SCHOOL OF
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Museum Visitation under Charged and Free Admission

An Analysis of Vertical Product Differentiation

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Abstract

The issue of museum entrance fees is widely debated. Traditionally, it has been commonly agreed that museums should be free, however nowadays charged admission is the norm. Although economic analysis is a relevant tool in order to understand the impact of a given admission policy on museum demand the notion of congestion has been previously overlooked. In this essay, I analyze how museum visitation is impacted by different admission policies with respect to congestion. Three admission policies are analyzed. First, the case of both days of free admission and days of charged admission. Second, the case of only charged admission. Third, the case of only free admission. I find that in general, as long as at least one group of visitors pays for admission, a profit-maximizing museum will have economic incentives to provide visits to all types of visitors. In essence, the entire market will be served. However, due to the nature of the museum product, the exact levels of the quantity sold, the quality supplied and the consumer surplus potentially enjoyed cannot be calculated within the scope of the model. For this purpose, a model which takes into account the relationship between quantity and quality is required.

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1. Introduction

1.1. Background

The issue of museum entrance fees is widely debated. Historically, there has been a widespread opinion that museums should be free of charge. At this point, however, charging for entry is common (O'Hagan, 1995). Whereas many museums are free in for example the United Kingdom and Washington D.C., the policy is rare globally. The most expensive museums in 2019 are priced at $25 in the United States, $22 in Europe and $20 in Australia, which is more than in other areas in the world (MuseumNext).

Economics as a field has never been generally focused on museums. However, economic analysis is an important tool in understanding the impact of a given admission policy on museum supply and demand, as visitors maximize their utility subject to time and budget constraints and as museums are productive units "which, in order to achieve certain objectives, engage in the transformation, via a production technology, of inputs into a mix of outputs that are valued by others" (Johnson and Thomas, 1998, p75). Thus, the debate about charging has been dominated by such arguments as regarding marginal costs and consumer composition (see Bailey and Falconer, 1998). At this point in time, economic analysis has contributed conclusions including, but not limited to, price elasticities, income elasticities and crosselasticities of demand. However, previous research on the area has generally overlooked the notion of congestion, which is a possibly major determinant of demand.

Museum visitors can impose negative externalities on each other when the level of attendance increases. Congestion causes "queuing, noise, occasional shoving, and ultimately an inability to view the exhibits" (Maddison and Foster, 2003, p173-174), which decreases the quality of the museum experience. Rational consumers will therefore consider these utility losses when choosing whether to attend a museum or not. In order to fully understand the economic impact of a given admission policy, analysis of its relationship to congestion is needed.

A museum can choose which quality (congestion) to supply through its admission policy. Furthermore, different visitors have different valuations regarding congestion. Thus, the museum can be analyzed as a firm producing vertically differentiated products.

1.2. Objective

The objective of this paper is to analyze how museum visitation is impacted by different admission policies with respect to congestion.

1.3. Method

The issue is analyzed through an economic model within industrial organization, regarding the museum as a profit-maximizing firm supplying vertically differentiated products. I first present the general model. Then I apply it to three different admission policies. Finally, I discuss the applicability of the general model and conclude which findings are relevant and not.

1.4. Limitations

The conclusions drawn strictly regard the ceteris-paribus impact of congestion on visitation and how this relationship is used by museums to maximize profits under certain admission policies. It is therefore not an analysis of the total impact of a given admission policy on demand. In order to demonstrate the previous conclusions of other factors of demand, a section is devoted to a literature review of those determinants. It is outside the scope of the purpose to analyze the relationship between the determinants.

1.5. Outline

The paper is organized as follows. First, I briefly present the traditional role of museums in society, their objective and the consequent arguments. Second, I will present an overview of other determinants of demand for museum visits than congestion. Museums has a wide variety of functions, which is evident from the previous findings. This literature review is, as it outlines what my analysis is meant to complement, important for the understanding of the overall impact of admission fees. Third, I will present the general model used to analyse the relationship between admission, congestion and utility on the market for museum visits. This is meant to provide an understanding of the scope and limitations of the theory. The model is developed for general firms, but since museums offer a unique type of product, it will have to be altered. Fourth, I will apply the general model to the case of the museum product. Three different cases will be analysed: supplying both free and charged days, supplying only charged days and supplying only free days. This will connect the analysis to the issue of charging. Fifth, I will problematize the application of the model to the museum product. Sixth, I will summarize the findings.

