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ORIGINAL ARTICLE

A count data travel cost model of theatre demand using aggregate theatre booking data

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Abstract Theatres have a market bounded by the distance theatregoers are willing to travel to see shows and productions. This paper uses count data models (Poisson regression and negative binomial models) to investigate the determinants of attendance at a regional theatre in England. It uses booking data for 29 theatrical productions supplied by the theatre, and matches this, using postcodes, with census socio-economic information on household characteristics. Socio-economic and travel cost (distance) are used to explore theatregoers attendance, and also to estimate consumer surplus, and to assess whether consumer surplus on ticket sales exceeds the annual government subsidy to the theatre.

Keywords Travel cost · Theatre demand · Attendance · Consumer surplus

1 Introduction

Despite the fact that many cultural attractions, like theatres and heritage sites, are well suited to the use of travel cost valuation methods, such studies are relatively rare, the only other travel cost model (TCM) to be applied to theatre being that of Forrest et al. (2000). Other examples of the use of TCMs in cultural economics include museums (Martin 1994; Bedate et al. 2004; Boter et al. 2005; Rouwendal

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and Boter 2009), special events and festivals (Prayaga et al. 2006) and heritage sites (Boxall et al. 2003; Poor and Smith 2004; Alberini and Longo 2006), most of which use zonal travel cost models.

Recreation demand models, such as Clawson–Knetsch zonal travel cost models (ZTCM), are based on continuous functional forms, estimated using ordinary least-squares (OLS) regression often with log-transformed variables (see Willis 1991). However, using OLS to estimate individual trips will lead to biased estimates, since trips are censored (between 0 and some upper bound quantity) and only occur in discrete integer quantities. An alternative is to use statistical models, such as count data models, that recognise the integer nature of recreation trips and their lower zero bound.

This article uses count data models to investigate both the determinants of trips to a regional theatre and to estimate the economic value of such visits. Many regional theatres are publicly subsidised. Policy makers are keen to assess whether the value of the theatre exceeds the cost of the subsidy, thus justifying it in economic terms. Subsidy to a theatre can also be more easily justified if the theatre engages with all sections of society rather than just with elite sections.

Many more valuation studies of cultural goods use stated, than revealed, preference to measure consumer surplus, the advantage of the former being that it can also measure non-use values. Non-use values refer to values that may arise from the existence of a good (such as option use, existence values and bequest values), even when the person in question does not actively use the good at present (Cuccia 2003). Whilst revealed preference (RP) methods can be used to infer values from observation of the actual use of heritage goods (such as travelling to the site or the purchase of tickets), non-use values can only be measured through asking respondents to state their preferences in hypothetical situations (Snowball 2008).

Economists may prefer to use revealed preference rather than stated preference (SP) techniques, on the assumption that what people do is a more accurate reflection of their behaviour than what people say they will do. This difference between actual and stated behaviour was noted quite early by Needleman (1976). Research has tended to show that SP [contingent valuation (CV) and choice experiment (CE)] methods can overestimate demand and values for marketed goods, because of 'yea-saying and 'warm glow' effects (see Blamey et al. 1999; Snowball 2008). So the use of RP methods is appealing. Moreover, CV and CE studies can result in the overestimation of total aggregate benefits of a programme when individual CV or CE estimates of elements of the programme are aggregated (see Hoehn and Randall 1989). The use of RP data avoids this overestimation of benefits.

Recreation demand models, based on actual visits to a recreational or cultural venue, measure the value of the good as any price paid for entry plus the cost of gaining access to the site. The latter is based on the money and time costs of travelling to the site: as cost or price increases demand declines. Demand is recorded as the visit a person makes or the number of visits a person makes to the site over a specified time period. The dependent variable can be expressed either as the number of visits per 1000 population from a given zone around the site or as the number of visits a person makes during a specified time period.

The recreation demand model first advanced by Clawson (1959) and Clawson and Knetsch (1966) was a ZTCM and estimated demand as the number of trips per

1000 population as a function of the cost of travelling to the site. ZTCMs are now relatively rare, but such a model was used by Forrest et al. (2000) in their study of whether consumer surplus generated by the Royal Exchange Theatre, Manchester, was large enough to justify a public subsidy to the theatre. Expressing the dependent variable as a rate per 1000 population in an area allows OLS regression to be used to estimate the model; thus, overcoming the problem of having a limited dependent variable as in the case of trips by an individual person.

Nevertheless, recreation demand models are now usually based on estimating the number of visits to a theatre, or other specific recreation site, made by an individual over a time period, say 1 year, as a function of price, socio-economic characteristics of the individual and the characteristics of the site or shows staged by the theatre.

2 Count data models

A substantial proportion of individuals in society do not go to the theatre, whilst those that do typically go a few times over a year, with very few individuals making frequent trips, e.g., once per week or per month. In a statistical sense, this is not a 'normal' distribution, and special types of models are required to estimate such a distribution.

Individual visits are censored at zero; whilst the number of individuals making a specific number of theatre visits per year declines as visit numbers increase. Such a distribution can be estimated using a Tobit model (see Gujarati 2003) or as a count data model. Analysing individuals' trip data using a censored regression or Tobit model can be problematic if trip numbers are few and there is little variation in trip numbers between individuals (see Willis and Garrod 1991a, b). Indeed, the maximum number of trips an individual makes to most cultural sites in a year can usually be expressed in terms of a single digit. This limited number of trips per time period can be better modelled using count data models, either a Poisson model or a negative binomial model.

Count data models, such as Poisson and negative binomial, are similar to binary models such as the logit, probit and Tobit models, since the dependent variable is limited (Cameron and Trivedi 1996). The count data model is appealing because a very small number of individuals make frequent trips to the theatre, some make a few trips to the theatre, whilst a large number do not visit the theatre at all. Such a distribution can be modelled either as a Poisson distribution or a negative binomial (NB) distribution.

