quality of sound in these areas and higher importance of sound quality in operas compared to ballets. The quality of seat in terms of the view and sound quality should be also taken into account in a model of demand with an attention to potential different seats quality estimate for various production types. It also may result in different estimates of price elasticity over the types of production and seats since willingness-to-pay for a particular seat associated with its quality may vary over operas and ballets.

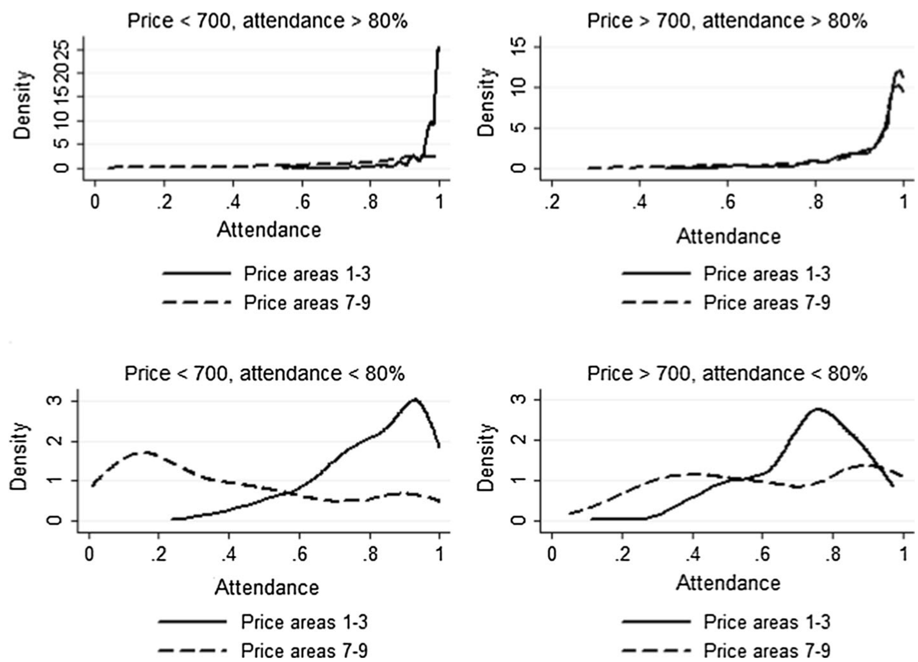

Figure 3: Attendance rate distributional plots by price and popularity.

Table 3: Descriptive statistics of attendance by production types

	Production types		
	All types	*Operas*	*Ballets*
Attendance rate	0.80	0.72	0.96
Seating area 1	0.86	0.83	0.93
Seating area 2	0.91	0.87	0.96
Seating area 3	0.89	0.85	0.97
Seating area 4	0.90	0.86	0.98
Seating area 5	0.84	0.76	0.98
Seating area 6	0.79	0.68	0.98
Seating area 7	0.68	0.52	0.97
Seating area 8	0.63	0.46	0.95
Seating area 9	0.72	0.64	0.87

METHODOLOGY

Since the effect of price and performance characteristics may vary over the seating areas and the performances of different quality, we apply the quantile regression approach to capture the heterogeneity of effects on the different levels of the attendance distribution quantile. Quantile regression estimates vary at each level of the dependent variable quantile, while the OLS estimates the mean effect on the dependent variable. We should also account for the censoring of the attendance rate since the substantial fraction of the seating areas in the sample is fully occupied. Ignoring the censoring leads to inconsistent and underestimated effects of price and other performance characteristics on the attendance rate because the potential (uncensored) demand for a particular seating area may exceed the observed (censored) one. The attendance rate is bounded by 0 and 1 but only 4 observations on seating areas have a zero attendance rate. This means that ignoring the censoring at the lower bound may only produce a negligible bias in estimates for a given data. The model of demand for theatre performances then may be represented by quantile regression with upper censoring only:

$$Q_{y_{ij}^*|x_i,p_{ij}}(\alpha) = x_i\beta(\alpha) + p_{ij}\gamma(\alpha) + \theta_j(\alpha),$$
$$Q_{y_{ij}|x_i,p_{ij}}(\alpha) = \begin{cases} Q_{y_{ij}^*|x_i,p_{ij}}(\alpha), y_{ij}^* \leq 1 \\ 1, y_{ij}^* > 1 \end{cases}, \quad (1)$$

where

$Q_{y_{ij}^*|x_i,p_{ij}}(\alpha)$ is the level α conditional quantile of potential attendance rate at the performance i in a seating area j,