2. The Role and Policy Objective of Museums

Traditionally, museums have taken on the role of collecting, researching and presenting objects to the public, with an educational objective (Arinze, 1999). The educational function does not only include a transfer of knowledge, but also stimulation of such virtues as curiosity, creativity and taste. Due to the diverse traditional roles of museums, they use a variety of methods to fulfill their purpose. Collecting is achieved through the ownership and preservation of collections, researching is achieved through acquiring the expertise to identify and interpret objects and making museums open to the public is achieved by exhibiting the collections, and their interpretations, to either the general public or to specific target groups such as school children. (The Smithsonian Institution, 2001)

According to the International Council of Museums (2017), museums are non-profit. However, there are museums that are for profit (Donley, 2014).

The educational role of museums is achieved primarily when individuals decide to pay a visit and there is therefore a strong belief that entrance to museums, as national cultural institutions, should be free. Furthermore, since the educational output is a (although arguably) public good, it should be charged through taxes rather than admission fees. On the other hand, museum visitors are not representative of the general population, and relatively few, which makes the educational benefits unevenly spread – general taxation should therefore be complemented by priced admission. (O'Hagan, 1995)

3. Museum Demand Determinants Other than Congestion

A wide variety of research has been made into demand for museum visits. In this section, I provide an overview of other determinants of demand than congestion.

3.1. Monetary Determinants

According to Frey and Meier (2002), demand is determined by three key factors related to costs:

- Entrance fee, the elasticity of which of demand is overall low. The authors write that the elasticities have been found to be between -0,1 and -0,2 across four Dutch museums (Goudriaan, 1985), -0,55 for a particular museum in Great Britain (Darnell, 1992) and between -0,26 and -0,12 depending on the type of museum – zoos, science museums and natural history museums have the highest value – art museums having specifically value -0,17 (Luksetich and Partridge, 1997).
- Opportunity cost of time, which is assumed to be higher for those with higher income and flexible scheduling than for those with lower income and strict work schedules. The opportunity cost and demand are assumed to be negatively related. However, no clear support has been found, the authors write, in the studies by Luksetich and Partridge (1997) and Gapinski (1986).
- Price of alternative activities, which primarily refer to other events such as theatre plays and other cultural activities, nights at a restaurant and time at home with friends. Such events are assumed to be substitutes for museum visits. Complementary products are also assumed to influence demand: travel costs, accommodation and meals for example, which have fundamental magnitudes, 80 % of the total visit cost (Bailey et al., 1998), and have been found to significantly have negative cross-price elasticities of demand (Gapinski, 1986) according to the authors.

Another monetary determinant is income. Previous studies include findings of positive income elasticity of demand, such as Withers (1980). Still, that type of estimates are unreliable as the increased demand from higher income can be offset by the corresponding rise in the opportunity cost of time. (Frey and Meier, 2002)

The “price of other alternatives” determinant is built on the assumption that activities such as cultural engagement is a substitute for museum visits. This has however been researched and found to not be obvious. In a study of the effects of free admission on visits to museums with charged admission in Italy the authors Cellini and Cuccia (2017) found that the latter increased. In other words, a complementary relationship was found. The authors also referred to a similar

study by Chen et al. (2016) in Taiwan who found the same: "the new free-admission policy in public museums leads to larger number of visits to both public and private museums" (Cellini and Cuccia, 2017, p2).

The two findings do however not undercut the whole point by Frey and Meier that there are substitutes to museum visits. It is reasonable to assume that complementarities exist uniquely for other cultural activities, due to theories of consumption capital. This is a point that will be returned to later.

3.2. Knowledge and Social Determinants

Demand for culture is determined by a cultivation of taste or learning-by-doing process. Without such processes, the consumer cannot enjoy the full utility possible of cultural consumption. In other words, the individual preferences regarding demand for culture exhibit intertemporal dependency. (Brito and Barros, 2005) This notion of addiction is a relevant characteristic in the consumption of cultural products (Cellini and Cuccia, 2017).

Cultivation of taste and learning-by-doing, and addiction, refer to the acquisition of cultural consumption capital. The concept is described by Bennet and Silva (2006) as a stock of competencies that gives knowledge of certain cultural practices. The basic concept was however outlined by Bourdieu. In his words, "a work of art has meaning and interest for someone who possesses the cultural competence, that is, the code into which it is encoded" (Bourdieu, 1984, p. 2).

The more one engages with culture, the easier it is to enjoy. Cultural capital can also be achieved by general education, since this increases general human capital. The better educated a consumer is, the more utility is within reach. However, this depends on the type of museum: museums of science and technology require less education than art and history museums. (Frey and Meier, 2002)

Having acquired cultural capital lowers the cost of gaining utility from further consumption. In other words, for consumers with high levels of consumption capital, price elasticity of demand is the lowest. The decrease in intellectual costs to enjoy the exhibitions may partly offset an increase in monetary costs.