2.1 Poisson model

The probability density function of the number of events N occurring in time (s, $s+t$) is

$$\Pr\{N(s, s+t) = y\}, y = 0, 1, 2, 3, \ldots \quad (1)$$

In a Poisson process, this probability is:

$$\Pr\{N(s, s+t) = y\} = \mathrm{e}^{--\lambda t}(\lambda t)^y / y!, y = 0, 1, 2, 3, \ldots \quad (2)$$

In the Poisson process, the events are assumed to occur independently, with mean and variance of Y equal to λ_t. The Poisson model assumes equality of population mean and variance. Exogenous variables X_{tj} ($j = 1,2,\ldots K$), including a constant, are included by specifying the parameter λ_t to be

$$\lambda_t = \exp(\mathbf{X}_t \boldsymbol{\beta}) \quad (3)$$

In such a count data model, the main focus is the effect of covariates on the frequency of an event.

The Poisson model may not always be appropriate for the data. The independence assumption may not hold (Cameron and Trivedi 1986) if, for example, the probability of one occurrence increases the likelihood of further occurrences. This may well be the case with theatre visits, for those few individuals who like theatre and develop the specific cultural capital required to appreciate it (Seaman 2005). In such a case, the Poisson model will overpredict the number of zeros, under-predict the number of non-zero counts and have variance in excess of the mean. This is a case of overdispersion, where sample variance is greater than the sample mean. In such a case, the assumption that the mean and variance are equal will produce spuriously small estimated standard errors for $\boldsymbol{\beta}$ (Cameron and Trivedi 1986).

2.2 Compound Poisson model

The restriction that the mean and variance of Y_i given $\mathbf{X}_i$ are equal can be relaxed to allow for unexplained randomness in λ_i by replacing Eq. 3 with the stochastic equation

$$\ln \lambda_i = \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i \quad (4)$$

where the error term (ε_i) can reflect a specification error in the exogenous variables (Cameron and Trivedi 1986). Such a specification can account for the observed overdispersion in the data and provides a better model fit than the basic Poisson model.

2.3 Negative binomial model

The negative binomial (NB) model can accommodate overdispersion. The NB has a mean of λ_i and variance $\lambda_i + \alpha\lambda_i^2$. The NB reduces to the Poisson in the special case where the overdispersion parameter α equals zero. Cameron and Trivedi (1996) argue that there are a number of reasons for using a NB: (a) when y_i is Poisson with parameter $\lambda_i\ v_i$ rather than λ_i, where v_i is unobserved individual heterogeneity; and (b) where events are not independent, but where the occurrence of an event increases the probability of further occurrences. Thus, the NB model can allow for heterogeneity between individuals by allowing λ_i to vary randomly according to some probability distribution. If $f(\lambda_i)$ or equivalently $g(\varepsilon_i)$ is a gamma distribution [in Eq. 4], then this gives the NB model.

Cameron and Trivedi (1986) point out that the NB model could be one which assumes (a) individuals have constant but unequal probability of experiencing an event, such as visiting a theatre; (b) where individuals are heterogeneous in respect to their probability (e.g. of visiting a theatre), with this heterogeneity attributable to individual (socio-economic/demographic) or environmental factors; (c) where events occur in clusters and are dependent. Unfortunately, these competing hypotheses cannot be identified and solved with a single cross-sectional data set.

When data are in counts, Cameron and Trivedi (1996) suggest that a sound practice is to estimate both Poisson and NB models. The Poisson model is a special case of the NB when $\alpha = 0$. Hellerstein (1991) also suggests using a NB count model to relax the assumption of the Poisson distribution that constrains the mean and variance of the expected number of trips $E(Y_i)$ to be equal.

2.4 Other count models

If the process determining zero counts differs from the process determining positive counts, then neither the Poisson nor the negative binomial models may be suitable. Alternative models are the Hurdle model that separately models zero and non-zero counts (see Cameron and Trivedi 1996) or an ordinal probit model (see Cameron and Trivedi 1986). Even though visits to a theatre may appear a cardinally measured variable, it could be treated as an ordinal variable, e.g., if theatre shows varied in length. Thus, visiting a theatre twice might not be double the consumption of one visit. However, there is nothing to suggest that these conditions hold for the data set used in the analysis in this paper; nor that either of these models should be employed in place of the Poisson and NB models. Rather, the Poisson and NB models are appealing because some individuals make recurrent trips to the theatre and because trips to a theatre over a time period are usually small in number whether recorded by individuals or by postcode area of theatregoers.

A count data travel cost model has the form:

$$E(Y) = f(P, Z; \beta) \quad (5)$$

where $E(Y)$ is the expected number of trips per period, P is the travel cost to the site; Z are 'demand shift' variables, such as socio-economic and demographic characteristics of the population, income, and substitute sites and β is a vector of coefficients (Hellerstein 1991). Since trips occur in non-negative quantities (data are censored at zero) and only in integer quantities, distributions which recognise the count nature of the data, like the Poisson distribution, can provide robust models (Perman et al. 2003).

Hellerstein (1995) also noted that, whilst it might be expected that a model based on individual observations would perform better than one based on aggregated data, this may not, if fact, be the case. Using a Monte Carlo simulation, he found that, although aggregated models may suffer from an 'errors in variables' bias, they are often more robust. Furthermore, the performance of individual models was particularly bad when per capita demand was small (as in the case of theatre attendance). The performance of aggregate models can also be improved by including intra-zonal covariance of explanatory variables. Since the postal code data used for this study covers small areas (3876 areas, with an average of 289 households in each area: see Table 1), variation in dependent variables within a particular zone is captured. It was thus decided to use the aggregated count data model with a Poisson distribution for the present study.