$Q_{y_{ij}|x_i,p_{ij}}(\alpha)$ is the level α conditional quantile of observed attendance rate at the performance i in a seating area j,

y_{ij}^* is the potential attendance rate at the performance i in a seating area j,

y_{ij} is the observed attendance rate at the performance i in a seating area j,

x_i is the vector of performance i characteristics,

$\beta(\alpha)$ is the effect of the vector of performance characteristics on the attendance quantile level α,

p_{ij} is the price of a ticket at the performance i in a seating area j,

$\gamma(\alpha)$ is the effect of price on the attendance rate on the attendance quantile level α,

$\theta_j(\alpha)$ is the unobserved quality of seating area j on the attendance quantile level α.

We apply Chernozhukov and Hong (2002) three-step procedure to obtain the estimates of the parameters β, γ and θ_j of censored quantile regression. This procedure accounts for the heterogeneity of the effects of price, performance characteristics and seat quality on different levels of attendance rate distribution quantiles and accounts for the censoring of the potential demand to 1 while it exceeds 1.

A crucial assumption for the consistency of estimates of the demand function parameters is the exogeneity of tickets price and performance characteristics. This may be violated if the ticket price set by the theatre is dependent on the observed and unobserved performance characteristics (for instance, unobserved performance quality). Then the theatre's prediction of potential demand shock may lead to an increase in the ticket price for some seating areas. One way to avoid the possible endogeneity problem is to rely on the assumption that the price is set only as a function of observed characteristics, which leads to the independence of price and error term conditional on the performance characteristics (Laamanen, 2013). An alternative way is to find proper instrumental variables for ticket prices and perform the test on the difference of estimates between the two models with and without applying instrumental variables. We employ the latter approach using censored quantile instrumental variables method (Chernozhukov *et al*, 2015) as the robustness check using price variation within a production as instrument for price. We found the conditional independence[1] between price and unobserved performance quality which allows relying on the estimates obtained in the next section.

RESULTS

We test the estimates whether it is necessary to account for demand censorship and use the censored quantile regression compared to OLS and quantile regression on the median attended performance. The estimation results are presented in Table 4.

The effects of explanatory variables vary over the three specifications. The difference in the first two specifications is explained by the fact that OLS estimates the value of the average effect, but the median regression estimates the effect at the median. The estimates of the second specification compared to the third are smaller in absolute value suggesting that the

Table 4: Results of OLS, median and censored median regression

Variable	*(1)* *OLS*	*(2)* *Median regression*	*(3)* *Censored median regression*
Log. of price	−0.069***	−0.053**	−0.065***
	(0.012)	(0.021)	(0.021)
Russian author	0.058***	0.057***	0.107***
	(0.010)	(0.018)	(0.017)
Premiere	0.117***	0.115***	0.146***
	(0.014)	(0.025)	(0.025)
Famous opera	0.084***	0.065***	0.107***
	(0.013)	(0.023)	(0.021)
Famous ballet	0.058***	0.063**	0.095***
	(0.016)	(0.029)	(0.030)
Ballet	0.317***	0.232***	0.408***
	(0.015)	(0.027)	(0.028)
Number of awards	0.056***	0.016	0.118***
	(0.012)	(0.021)	(0.029)
Band director: Platonov	−0.029**	−0.052**	−0.056***
	(0.012)	(0.022)	(0.020)
Band director: Currentzis	0.009	0.009	−0.008
	(0.012)	(0.022)	(0.021)
Age recommended: from 12 y.o.	−0.031*	−0.009	−0.060**
	(0.018)	(0.031)	(0.028)
Age recommended: from 16 y.o.	−0.033**	−0.018	−0.041
	(0.014)	(0.025)	(0.025)
Time of day: after 2 p.m.	−0.019	−0.006	−0.037
	(0.013)	(0.024)	(0.023)
Constant	0.043***	0.032	0.078***
	(0.012)	(0.021)	(0.021)
N	2682	2682	2682
k	37	37	37
R^2	0.368	0.211	0.498

Notes The dependent variable is attendance rate of seating area at a performance.
Bootstrap standard errors based on 100 replications in parenthesis.
N is a number of observations, k is a number of estimated parameters.
We also control for year, month, day of week and seating area effects.
*** indicates significance at 10 per cent level, ** at 5 per cent level, * at 1 per cent level.

values of the effects are underestimated if one ignores the demand censoring. Estimate bias for price elasticity on different levels of attendance quantiles is shown in Figure 4.