The complementarity between acquisition of cultural capital and cultural participation has been subject to a variety of studies. For example, art lessons as youngsters increases visits to museums of art as adults. This was found in a study of the relationship in the United States by Gray (1998). The author also concluded that schools are not for sure the best providers of the lessons. Also, Kisida et al. (2014) find that early exposure to museums as children increases future museum visits (Lattarulo et al., 2017), writing that students with higher levels of initial cultural capital are more interested in cultural consumption, in their study of cultural capital amongst children in the United States. Furthermore, in his study of cultural consumption in science in Japan, Kato-Nitta (2013) found that "those who frequently accumulate scientific and technical capital consumed the most science at the open house event," which implies that accumulation of the capital should raise attendance to science museums too. Robinson et al. (1985) find in their study of participation in arts activities in the United States that "there was a clear tendency for people already involved and active in leisure pursuits and arts-related activities to participate more," (p. 25) and more so than other consumers. In their study of arts education and art participation in the United States, Bergonzi and Smith (1996) find that "Arts education is the strongest predictor of all types of art participation, except arts performance. The more arts education a person has, the more extensive one´s participation in the arts" (p. 50). According to DiMaggio (1996), the best predictor of visits to museums of art is education level, in the United States (DiMaggo et al., 1978; Schuster, 1991), in Germany (Kirchberg, 1996), the Netherlands (Ganzeboom, 1982), and France, Poland and Greece (Bourdieu and Darbel, 1990). The studies by Cellini and Cuccia (2017) in Italy and Chen et al. (2016) in Taiwan, that free museum admission stimulates attendance to charged museums, also indicate the complementarity between cultural capital and museum visits.

There is a positive relationship between socioeconomic profiles and museum visits. Socioeconomic status has been found in the United States to be positively related to level of arts education (Bergonzi and Smith, 1996). There is in other words a correlation between acquisition of cultural capital and class. In the United States, art museum visitors are generally

wealthier than other people (Schuster, 1991) and more secular, more politically left oriented and more open to other ethnic groups, cultures and lifestyles (DiMaggio, 1996). Also, taste for high culture has in previous societies been a valuable social signal for some social groups (Goffman, 1951), but this may now has developed into a tool for approaching any social group (DiMaggio, 1996).

The findings may have two different explanations. Firstly, cultural consumption capital may be passed down through generations (Bourdieu, 1984). The initial level is therefore not chosen but related to class. Secondly, cultural consumption may partly be related to lifestyle, creating a decrease not just in intellectual costs (consumption capital) but adding a social gain, meaning that not just the cultural experience is consumed but the social inclusion as well.

Consumers also differ from each other with regards to purpose of the visit. Hood (1983) identifies three types of museum visitors in her research of motivation to museum consumption in the United States. Frequent participants visit museums at least three times per year. They most highly value, and perceive as being supplied by museums, quality of time, challenge to experience and opportunity to learn. The type is 14 % of society but 45-50 % of museum visitation. For them, admission, travel tickets, inconvenience and other barriers are outweighed by the utility from visiting. Occasional participants visit museums one or two times per year and most value active participation, comfortability and social interaction. They regard museums as insufficient at providing comfort (due to lack of cultural capital) and value socialising higher than special interests, which is why they usually substitute museum visits for other leisure activities. Nonparticipants value the same features as occasional participants, and find none to be supplied by museums. Occasional participants are 40 % of society and nonparticipants are 46 % of society.

Although most studies regard museums of art, there is no obvious reason to assume that the case would be different considering other museums. The reason to why art museums have gotten the most focus may be because they are amongst the most famous museums (for example, the Louvre in Paris, the Metropolitan Museum of Art in London and the Guggenheim Museum in Bilbao) and are seen as the most cultural type of museums. Still, there is no reason to assume that it would not be the case. Important future research areas will be discussed further.

3.3. Supply Determinants

Perhaps the primary supply determinant of demand for museums is the quality of the exhibition. The more educating, entertaining and fascinating a museum is, the more visitors will be attracted.
Museum consumers demand a "total experience", which includes ancillary services such as cafés, restaurants and gift shops. This implies that there are cross-elasticities between museum entrance fees and ancillary museum services.

The issue has been studied in Italy by Marra and Palumbo (2018). They find that ancillary services are key to attract young visitors to big museums (however not for other sizes of museums). Furthermore, McIntyre (2008) finds in England that "There is an apparent desire that café and foodservice spaces within a museum, gallery or house attraction offer elements that supplement the 'core' experience of the visit" (p. 185). McIntyre (2010) also finds in England that consumers consider museum gift shops to be an integral part of their museum/gallery experience.