3 Travel cost studies in cultural economics

The only travel cost model (TCM) applied to a theatre, to our knowledge, is the study by Forrest et al. (2000), which used a Clawson–Knetsch zonal travel cost model (as do some of the other case studies discussed below). Findings showed that consumer surplus was significantly greater than subsidy received by the theatre, with a benefit/cost ratio of 1.33. Demand with respect to ticket price was found to be slightly elastic for all zones, except those with the highest level of education, suggesting that increasing ticket prices would not increase revenue, further supporting the case for public subsidy.

There is also a group of studies that used combinations of revealed and stated preference data, but making use of individual (rather than zonal) travel cost models and then combining or comparing average cost per trip (revealed preference) with stated preference valuation. An early valuation study of a Canadian museum (Martin 1994) combined travel cost and CV techniques and found that the museum's subsidy was less than its social value. Boxall et al. (2003) investigated willingness-to-pay for visits to Nopiming Wilderness Park in Manitoba (Canada) to see Aboriginal rock paintings. They found that, whilst respondents were willing to incur increased trip costs of $77 to see pristine paintings, their value fell by as much as 90% for defaced paintings. Alberini and Longo (2006) evaluated the benefits of increasing the conservation of, and amenities available at, cultural heritage sites in Armenia. The travel cost study showed the expected results, with the number of trips negatively related to price.

A comparison of travel time to 108 Dutch museums (Boter et al. 2005) used different distances of museums from the population to account for willingness-to-travel as a way of investigating the relative value of cultural organisations in competition with each other. Using museum visits data from loyalty cards, they use a multinomial logit model to investigate the attributes that have an effect on the probability a museum visit. A zonal travel cost study—to evaluate the impact of a special event (a gem festival) in Australia over time—(Prayaga et al. 2006) found that consumer surplus decreased by almost 50% between 1998 and 2002. Prayaga et al. (2006) argued that such a change over time (which could have been the result of price increases, lower visitor numbers and declines in tourism since 9/11, amongst others) needed to be carefully investigated for reliable long-term planning decisions.

Bedate et al. (2004) used a ZTCM to construct demand curves for four cultural goods in Castilla y Leon in Spain: the museum of Burgos, the cathedral of Palencia, the walled city of Urueña and the Iberian organ festival (as an example of a cultural event). They found that the rate at which the probability of attendance declined, as distance from the good increased, varied with the good. For example, whilst the

Table 1 Poisson and negative binomial models of theatre attendance

Variable	Poisson			Poisson with over dispersion			Negative binomial		
	Coefficient	St error	Pr > Chi-sq	Coefficient	St error	Pr > Chi-sq	Coefficient	St error	Pr > Chi-sq
Intercept	1.0928	0.2780	<.0001	1.0928	0.3961	0.0058	0.6003	0.4623	0.1941
Travel cost	−0.0221	0.00??	<.0001	−0.0221	0.0014	<.0001	−0.0143	0.0012	<.0001
Population	0.0003	0.0001	0.0001	0.0003	0.0001	0.0064	0.0009	0.0003	0.0044
% Pop ≤17	1.4899	0.4702	0.0015	1.4899	0.6698	0.0261	1.7093	0.7322	0.0196
% Pop 18–29	1.6408	0.1619	<.0001	1.6408	0.2306	<.0001	1.8766	0.2889	<.0001
% Pop 30–44	−0.7486	0.3196	0.0191	−0.7486	0.4552	0.1001	−0.3697	0.5184	0.4757
% Pop 45–59	0.8123	0.2868	0.0046	0.8123	0.4085	0.0468	0.8770	0.4489	0.0508
% Pop EU	1.4973	0.4954	0.0025	1.4973	0.7057	0.0339	−0.7592	0.8022	0.3440
% Christian	−2.3761	0.1571	<.0001	−2.3761	0.2238	<.0001	−2.4064	0.2792	<.0001
% Buddhist	5.9952	1.6888	0.0004	5.9952	2.4057	0.0127	5.3091	3.4598	0.1249
% Jewish	−2.2870	0.5013	<.0001	−2.2870	0.7141	<.0014	−1.8441	0.8598	0.0320
% Econ inac	0.4208	0.2570	0.1016	0.4208	0.3661	0.2504	0.6828	0.3976	0.0859
% Prof emp	0.8914	0.2180	<.0001	0.8914	0.3106	0.0041	0.6458	0.3533	0.0675
% Edu 1 and 2	−1.5928	0.2401	<.0001	−1.5928	0.3420	<.0001	−1.0871	0.3754	0.0038
% Prof pop	2.8094	0.3182	<.0001	2.8094	0.4532	<.0001	3.3150	0.5260	<.0001
% h owner	0.4776	0.0897	<.0001	0.4776	0.1278	0.0002	0.5422	0.1351	<.0001
% hhold dc	−0.9299	0.2943	0.0016	−0.9299	0.4192	0.0265	−1.6821	0.4786	0.0004
% Lone	−0.0208	0.0034	<.0001	−0.0208	0.0049	<.0001	−0.0203	0.0051	<.0001
Scale	1.000	0.0000		1.4245	0.0000		0.5260[a]	0.0258	
df	3858	Value/*df*		3858	Value/*df*		3858	Value/*df*	
Deviance	7828.79	2.0292		7828.79	2.0292		3880.12	1.0057	

Table 1 continued

Variable	Poisson			Poisson with over dispersion			Negative binomial		
	Coefficient	St error	Pr > Chi-sq	Coefficient	St error	Pr > Chi-sq	Coefficient	St error	Pr > Chi-sq
Scaled dev	7828.79	2.0292		3858.00	1.0000		3880.12	1.0057	
Scaled P χ^2	9933.17	2.5747		4895.03	1.2688		4956.40	1.2847	
AIC	14780.95			7302.26			13014.70		

df degrees of freedom, *Scaled dev* scaled deviance, *Scaled P* χ^2 Scaled Pearson Chi-square, *AIC* Akaike information criterion

%edu 1 and 2 = % of population 16–74 who have educational qualifications: up to ‘O’ level, of GCSE standard, or 1 ‘A’ level pass

[a] Dispersion

probability of attendance at the festival was much higher for those in the 40 km zone than for the other goods, it also declined much more quickly as distance increased. Patterns of attendance were also found to be dependent on how well known and advertised the good was and on the 'touristic appeal' of the site or event. In terms of consumer surplus, the study found that the museum generated the highest levels (about five times more than for the organ festival) followed by the cathedral, the walled city and finally the organ festival.