The results of estimation on the different levels of attendance quantile (Table 5) indicate that the price elasticity estimates range from −0.21 to −0.01 which mean that the demand is weekly elastic by price. The estimate testifies in favour of weakly elastic demand that is explained by the number of reasons. The price level is relatively low because of the affordable pricing policy of the theatre administration. Perm Opera and Ballet Theatre is a famous for its high-quality productions, and the consumers' willingness-to-pay exceeds the ticket prices. Finally, as numerous authors earlier noted, the audience of the theatre is elite in terms of education, occupation and income. Therefore, the share of expenses on the theatre

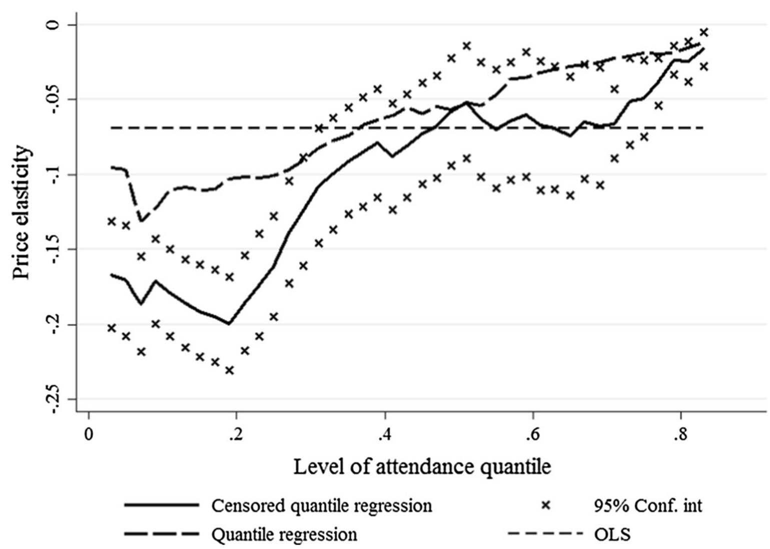

Figure 4: Estimates of price elasticity using different models.

visit in their income is low, and the increase in price does not lead to a decrease in attendance. This reason is in line with the results of Pommerehne and Kirchgassner (1987), where the authors reveal the low elasticity for higher paid segment of population. Forrest *et al* (2000) also prove, if the ticket price takes only the small share in income, the demand will be weakly elastic or inelastic by price. Nonetheless, the results are clearly comparable with the most part of price elasticity estimates obtained in the performing arts literature review (Seaman, 2006). With an increase in the attendance quantile, the price effects become smaller and significant at lower significance level. The increase in attendance quantile leads to a higher quality of performance and/or seating area. Results indicate that the demand for better-attended productions and seats is less elastic than the demand for poorer-attended productions and seats. The more expensive and prestigious areas have better attendance which means that these areas belong to a higher quantile. Then the audience of expensive seats is expectedly less elastic compared with the audience of other seating areas. The decrease of the price effect for popular productions and seats indicates that the theatre may differentiate ticket prices to increase box-office revenue. However, the subjective quality of seats may vary with the type of production as discussed above and checked further.

The estimates of the effects of other explanatory variables are intuitively clear. Demand is higher for productions of Russian authors. New productions are better attended than old ones. Theatregoers on average prefer ballet to opera, which is consistent with the fact that ballet is a more understandable cultural product than opera. The number of Golden Mask awards is a significant determinant of demand and impacts on the demand positively as well as world fame of musical composition. The demand for the family productions is less than for children and adult productions. If the difference in attendance for family and children's productions may be explained by the distinction in content, then the less popularity of adult productions arises from the narrowing of the range of potential visitors.