There is a strong complementarity between social spaces such as restaurants and museum visits. It is suggested that the possibility of social interaction is not just ancillary to the experience of the arts, but the primary feature demanded (Johanson and Glow, 2012). The demand for the opportunity to socialize with others during the museum visit is, according to Gofman et al. (2011), found in Falk and Dierking (2000), Grinter et al. (2002), Leinhardt et al. (2002), Hooper-Greenhil (1999), Thyne (2001) and Kinghorn and Willis (2008). It is also suggested by Kelly et al. (2004), that social interaction and learning is the key driver of demand for museum visits. This implies that the exhibition, to some, is a type of tie-in sale to access to social spaces.

Another type of tie-in sales are present in the museum product. According to Frey and Meier (2003), complementary services to museum visits are travel, accommodation and meals: between which and museum visits there are negative cross-price elasticities of demand. They also write that Bailey et al. (1998) have found that such complementarities represent over 80 % of the total costs of a city visit. Tourists, who visit museums, spend of their money 21 % on accommodation, 20 % on restaurants, 20 % on travel tickets and 11 % on shopping (Levä,

2016). Furthermore, it has also been found that in 2016, accommodation represented the largest part of the budget for tourists (37 %) and transport was second (32 %), for citizens of the European Union (European Union, 2018). Such complementary services are a must for the museum visit for tourists. There is in other words tie-in sales of such products as accommodation, food and transport to museum visits. Although not all visitors are tourists, significant amounts are. In the Netherlands, around 40 % of foreign tourists visited at least one museum in 2009 (Aarsman et al., 2012). According to Levä (2016, p18), "cultural tourism, in which museums are a key player, is growing rapidly and is a major driver of destination attractiveness and competitiveness."

Another supply determinant is the prominence of the museum. Frey (1998) has developed a concept of superstar museums. According to him, such museums are a must for tourists, attract large amounts of visitors, exhibit world-famous artists and works of art, are located in architecturally outstanding buildings and have a fundamental impact on the local economy. Consumers of art are "unwilling to substitute lower for higher talent even for a cheaper price" (p. 116). This explained to be partly because the comparison cost is low, due to for example the internet, because it is the easiest to remember just a few masters in every category, and because much of the utility of consuming art originates from discussing it with others – the more who know an artist, the more fun it is to learn about the same artist.

The superstar museum concept is narrowed down to museums of art, but is applicable to other museums too. However, instead of talent, the reason for superstar status is such factors as completeness and significance. Within technical museums for example, the first airplane may be more prominent than a later model. Within natural historical museums, a complete dinosaur skeleton may be more prominent than just a tooth.

4. The General Model

In this section, the general model of vertical product differentiation in a market with one firm and two consumer groups is presented. The purpose is to provide an understanding of the scope and limits of the model. In the next section, the model will be applied to the case of museums.

First, I explain the concept of vertical product differentiation. Then I present the model. All the information in the second section is from the same source.

4.1. Vertical Product Differentiation

Vertical product differentiation refers to products that differ objectively from each other. In other words, the product mix is distinguished not based on individual taste, but on quality. If a high-quality product and a low-quality product are offered for the same price, all consumers will choose the one with the highest quality. Although the recognition of quality is equal for all consumers, the valuation of quality differs between consumers, due to factors such as incomes or attitudes to how much quality is worth. (See Pepall et al., 2014)

4.2. Review

Assume that there are only two consumer groups, one with high willingness to pay, and one with low willingness to pay, for quality of a monopolist's product. Every individual consumer consumes one or no units of the firm's products and chooses the quality which gives the largest consumer surplus. The utility obtained indirectly for one consumer type *i*, of two, is:

$$V_i = M_i\left(q - \underline{q_i}\right) - p \qquad (1)$$

Here M_i is a valuation of quality, q is the quality, $\underline{q_i}$ is a lower bound on quality for which the consumer consumes the product and p is the price. It is assumed that $M_1 > M_2$, in other words the first consumer group values quality higher than the second consumer group. It is also assumed that $\underline{q_1} > \underline{q_2} = 0$, in other words the first consumer group demands a higher minimum quality than the second consumer group, which will is satisfied with any quality. (See Pepall et al., 2014)

Since the profit-maximizing monopoly firm cannot distinguish the groups of consumers, its optimal product mix makes the first and second consumer group self-select into high and low quality product consumption respectively. It will charge a high price for the high-quality product and a low price for the low-quality product, equal to the willingness to pay of the second consumer group. (See Pepall et al., 2014)