Poor and Smith (2004) used a similar approach to estimate the consumer surplus of visits to historic St Mary's City in Maryland. As expected, the probability of visiting declined as the distance to the site increased, but the income coefficient was negative (indicating that as income increased, the probability of visiting declined), contrary to a priori expectations. They suggested that the fairly remote location of the site made it both better known, and more attractive, to lower income rural households than to higher income urban ones.

A recent study by Rouwendal and Boter (2009) uses an innovative two-stage model to assess the value of Dutch museums. Based on the Hausman–Leonard–McFadden method, their model accounts for the separation the trip generation and trip distribution decisions (using a count data model for the latter). For trip distribution, they find that the welfare effects of one less museum may be overstated unless substitutes are taken into account.

4 Theatre attendance

Apart from the cost of access to the theatre, there are other factors determining attendance. A determinant of theatre attendance has often been revealed to be education. It has been shown that education is a significant determinant of public participation in the performing arts in the USA, and that higher income increases the probability of receiving higher education (Borgonovi 2004). But policy makers are also anxious to demonstrate that regional grant-aided theatres and companies appeal to all.

Theatregoers are often shown to come from middle- and high-income groups, but the effect of income on attendance is mixed, partly because higher earnings are often associated with less leisure and a higher opportunity cost of time (Borgonovi 2004). In many cases, education is actually shown to be a more important determinant of attendance than income (Seaman 2005). For example, in a study of determinants of demand for live theatre produced by the Pacific Conservatory of the Performing Arts in California, Corning and Levy (2002) found that in only one case was income significant. Ateca-Amestoy (2008) used a count data model of live theatre performance in the US (using US Survey of Public Participation in the Arts (SPPA) 2002 data) to investigate the determinants of attendance. This study also found that, for those with a positive probability of attendance (as opposed to the 'never-goers'), income is only significant for attendance for the last quartile of the distribution.

Borgonovi's (2004) study of public participation in the performing arts in the US has similar findings, showing that education, particularly arts-specific education, is much more significant than household income. She suggested that higher current and family income increased the probability of receiving arts-specific education and, though this, the probability of attendance. This finding links with theories of taste formation, including 'rational addiction' and 'learning by consuming' (Levy-Garboua and Montmarquette 2002; Seaman 2005; Colbert 2003). Findings by Gayo-Cal (2006:186) on general leisure participation in Britain agree with this: 'Economic capital does not have a big impact on dimensions of leisure participation', but that education does play an important role, especially in frequency of participation. The Forrest et al. (2000) study on regional theatre demand in the UK also found education to be one of only two significant socio-demographic variables, the other being age (measured as the percentage of the population over retirement age).

Results for the impact of age on live performing arts attendance are even more mixed than that of income. Seaman's (2005) review reflects this, reporting both increasing participation for higher age groups in some studies and the opposite in others—results seeming to be highly dependent on how 'performing arts' were defined, data sets and the country in which the research was done. The recent study by Ateca-Amestoy (2008) found that being older reduced the probability of never attending live theatre performances and increased the probability of going more often. This was explained via taste formation and the accumulation of cultural capital, both of which take time, and are expected to impact positively on participation. The Borgonovi (2004) study, which also uses the SPPA data set, found the same general result for age in relation to classical music, although younger people were more likely to attend theatres.

In a study by Gayo-Cal (2006) on out-of-home leisure activities in Britain (including cinema, museums, pubs, theatre, night clubs and many others), age was found to be an important determinant. Using factor analysis, this study found that older people were more likely to engage in 'legitimate' or 'prestigious' leisure practices (including theatre, opera and art galleries) and less likely to participate in more 'popular' forms (night clubs, pubs and rock concerts). Willis and Snowball (2009), in a study of determinants of attendance at theatre performances at the South African National Arts Festival, found that age was a significant determinant of utility for certain types of show, for example, older people gained more utility from shows with music than from comedy or drama. The impact of the age variable on theatre attendance is thus likely to depend, at least to a certain extent, on the broad genre of shows being offered.

It is generally found that women participate more in the arts than men, since women are socialised on cultural activities more and earlier than men, who are often more exposed to sport (Seaman 2005; Ateca-Amestoy 2008). However, Borgonovi (2004) found that, while women were more likely to attend than men, they did so less frequently. Grisolia and Willis (2010) found that women were less affected by 'reviews' and 'word of mouth' assessments of theatre productions, compared to men, in their choice of which play to attend.

Seaman (in his 2005 review of the literature on studies of the demand for the performing arts) noted the general lack of research on the impact of ethnicity and race on attendance. Whilst results depend crucially on the art forms being discussed, the expected result for European or western art forms is that white people will attend more than other groups. However, in referring to US studies by DiMaggio and Ostrower, Seaman (2005:45) commented that, ‘The negative effect of race on euro-American high culture arts participation is modest’. Different levels and types of cultural capital (often captured by race or ethnicity variables) were found by the Gayo-Cal (2006) study on leisure participation in Britain, to have a significant effect on the types of leisure activities engaged in and the frequency of attendance.

5 Case study and data

The case study for the research in this paper was Northern Stage, a regional theatre and production company which began in 1970 in Newcastle upon Tyne, in north-east England. It is located close to the city centre and next to the University of Newcastle upon Tyne. Northern Stage reopened in September 2006 after a 2 year £9 million refurbishment. Bookings data were collected from Northern Stage for all 29 productions[1] between April 2007 and October 2008. These data recorded the postcode of each booking for each production, essentially documenting the origin of the theatregoer, and thus how far a person had to travel to see a show at the theatre.