As with price elasticity, a rise in the attendance quantile leads to the decline in the effect of most part of the explanatory variables. This pattern gives evidence that a particular attribute has a greater effect on less popular productions. As the popularity of performance increases, the

Table 5: Results of censored quantile regression on different levels of quantile

	(1) $\alpha = 0.1$	(2) $\alpha = 0.3$	(3) $\alpha = 0.5$	(4) $\alpha = 0.7$	(5) $\alpha = 0.9$
Log. of price	−0.186***	−0.115***	−0.075***	−0.071***	−0.007**
	(0.016)	(0.023)	(0.021)	(0.024)	(0.003)
Russian author	0.080***	0.084***	0.107***	0.082***	0.018***
	(0.014)	(0.019)	(0.017)	(0.018)	(0.003)
Premiere	0.179***	0.199***	0.146***	0.110***	0.010***
	(0.020)	(0.028)	(0.025)	(0.027)	(0.004)
Famous opera	0.108***	0.149***	0.107***	0.087***	0.015***
	(0.018)	(0.024)	(0.021)	(0.022)	(0.003)
Famous ballet	0.143***	0.095***	0.095***	0.111***	0.016***
	(0.023)	(0.033)	(0.030)	(0.037)	(0.005)
Ballet	0.564***	0.487***	0.408***	0.333***	0.028***
	(0.022)	(0.030)	(0.028)	(0.031)	(0.004)
Number of	0.068***	0.074***	0.118***	0.067**	−0.001
awards	(0.016)	(0.024)	(0.029)	(0.027)	(0.003)
Band director:	−0.027	−0.029	−0.056***	−0.046**	−0.012***
Platonov	(0.017)	(0.023)	(0.020)	(0.022)	(0.003)
Band director:	−0.036	−0.036	−0.019	−0.009	−0.021***
Currentzis	(0.017)	(0.024)	(0.021)	(0.024)	(0.003)
Age recommended:	0.048***	−0.030	−0.008	0.013	0.003
from 12 y.o.	(0.017)	(0.024)	(0.021)	(0.024)	(0.003)
Age recommended:	−0.020	−0.055*	−0.060**	−0.024	0.000
from 16 y.o.	(0.023)	(0.032)	(0.028)	(0.029)	(0.005)
Time of day: after	−0.060***	−0.058**	−0.041	−0.045*	−0.001
2 pm	(0.020)	(0.028)	(0.025)	(0.027)	(0.004)
Constant	0.721***	0.731***	0.781***	1.106***	0.999***
	(0.069)	(0.097)	(0.090)	(0.104)	(0.014)
N	2682	2682	2682	2682	2682
k	37	37	37	37	37

Notes The dependent variable is attendance rate of seating area at a performance.
Bootstrap standard errors based on 100 replications in parenthesis.
*** indicates significance at 10 per cent level, ** at 5 per cent level, * at 1 per cent level.
N is a number of observations, k is a number of estimated parameters.
We also control for year, month, day of week and seating area effects.

contribution of each attribute to the demand function falls but the quality unexplained by the observed explanatory variables grows.

In order to capture the heterogeneity in price elasticity estimates and explain the heterogeneity by observable ticket characteristics, we estimate the price elasticity for each observation. For every observation attributed by performance identificator i and seating area identificator j, we calculate the quantile level of its attendance α_{ij}. Then for this observation, we estimate the parameter of price elasticity at the level of attendance quantile α_{ij}. Aggregation of price elasticity estimates by types of productions (operas and ballets) and seating areas allows to capture the differences in elasticities and, consequently, willingness-to-pay for seats. Results for these estimates are reported in Table 6.

Results indicate that demand for ballets is significantly less elastic compared with the demand for operas. This result remains even if

Table 6: Estimates of price elasticity by types of productions and seating areas

Area	*Ballets (106 plays)*		*Operas (192 plays)*		*Difference*	
	Mean	*SD*	*Mean*	*SD*	*t stat*	*p value*
All areas	−0.053	0.038	−0.110	0.055	27.15	0.00
Seating area 1	−0.068	0.036	−0.097	0.044	5.71	0.00
Seating area 2	−0.051	0.035	−0.081	0.045	5.96	0.00
Seating area 3	−0.044	0.031	−0.089	0.047	8.70	0.00
Seating area 4	−0.045	0.029	−0.085	0.048	7.71	0.00
Seating area 5	−0.041	0.028	−0.110	0.055	11.99	0.00
Seating area 6	−0.037	0.029	−0.120	0.056	14.07	0.00
Seating area 7	−0.050	0.035	−0.139	0.052	15.58	0.00
Seating area 8	−0.054	0.038	−0.147	0.049	16.94	0.00
Seating area 9	−0.081	0.048	−0.117	0.055	5.63	0.00
$\chi^2(9)$	199.1 (p value = 0.00)		42.8 (p value = 0.00)			