It is assumed that marginal costs of production are zero for all qualities of the product and that the firm can offer any quality within a certain range $\left[\underline{q}, \overline{q}\right]$. Furthermore it is assumed that:

$$\overline{q} > \frac{M_1 \underline{q_1}}{M_1 - M_2} \quad (2)$$

This is the easiest satisfied when the difference between the valuations of quality between the types of visitors is great. (See Pepall et al., 2014)

The second type of consumer will be charged a price at which they will buy the low-quality product, which, considering equation (1) and given that $q_2 = 0$, is:

$$p_2 \leq M_2 q_2 \ (3)$$

A profit-maximizing monopoly firm will set this price equal to $M_2 q_2$. The first type of consumer, however, will buy the high-quality product only if the consumer surplus is greater than if buying the low-quality product and non-negative:

$$M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq M_1\left(q_2 - \underline{q_1}\right) - p_2 \quad (4)$$

$$M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq 0 \quad (5)$$

Both types of consumers face an incentive compatibility constraint since they can both choose to purchase one product of any quality. The first type of consumer must face a price respecting

the conditions above to purchase the product with high quality. This product will, using the fact in equation (3) to substitute into condition (4), be priced at:

$$p_1 \leq M_1 q_1 - (M_1 - M_2) q_2 \qquad (6)$$

There is however a lower bound, for the second type of consumer to not have incentives to purchase the high-quality product. The equivalent condition of the first group of consumers, condition (5), for the second group of consumers implies that for this purpose:

$$p_1 > M_2 q_1 \quad (7)$$

In other words, the high-quality product must be priced at:

$$M_2 q_1 < p_1 \leq M_1 q_1 - (M_1 - M_2) q_2 \qquad (8)$$

Using the pricing in equation (3) and equation (8), the first group of consumers will purchase the product of low quality and the second group of consumers will purchase the product of high quality. This makes the firm overcome the issue of incentive compatibility constraints by making consumers self-select into their assigned products. (See Pepall et al., 2014)

A profit-maximising monopoly firm has incentives to increase the quality differences between the products since consumers of the high-quality products then can be charged more. Furthermore, according to equation (6), the price for the product of high quality can be set higher for higher values of the level of valuation of quality by the two consumer groups. (See Pepall et al., 2014)

The total profit of the firm, considering the assumption that marginal costs are zero and adding the assumption that there are no fixed costs, and if there are N_1 consumers of the first type and N_2 consumers of the second type, is:

$$P = N_1 p_1 - N_2 p_2 = N_1 M_1 q_1 - N_1 (M_1 - M_2) q_2 + N_2 M_2 q_2$$

$$= N_1 M_1 q_1 - (N_1 M_1 - (N_1 + N_2) M_2) q_2 \qquad (9)$$

The firm maximizes its profits when q_1 is set as high as possible. The rule that profits increase as q_1 increases is shown in equation (9). In other words, the firm's profits are maximized when:

$$q_1 = \overline{q} \qquad (10)$$

In order to maximize its profits, the firm sets the quality of its best product as high as possible. The quality choice of the low-quality product depends from case to case. If the coefficient $(N_1M_1 - (N_1+N_2)M_2)$ is positive, profits decrease when q_2 increases; if it is negative, profits increase when q_2 increases. In the second case, $N_1M_1 < (N_1+N_2)M_2$, the firm's profits are maximized when the q_2 is set as high as possible, in other words:

$$q_1 = q_2 = \overline{q} \qquad (11)$$

In this case, both products are set at equal levels of quality. Thus, the firms sells only one product, of the highest quality possible. The case is also that the product will be priced at $M_2\overline{q}$ and supplied to both types of consumers, since the profits of this option $(N_1+N_2)M_2\overline{q}$ being greater than those $N_1M_1(\overline{q} - \underline{q_1})$[1] of the alternative option, makes this more profitable[2]. Thus, all consumer surplus is extracted from the second type of consumer. However, the first type of consumer enjoy consumer surplus. If instead $N_1M_1 > (N_1+N_2)M_2$, the monopoly firm will, in order to profit-maximize, offer two qualities that are as different as possible: $q_1 = \overline{q}$ and q_2 as low as reasonable. The quality of the worst product cannot be as low as possible, because condition (5) must hold, but, by substituting the information in equation (10) and equation (6) into condition (5), at:

$$\overline{q} \geq \frac{M_1\underline{q_1}}{M_1 - M_2} \qquad (12)$$

A profit-maximizing monopoly firm will set the quality equal to $\frac{M_1\underline{q_1}}{M_1 - M_2}$. Considering the assumption in equation (2), this is lower than the maximum quality that can be supplied, in other words, the quality of the high-quality product can be set higher. The price of the highquality product will, by substituting $q_2 = \frac{M_1\underline{q_1}}{M_1 - M_2}$ and equation (10) into $p_1 = M_1q_1 - (M_1 - M_2)q_2$, be set equal to $M_1(\overline{q} - \underline{q_1})$. The price of the low-quality product will, by substituting $q_2 = \frac{M_1\underline{q_1}}{M_1 - M_2}$ into $p_2 = M_2q_2$, be set equal to $\frac{M_2M_1\underline{q_1}}{M_1 - M_2}$. By doing this, all consumer surplus from both groups of consumers is extracted. The total profits in this case are $N_1M_1\left(\overline{q} - \underline{q_1}\right) + N_2\frac{M_2M_1\underline{q_1}}{M_1 - M_2}$. (See Pepall et al., 2014)

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[1] When the product is supplied only to the first consumer group and priced at the level extracting all consumer surplus $M_1(\overline{q} - \underline{q_1})$.

[2] This holds only if $N_2M_1\left(\overline{q} - \underline{q_1}\right) < (N_1+N_2)M_2\overline{q} \rightarrow N_1M_1 < (N_1+N_2)M_2\frac{\overline{q}}{\overline{q} - \underline{q_1}}$ which is the case.

In the first case, when one product is supplied to both groups of consumers, the price is in between those offered in the second case, when one products is supplied to each group respectively. The price for the high-quality product is higher than for the single product in the first case and the price for the low-quality product is lower than the same single product, according to assumption (2). Which case is more profitable is ambiguous. The first case will be chosen by the profit-maximizing firm if there are enough of the second type of consumer in relation to the first type; the second case will be chosen by the profit-maximizing firm if there are enough of the first type of consumer in relation to the second type. (See Pepall et al., 2014)

5. The Model Applied to Museums

In this section, I apply the model presented in the previous section to the case of museums. Alterations of the general model will necessarily be needed.

First, I discuss the notion of profit maximization in the case of museums. Second, I discuss the necessary assumptions in the case of museums. Third, I apply the general model to the case of the museum product. This third section will be divided into three different admission policies. They are, both charged and free admission, only charged admission and only free admission.

5.1. Profit Maximization

It should also be noted that the idea of maximizing profits is arguably inappropriate. Museums are, as mentioned, supposed to be non-profit. Also as mentioned, there are however some museums that are run for profit. The notion of profits is however easily adjusted to a non-profit nature by assuming that all revenues over total costs are invested into the museum. This changes the motive to fit into museum objectives, while keeping everything else intact. The term will

however be kept in the rest of the paper. This keeps the link between the general model and museums, however awareness of the adjustment discussed is important.

5.2. Assumptions

First of all, it is assumed that the museum is a monopoly. In other words, consumers regard its output as having no (close) substitutes. If there are other museums in the area, potential visitors recognize that their exhibitions are different and do not see them as competitors. For example, consumers of a local art museums do not consider a potential local history museum to be a competitor, neither do museum consumers in Amsterdam regard the collections in the Madame Tussauds to be competitors to the collections in the Rijksmuseum.

Secondly, it is assumed that there are only two groups of potential visitors, who differ from each other with respect to their willingness to pay for entrance to the museum and who cannot be distinguished by the museum. Each consumer will either not pay a visit or pay a visit once per time period. Visiting consumers choose a day when the quality is such that their consumer surplus is the greatest possible.

Thirdly, it is assumed the output of the museum only differs with respect to quality, and that the quality is only determined by the level of congestion. The level is either low for the whole day, which makes the quality high, or high for the whole day, which makes the quality low. Furthermore, the quality is assumed to be objective, in other words, every potential consumer is aware of which level of congestion is present and agree that high levels are worth less than low levels. Finally, it is assumed that consumers know when congestion will be high and when it will be low and are available to visit under both circumstances.

The first consumer group values low congestion higher than the second consumer group. Furthermore, the first type of consumer demands a higher minimum level of low congestion than the second type of consumer which is willing to visit the museum even under the fullest possible level of congestion. In other words, visitors of the first type are more bothered by

congestion than visitors of the second type and will only visit up to a certain level of congestion, whereas the second type will visit under any level. However as mentioned, the first consumer type has a higher willingness to pay for admission. Visitors thus differ both with regards to willingness to pay and with regards to tolerance to congestion.