These theatre booking data were matched to socio-economic and demographic data from the UK Population Census surrounding the theatre, identified in the previous section as being determinants of theatre attendance, to assess the impact of different socio-economic/demographic characteristics on theatre bookings. A summary of the means and standard deviations for the socio-economic characteristics of the population in the 3858 Population Census Output Areas (OAs), which formed the variables in the models, is outlined in Table 1.

The cost of seeing a theatre production is the price of the theatre ticket plus the cost of travel to the theatre. The price of the theatre ticket is invariant over space, but the cost of travel varies according to distance travelled. The cost of travel comprises both the actual expenditure incurred by car (bus or train) to reach the theatre plus the opportunity cost of the travel time involved.

Estimating the value for the cost of travel, and time cost involved, in accessing a recreation site is not an easy task. Theatre attendance bookings did not record information on how people travelled to the theatre, whether by car or public transport. Costs can be obtained for public transport; but people aged >60 have free public (bus) transport, and although they spend more time travelling compared to car transport they may also have a lower opportunity cost of time. For two or more people <60 years old travelling together, car transport can be a cheaper alternative to public transport. For car transport, distance from the home of a person booking a theatre ticket was calculated as Euclidean distance. There was a very high correlation between Euclidean distance and actual road distance from theatregoers homes to Northern Stage theatre, as a result of the density of roads in the urban area.

[1] These productions included comedy (e.g. Cattle Call; Brendon Burns), drama classical (e.g. Far From The Madding Crowd; Molora), drama modern (e.g. Delirium), experimental (e.g. My Arm Oak Tree), and family shows (e.g. Gormenghast; Life of Pi) and family Christmas shows (e.g. The Goblin who saved Christmas; Hansel and Gretel).

Car transport is calculated as cost per kilometre. Motoring costs comprise depreciation, cost of finance, fuel, insurance, road tax, maintenance and breakdown assistance insurance. These costs can vary across households depending on the type of car used and also on whether the car is a company car or a private car. In addition, the perceived cost of car transport may differ from the actual cost to an individual. Some car owners replace their cars on a regular basis, whilst others use their car over its entire life (10–20 years) before replacing it. This affects depreciation and cost per kilometre. Others may not perceive the full cost of using a car and ignore depreciation cost and cost of financing (opportunity cost of capital). In addition, car insurance and road tax can be regarded as a sunk cost in determining the marginal cost of car usage. The cost per kilometre assumed for car usage was £0.1261 per kilometre: a cost estimated by the Royal Automobile Club (RAC) as the average cost in 2008 for a typical family car (excluding depreciation and financing costs). The application of this value is additionally complicated by the occupancy rate in the car: the cost may not be applicable to all occupants.

The costs of the actual travel also include the opportunity cost of the time spent travelling. If a positive value of the opportunity cost of time is assumed, the question then becomes how to value this opportunity cost. McKean et al. (1995) demonstrate that, especially for populations with a high proportion of retirees and students, hourly earnings overestimate the marginal value of time and that, even for employed people, institutional constraints (regular working hours) may prevent the substitution of leisure time for income.

Theatre trips usually occur in the evening and involve a loss of alternative recreational opportunity rather than any loss of earnings. Smith and Karou (1990), in a meta-analysis of 77 travel cost studies, found travel time was valued at 0.37 of wage rate. The Department for Transport (2009) uses value of £5.04 per hour (2002 prices) for commuting time and £4.46 per hour (2002 prices) for other journeys not involving working time. The Department of Transport (2009) also assume a non-working time income elasticity of 0.8, to derive a non-working time value in future years as income increases. A complication for some recreational trips is that the trip may itself provide some utility, and, in addition, have multiple purposes (Perman et al. 2003). Forrest et al. (2000) suggest that this is less likely in the case of theatre performances that often occur at night and are not generally combined with visits to other sites. However, the problem of substitute sites (which could include other theatres, but also other cultural leisure activities, like television programmes, dance shows, orchestras) is also one to keep in mind, although it is extremely difficult to account for in travel cost studies. If such omitted variables are important, estimates of consumer surplus may be biased.

Both Throsby (2001) and Forrest et al. (2000) point out the possibility that people who like theatre may choose to live closer to areas where it is available (usually cities), thus introducing endogeneity bias. If this is the case, consumer surplus estimates are likely to be downwardly biased because ‘distance will appear to be more of a deterrent than it actually is’ (Forrest et al. 2000).

Poor and Smith (2004) simply valued trip time as a third of the average zonal wage rate multiplied by the estimated average time spent travelling to and from the site. Forrest et al. (2000) use the UK Department of Transport ‘behavioural value of (non-working) time'. They also note, however, that since education was a significant determinant of attendance, and since education is positively related to income, average income for the whole population is probably an underestimate of the value of time for theatregoers, who tend to have higher than average levels of education. Whatever the method used, sensitivity analysis to determine the impact of such assumptions on results is probably wise. As Perman et al. (2003:417) note, placing a value on time ultimately 'involves some level of judgement on the part of the TCM analyst'.

Because of the problems of deriving an value for the opportunity cost of time travelling to the theatre, only the cost of travel at £0.1261 per km is used. This provides a conservative estimate of the value of theatre access, and thus a conservative estimate of consumer surplus to theatre visits.

6 Results: determinants of attendance

The results of the three data count models are presented in Table 2.

6.1 Poisson regression

The goodness-of-fit criteria for the Poisson regression model indicates that because the value/*df* for deviance is higher than 1, Poisson regression is not adequate to describe the counts of theatre attendance across the 3858 postcode areas surrounding the theatre. It also suggests that there is greater variability amongst the counts than would be expected for a Poisson distribution. This extra variability (or 'overdispersion') could have arisen because the repeated events are not independent: some people are more likely to attend the theatre than others, or because some areas are more likely to have theatregoers than others. Clearly, overdispersion is present in the basic Poisson regression model since value/*df* for deviance is 2.0292. Overdispersion still allows consistent means of parameters to be estimated, but the standard errors of these estimates are biased downwards, resulting in erroneous tests of their statistical significance (Cameron and Trivedi 1996).