Notes t stat and its p value correspond to the difference between ballets and operas with null hypothesis on the same price elasticity for different production types.
χ^2 and its p value correspond to the difference to the difference between seating areas within production type with null hypothesis on the same price elasticity for various seating within production type, opera or ballet.

we compare elasticities in each seating area. Test on the difference in elasticities across seating areas within each type of production indicates that price elasticity significantly varies across the different seats. Moreover, demand for seats with higher quality is less elastic. Thus, the less elastic demand for operas is in areas 2–4 which are located in stalls and closer to the stage part of upper stalls. These seats have a higher quality of sound and proximity to the stage and its main actors. The less elastic demand for ballets is in areas 4-6 which are located mostly in the upper stalls and circle. These seats are associated with better quality of view that is crucial when watching ballet. Results of price effect heterogeneity indicate the differences in quality perception of the same seats at various productions.

CONCLUSION

Accounting for consumer heterogeneity in the models of demand became an important topic in revenue management since it establishes the theoretical base for price differentiation among consumer segments. In this article, we introduce the model of demand that accounts for heterogeneity in price and product characteristics effects. We also model the seat quality explicitly and allow the model estimates of seat quality to vary over the seats and performances without any assumptions on the underlying tastes distribution. Since the theatre house and each particular seating area have capacity constraints, we observe the censored (constrained) demand only. Account for censoring allows to identify effects on potential (unconstrained) demand. The model of demand is estimated using censored quantile regression. The demand is measured as an attendance rate of the seating area on a particular performance. The variation of demand is explained by ticket price, performance characteristics and seating areas dummies with effects depending on the level of attendance. This approach allows to obtain the estimates of effects separately for each observation and analyse patterns of effects among certain groups of observations, for instance, to obtain estimates of price elasticity for each seating area and type of production. The proposed method is also useful for estimating the range of effects on aggregate demand across the sample making it similar with mixed logit model of individual choice.

Both kinds of results are helpful for the optimisation of tickets price for a product with a given set of characteristics and seats allocation.

Using the data on tickets sales for performances of Perm Opera and Ballet Theatre, we estimate the model of demand aggregated to the level of performance and seating area. We find that demand is weakly elastic by price with an elasticity changing from -0.21 to -0.01. We reveal a strong link between price elasticity and attendance quantile. Demand for higher-attended performances and seats is less elastic compared with less attended ones. This result gives an evidence of higher willingness-to-pay for certain combinations of performances and seats that leads to high demand and low price elasticity with a given set of prices. Estimating the effects separately for each observation and aggregating the estimates by production types (operas and ballets) and seating areas, we reveal the heterogeneity in price elasticity among production types with lower elastic demand on ballets. We also reveal the heterogeneity in price elasticity among seating areas with lower elastic demand on seating areas of higher quality. An important result is that the perception of quality for the same seat may vary with the production type because seats with better view of the stage are valued more on ballets while closer to the stage seats with better quality of sound are valued more on operas. These results have practical significance for a theatre industry if ones will be implemented in a demand forecasting and revenue management system.

There are two important limitations for the research which suggest the directions for further research. First is the lack of consumer data that is not allowing to segment consumers by observable attributes and differentiate the price with respect to consumer characteristics. Second is the multicollinearity in prices for seating areas that is not allowing to model the substitutional effect between seating areas within a performance when the only price for one seating area changes. The current pricing policy of the theatre is to change the whole set of prices according to one of the eight pricing schemes making prices collinear. The combination of revealed and stated preferences data approach may help to overcome both challenges. Survey-based discrete choice experiment with wide variation in tickets prices among alternatives (performances and seats) combined with revealed preferences data on previous consumption may help with the identification of cross-price elasticities for different seats and with segmentation of consumers.

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NOTES

1 The results of the check may be provided by request.

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