5.3. Case 1: Mix of Free Days and Charged Days

If the museum wants to raise revenues through profit-maximized admission, it needs to make sure that the first type of visitor sees the collections on a day with the low level of congestion only and that the second type of visitor sees it on a day with the high level only. Since both groups of consumers face incentive compatibility constraints, they need to be charged admission for the different days at a level that makes the first and second group self-select into visiting on a low and high congestion day respectively. The museum will price days with low congestion highly and days with high congestion low.

A remark here is appropriate. Museum exhibitions with congestion as its only determinant of quality differ from normal products in one important regard. High levels of congestion per definition require high visitation and vice versa. Quantity and quality are strongly related. In contrast to a firm selling, for example, cars or training advice, who can produce any quantity of any quality, a museum can only supply days of low congestion to a maximum amount of visitors and days of high congestion to a minimum amount of visitors. If enough visitors come on a day of low congestion, the level will increase to high congestion. Similarly, if too small amounts of visitors come on a day of high congestion, the level will decrease to low congestion. According to the basic law of demand, saying that price and quantity sold are negatively related, price and quality are also related. Thus, in order to supply both days with low congestion and days with high congestion, different pricing is fundamentally required, not just desirable in order to maximize profits.

Furthermore, it should be noted that for the purpose of this paper, the low-admission level will always be zero, even if it is possible to profitably charge more. Thus, in the case of uniform pricing, this will be zero, and in the case of two entrance fees, the cheapest days will be free.

It is assumed that the museum has no marginal costs. In other words, marginal consumers do not increase the operational costs for the museums. Additional visitors do not, for example, raise the costs for staff or maintenance. It is also assumed that the museum can offer any level of congestion within a certain range. The minimum level is zero congestion, in which case no one visits the museum, supposedly under very high admission. The maximum level depends on the size of the museum. There is however always an upper limit due to museums having capacity constraints. The level depends more on the size of the collection than on the size of the museum, since only the space close to each piece is relevant (outside of it, the piece cannot be enjoyed) and the pieces are expected to be displayed as to not need to share space. The constraints are not always the limits though, since some museums never operate at full capacity.

According to equation (3), there is only an upper bound on the admission charged on days of high congestion. This price is therefore set to zero. In other words:

$$p_2 = 0 \qquad (13)$$

Substituting equation (13) into condition (4) gives that:

$$M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq M_1\left(q_2 - \underline{q_1}\right) \qquad (14)$$

In other words, admission on low-congestion days must be:

$$p_1 \leq M_1(q_1 - q_2) \qquad (15)$$

Thus, admission on charged days must be set lower when entry on the other days is free, compared to when entry on the other days is charged[3][4]. This is because the museum must make sure that consumers self-select into the two days. Consumers must still enjoy a non-negative surplus in addition to condition (14). In other words:

$$M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq 0 \qquad (16)$$

The price must, substituting condition (7) into condition (15), be set:

$$M_2 q_1 < p_1 \leq M_1(q_1 - q_2) \qquad (17)$$

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[3] $M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq M_1\left(q_2 - \underline{q_1}\right) \rightarrow p_1 \leq M_1(q_1 - q_2)$ compared to
$M_1\left(q_1 - \underline{q_1}\right) - p_1 \geq M_1\left(q_2 - \underline{q_1}\right) - p_2 \rightarrow p_1 \leq M_1(q_1 - q_2) + p_2$

[4] $M_1(q_1 - q_2) < M_1(q_1 - q_2) + p_2$ for $p_2 > 0$

By setting an admission fee of the low-congestion days within these constraints, the two groups of visitors will self-select into attending on their respective assigned days. A profitmaximizing museum will set the admission fee equal to the upper bound.

Due to incentive compatibility constraints, if the charge is set above the upper bound of the constraints in equation (17), the first type of consumer will self-select into a free day, if they tolerate the level of congestion on those days. In that case, consumer surplus is greater if visiting on a free day than if visiting on a charged day. Nothing will then be sold on charged days. If the first group of consumers do not tolerate the level of congestion on free days, they will not visit the museum either on a charged day or a free day. If the price is set below the constraint in equation (7), the first type of consumer will self-select into a charged day, as long as they enjoy a non-negative surplus. In that case, nothing will be sold on free days.