6.2 Poisson regression corrected for overdispersion

Overdispersion can be accounted for in the Poisson model by introducing a dispersion parameter into the relationship between the variance and the mean. When this scale parameter $\varphi = 1$, the model is the basic Poisson model. The φ factor does

Table 2 Actual and predicted theatre visits

		Mean	SD	Minimum	Maximum
Actual data	Actual visits	2.0492776	3.6312475	0	60
Poisson	Predicted	2.0492775	2.3433398	0.0497379	24.0715598
Negative binomial	Predicted	2.0585934	2.7720555	0.1267734	101.4860870

not affect parameter coefficients but scales the estimated covariance matrix and hence affects the standard errors of the coefficients. If overdispersion is modest, which appears to be the case, then the Poisson model corrected for overdispersion produces an appropriate inference. In the Poisson model, the scaled deviance is held at 1 and the scale parameter is estimated as 1.4245 ($=\sqrt{\text{deviance}/df}=\sqrt{2.0292}$). The parameter estimates remain the same as in the basic Poisson model, but their standard errors are inflated by the scale parameter, resulting in wider confidence intervals, higher p values and more conservative significance tests.

6.3 Negative binomial

The negative binomial model allows for overdispersion since its variance is always greater than the variance in the basic Poisson model with the same mean μ. As the scale factor in the model approaches 1.0, the negative binomial model approaches the Poisson model.

6.4 Choice of model

There is no single criterion to identify the best model. A range of criteria are used: model goodness-of-fit measures, expected signs and significance of explanatory variables, accuracy of prediction of actual visits and realism of consumer surplus estimates.

Table 2 reveals that the Poisson model corrected for overdispersion has the best goodness-of-fit measures, e.g., in terms of log likelihood. Moreover, this Poisson model has fewer explanatory variables that are not statistically significant; there are four explanatory variables which are not statistically significant in the NB model, whilst there is just one explanatory variable that is not statistically significant in the Poisson model corrected for overdispersion.

Table 3 shows the predicted visits estimated by the two models: Poisson model accounting for overdispersion and the NB model. The Poisson model accurately predicts mean visits to the theatre and better estimates the minimum and maximum number of visits. The NB model predicts the actual mean visit rate slightly less accurately than the Poisson model and has a higher standard deviation, as shown in

Table 3 Predicted theatre visits with changes in market area population

		Mean	SD	Minimum	Maximum
Actual data	Actual visits	2.0492776	3.6312475	0	60
Status quo	Predicted visits	2.0492775	2.3433398	0.0497379	24.0715598
−10% Population	Predicted visits	2.0307292	2.3182721	0.0495533	23.9366315
+10% Econ inac	Predicted visits	2.0808640	2.3820932	0.0504988	24.6309691
+10% Prof employ	Predicted visits	2.1663885	2.5162416	0.0523048	25.7824337
−10% Prof pop	Predicted visits	1.8724976	2.0823112	0.0466978	22.3524337
−10% Educ 1 and 2	Predicted visits	2.1475428	2.4040107	0.0535936	24.4303685
+10% hhold dc	Predicted visits	2.0038004	2.3069657	0.0480762	23.9275586

Table 3. Moreover, as revealed later, the Poisson model corrected for overdispersion produces more conservative and realistic estimates of consumer surplus on theatre visits. Thus, the Poisson model accounting for overdispersion is the preferred model.

6.5 Effect of socio-economic factors on theatre visits

Only socio-economic variables which are statistically significant in determining visit numbers from Census OAs are included in Table 2. Multicollinearity between the variables in Table 2 is low, partly because in any set of variables, e.g., housing type, all the variables representing housing type are not included.

The results in Table 2 show that *travel cost* has, as expected a priori, a negative coefficient and effect on the number of trips to the theatre. This indicates that the further away people live from the theatre, the fewer the number of trips they make.

The number of people (*population*) in a postcode group has a positive influence on the number of trips to the theatre. The age profile of an area affects theatre trips: the higher the proportion of young (≤29 years old) and 45–59 age groups, the greater the number of trips; whilst a higher proportion of 30–44 year olds decreases trips (perhaps, because in the latter age group, households have young dependent children, which constrain evenings trips, and there are also other, more important, calls on the family budget relative to the theatre). These age differences are measured with respect to the percentage of the population more than 60 years old.

The types of productions at the theatre also appeal to people born in the EU (*% pop EU*), but not in UK and Ireland: the higher the percentage of EU born citizens, the greater the number of trips relative to UK, Ireland and non-EU populations. The theatre also appears to have differential appeal to different religious groups. Areas with higher proportions of Christian and Jewish populations are negatively associated with visits to the theatre.

The number of theatre visits is positively associated with the proportion of the population economically inactive (*% econ inac*) (e.g. students, housewives, unemployed, retired), suggesting that those with more time available are more likely to visit the theatre. Conversely as the percentage of the economically active employed in managerial and professional occupations (*% prof emp*) increases, theatre visits increase. A positive effect is also observed between visits and the % of population economically active and inactive that are, or were, in managerial and professional occupations (*% prof pop*). However, as the proportion of population with only basic levels of educational attainment (%edu 1 and 2) increases, theatre attendance declines.

As the % of households in an area living in owner occupied houses (*% h owner*) increases, theatre trips increase. Conversely, as the % of households with dependent children (*% hhold dc*) or the % of single parents with dependent children (*% lone*) in an area increase, theatre visits decrease.

The size of the coefficients relates to the metric in which the variable is measured. Since most variables are measured in terms of a percentage, the coefficients reveal the relative importance of the impact of that factor. So education level attained, and population in professional employment, are quite influential in determining the number of visits to the theatre. Religious affiliation also seems to have an important role; although some coefficients here are large because the percentage of some religious groups (e.g. buddists) in the population is quite small. The population coefficient is small because population is measured in absolute terms. The travel cost metric is somewhat analogous to percentage, being a measure from zero to 50 km. The effect of distance and travel cost is perhaps surprisingly small, indicating that people are not particularly deterred from visiting the theatre over this distance, relative to other factors or covariates.

The characteristics of the market area of the theatre are changing over time. This will affect the number of visits and may affect the financial viability of the theatre in the future. The impact of a change in the population and population characteristics surrounding the theatre, on the number of visits, can be assessed by making a unit change in a variable, holding all other variables constant, and noting the effect on the visit rate. Table 4 reports the results for a change in the population total, the percentage economically inactive, the percentage in professional employment, the percentage in education groups 1 and 2, and the percentage of households with dependent children.

North-east England has lost population through migration to the more prosperous south-east and midland regions of England. Moreover, there is a drift of population from inner city areas to suburbs and rural areas in England. The effect of this on theatre attendance is tested by assuming a 10% decrease in catchment area population of the theatre, holding all other variables constant.

The percentage of economically inactive population is growing, as the population ages, and with rising unemployment levels. The effect of a change in the proportion of the population economically inactive on theatre attendance is assessed through a 10% increase in this variable. The character of the workforce is changing in England with an increase in white collar and a decrease in blue collar workers. The effect of a change in the structure of the workforce on theatre attendance is evaluated by assuming a 10% increase in professional employment. However, the economic recession, and the high dependence of the north-east England economy on public

Table 4 Consumer surplus (CS) and required subsidy if population characteristics changed (£ per year, 2009 prices)

	Original variable percentage	Mean number of bookings per OA	CS per ticket	Total CS	Additional subsidy
Actual data		2.0492776	19.72947	1,052,153	0
−10% Population	264.5[a]	2.0307292	19.55068	1,042,618	9535
+10% Econ inactive	37.2	2.0808640	20.03335	1,068,358	−16,205
+10% Prof employ	50.4	2.1663885	20.85673	1,112,269	−60,115
−10% Prof pop	24.7	1.8724976	18.02732	961,379	90,774
−10% Educ 1 and 2	34.1	2.1475428	20.67529	1,102,593	−50,440
+10% hhold dc	26.5	2.0038004	19.29143	1,028,792	23,361

[a] This is mean of actual population per Population Census Output Area (OA). The other figures in this column are percentages

sector employment, may mean that the professional population decreases. The Conservative-Liberal coalition government is committed to making large cuts in public sector employment, which could reduce the percentage of professional population in north-east England. The effect of this on theatre attendance is assessed by assuming a 10% decrease in the professional population in the catchment area of the theatre. The final variable considered is households with dependent children. The population of the UK is growing, not only through in-migration, but also from an increase in the birth rate. Moreover, high house prices, together with higher unemployment amongst younger age groups, have resulted in more children living at home. The effect of a greater proportion of households with dependent children on theatre attendance is assessed by assuming a 10% increase in households with dependent children.

The results of changes in the size and socio-economic composition of the population on theatre attendance are presented in Table 4. The results, based on the Poisson model accounting for overdipersion—the best fitting model—show that a 10% decline in the population in postcodes within 50 km of the theatre will not have a hugely significant effect on theatre bookings. The mean booking rate will decline from 2.049 per area to 2.030. A 10% increase in the economically inactive, *ceteris paribus*, will increase the mean number of bookings from 2.049 to 2.080.

More significant changes in booking will occur if the socio-economic composition of the population was to change. For example, a 10% increase in the number of professional employees in the labour force will, *ceteris paribus*, increase the mean number of bookings from 2.049 to 2.166. Conversely, if the percentage of professional people in the population (active and inactive) were to fall by 10% then bookings would fall to an average of 1.872 per Census Population Output Area (OA). A change in the education level of the population also has a significant effect on visit rates. A 10% decrease in the population only achieving education levels 1 and 2 (implying that the percentage of more educated people in the population increases) will increase the mean number of bookings from 2.049 to 2.147 per area. On the other hand, if the percentage of households with dependent children living at home were to increase by 10%, then the number of bookings would fall from an average of 2.049 to 2.003 per area.

7 Results: consumer surplus

Consumer surplus is equal to the inverse of the travel cost coefficient for the semi-log functional form, which results from a Poisson regression (McKean et al. 1995). Thus, average consumer surplus per booking was calculated for each model as $q/\text{-}\beta$, where q is the number of bookings and β is the estimated travel cost parameter. This is the general case for an exponential model (see Willis and Garrod 1991b). Consumer surplus estimates from the Poisson and negative binomial models are £92.72 and £143.95, respectively, per booking. Across all productions in the sample, on average, 4.7 tickets were purchased with each booking. Thus, consumer surplus per ticket was £19.73 for the Poisson model and £30.63 for the negative binomial model.

The negative binomial consumer surplus estimate is about 55% higher than the Poisson estimate. Overdispersion does not have an effect on mean consumer surplus, but the difference in functional form between the Poisson and negative binomial models clearly affects consumer surplus estimates.

This result indicates that distributional assumptions can have substantial effects on estimated consumer surplus. The negative binomial is more skewed to the right than the Poisson distribution, and the negative binomial is also more peaked than the Poisson distribution. However, in this study, the log likelihood, other goodness-of-fit measures, accuracy of prediction and realism of consumer surplus estimates, clearly point to the Poisson model corrected for overdispersion as the preferred model.

Consumer surplus derived from RP data relates to use value only. The local community may have some non-use value for Northern Stage, but this is unlikely to be a significant amount compared to non-use value for a national theatre, where non-use value can be significant (see Bille-Hansen 1997).

Grant income to Northern Stage for the financial year ending 31 March 2009, amounted to £1,601,467; of which, the largest portion (£1,441,357) came from the Arts Council England. Across the financial year 1 April 2008 to 31 March 2009, there were 8763 bookings and 53,329 tickets were sold. Applying the consumer surplus estimate for each ticket to the number of tickets sold in the 2008/09 financial year implies that Northern Stage generates a consumer surplus of £1,052,153 (based on the Poisson model) to £1,633,434 (based on the negative binomial model). Thus, under the negative binomial model, the consumer surplus generated by Northern Stage just exceeds the income or subsidy it receives in grants. However, under the Poisson model, the consumer surplus generated by Northern Stage falls short of the subsidy it receives by approximately £0.5 million, although it should be recalled that the ZTCM used excludes non-use values and the opportunity cost of time in calculating consumer surplus.

The current level of subsidy is dependent upon the population characteristics in the market area of Northern Stage. If the population characteristics changed, then the number of bookings and ticket sales would change. For example, if the population changed such that there was a 10% increase in professional employment, then the mean number of bookings per Population Census Output Area (OA) would increase from 2.0492776 to 2.1663885, resulting in a change in the number of tickets sold, consumer surplus per ticket and a change in total consumer surplus from £1,052,153 to £1,112,269. This would allow the subsidy to Northern Stage to be reduced by £60,115 per year (see Table 4). This assumes that Northern Stage requires the current subsidy of £1,601,467, and that this additional consumer surplus could be captured by an increase in ticket prices.

On the other hand, if there was a 10% decrease in the professional population (employed and economically inactive) in the market area of Northern Stage, then mean bookings would fall, and Northern Stage would require an additional £90,774 in subsidy per year (assuming no adjustment in costs). Table 4 reveals that the consumer surplus generated by Northern Stage depends on the population characteristics of its market area, and that a change in these characteristics will affect whether the consumer surplus generated by the theatre exceeds the subsidy to the theatre. A change in the population characteristics may also affect the subsidy required by the theatre, assuming the theatre is unable to change its operating costs. These hypothesised changes in population structure are not large: a 10% increase in the economically inactive population would change the percentage of economically inactive from 37.2 to 40.9%; whilst a 10% decreased in the professional population would reduce the professional population from 24.7 to 22.2%. But they do have significant effects on ticket sales and hence on the consumer surplus generated by the theatre.

It is worth pointing out that the viability of Northern Stage, as a theatre, is dependent on its location in the city of Newcastle with the large population in the city and other surrounding urban local authority areas. Across all the theatre productions, on which this analysis in this paper is based, some 4409 bookings, representing 20,722 tickets, were purchased by people living within 10 km of Northern Stage. If a similar theatre opened in say Hexham, a market town 25 km to the west of Newcastle, the number of ticket sales would be much less. Applying the Northern Stage Poisson model to OAs within 10 km of Hexham generates a similar number of bookings per thousand population, since the population characteristics are similar to those surrounding Newcastle. However, because the population surrounding Hexham is much smaller than that surrounding the centre of Newcastle, the model predicts fewer bookings (162) and ticket sales (763) for such a theatre located in Hexham. This fact explains the dearth of theatres such as Northern Stage outside the major urban areas in the UK.

The viability of a theatre also depends upon what shows the theatre stages throughout the year. A stated choice study of Northern Stage theatregoers preferences revealed the genres of drama, comedy and experimental theatre to be statistically significant (Grisolia and Willis 2010). The smallest contribution to the utility came from experimental adaptation, perhaps because it is a more difficult play to appreciate and is therefore less popular. However, because the revealed preference booking data only covered 29 productions across all genres between April 2007 and October 2008, it was not possible to model the effect of genre using count data models in the current study.

8 Conclusion

This study applies an innovative approach to assess the determinants of attendance at a regional theatre in England, Northern Stage. This method is inexpensive because it uses postcode data from theatre bookings combined with Census information on the socio-economic profiles of postcodes, to assess the socio-economic and demographic determinants affecting theatre attendance, and also the consumer surplus or value attached to attending theatre productions in addition to the ticket price paid.

Socio-demographic variables and composition of the population were found to have a relatively larger impact on average attendance than distance from the theatre. For instance, the higher the proportion of younger (<29 years old) and older (45–59) people, the greater the number of trips, whilst the 30–44 year old age group made fewer trips. This is almost certainly related to the presence of dependent children in households of this age category—as the proportion of households with dependent children increased, the average number of theatre visits fell. A 10% increase in households with dependent children would result in the average number of trips per area falling from 2.049 to 2.003. These findings may explain the mixed results on the relationship between age and attendance at performing arts found in other studies (Seaman 2005).

As in other studies (Borgonovi 2004; Corning and Levy 2002; Ateca-Amestoy 2008), education was found to be a more important determinant of attendance than income. A higher proportion of economically inactive people increased attendance, as did the proportion of those who were currently, or had been, in professional or managerial occupations. Whilst a 10% decline in population within 50 km of the theatre was shown not to have a very big impact on attendance, changes in population composition would have more dramatic effects. A decrease in 10% in professional population would reduce the average booking rate from 2.049 to 1.872 per census area.

The subsidy received by Northern Stage (mainly from the Arts Council of England) was less than the consumer surplus generated for the 2008/9 financial year. However, the extent of the benefit/cost depends quite substantially on which model was used (Poisson or negative binomial) to estimate consumer surplus, indicating that, in such studies, distributional assumptions can have significant effects on the outcome. Thus, even quite small changes in population composition would have a significant effect on ticket sales, consumer surplus generated and subsidy required. The viability of Northern Stage is very much dependent on its location in the city of Newcastle, with its large population.

Such information, which is relatively inexpensive to obtain, can be of importance to theatre managers, in terms of marketing, choice of production and motivation for public support.

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