Zero marginal costs has been assumed. Furthermore, zero fixed costs is assumed. Also, the number of consumers of the first type is N_1 and the number of consumers of the second type is N_2. Thus, the total profits of the museum is:

$$P = N_1 p_1 + N_2 p_2 = N_1 M_1 (q_1 - q_2) \qquad (18)$$

The museum maximizes its profits when the quality of the charged days is as high as possible, which is to the general model, when profits increase as q_2 decreases. Similarly in this case, the museum maximizes its profits when the level of congestion on the free days is as high as possible. This rule is shown in equation (16). In other words, the museum's profits are maximized when:

$$q_1 = \overline{q} \qquad (19)$$

In order to maximize its profits, the museum thus wants to offer as low a level of congestion possible on days with charged entry. Similarly, the museum maximizes its profits when the level of congestion on the free days is as high as possible, as shown in equation (18). However, the quality choice regarding free days is still subject to the constraints in equation (12). According to that rule, congestion on those days should be as high as possible up to a certain level. In other words, the museum's profits are maximized ceteris paribus when:

$$q_2 = \frac{M_1 q_1}{M_1 - M_2} \qquad (20)$$

The consumer surplus for the second type of consumer is $M_2\left(q_2-\underline{q_2}\right)-p_2$, which considering that admission is free and that the minimum quality accepted by them is zero, is M_2q_2. Considering that $M_2>0$, and $q_2=\frac{M_1\underline{q_1}}{M_1-M_2}>0$, the second type of consumer enjoys a positive consumer surplus.

The consumer surplus for the first type of consumer is $M_1\left(q_1-\underline{q_1}\right)-p_1$, which considering that admission is $M_1(q_1-q_2)$, is $M_1\left(q_2-\underline{q_1}\right)$. In other words, the greater the quality is on free days, the greater is the consumer surplus for the first type of consumer. As long as the quality of the free days is greater than the minimum quality tolerated by the first type of consumer, the first group of consumers will enjoy a positive consumer surplus.

In conclusion, when a museum both wants to supply free days and charged days, it will offer the highest possible congestion on free days and low, although not the lowest possible, congestion of charged days.

5.4. Case 2: Only Charged Days

In this case, the analysis is equal to that in the general model.

If the coefficient $(N_1M_1-(N_1+N_2)M_2)$ is positive, the museum sells only one type of day, of the highest quality possible. However, the price will be set low enough for the second type of consumer to want to purchase it, in other words, at level $M_2\overline{q}$. Thus, both types of consumers will visit the museum. All consumer surplus is extracted from the second type of consumer. The first type of consumer enjoys consumer surplus.

If the coefficient $(N_1M_1 - (N_1+N_2)M_2)$ is negative, the museums both sells days of low congestion and days of high congestion. The level of congestion on charged days will be as low as possible. On free days, it will be $\frac{M_1\underline{q_1}}{M_1-M_2}$, which is higher than the minimum level. The prices on the respective days will be set to profit-maximize, as in the general model. The high-quality day will have a $M_1\left(\overline{q} - \underline{q_1}\right)$ charge. The low-quality day will have a $\frac{M_2M_1\underline{q_1}}{M_1-M_2}$ charge. No type of visitor will enjoy consumer surplus in this case. The level of congestion on low-quality days will be the same as in the case when they were free. Similarly, the level of congestion on high-quality days will be the same as in the case when low-quality days were free.

The case, as in the general model, depends on the relative sizes of the first and second group of consumers. If there are enough second-type visitors, it is the most profitable to supply two types of days of two different qualities. If there are enough first-type visitors, it is the most profitable to supply one type of day. However, what is enough is ambiguous. The case depends on the amount of first-type consumers, the amount of second-type consumers, the valuation of quality by the first group of consumers and the valuation of quality by the second type of consumers.

5.5. Case 3: Only Free Days

In this case, both types of consumers face the same price. Each type will visit if its consumer surplus at worst is all extracted. Since museum visits are vertically differentiated, in other words they objectively differ from each other, the museum has an incentive to supply only one quality.

The second type of consumer will visit the museum if $M_2\left(q - \underline{q_2}\right) - p \geq 0$ (condition (4) is irrelevant since only one product is available), which as explained in 4.6., the section above, is the case. In other words, the first type of visitor will attend the museum. Whether or not they enjoy positive consumer surplus depends on q, in other words the quality of the visit. If the level of congestion is so high that the quality is zero (for example, if nothing can be heard over

the noise and nothing can be seen over the crowds and no one can move), all their consumer surplus is extracted. However, as long as the quality is better than this, they enjoy positive consumer surplus. It should be noted that the museum is indifferent, with regards to profits, to the quality supplied. The level of congestion does not impact profits. Still, the museum may have non-economic incentives. For example, it may have policy objectives to reach many visits.

The first type of consumer will similarly visit the museum if $M_1\left(q - \underline{q_1}\right) - p \geq 0$, which

considering that admission is free depends on $M_2\left(q - \underline{q_1}\right) \geq 0$. In other words, the first group of consumer will visit if $q \geq \underline{q_1}$. As long as the level of congestion corresponds to at least the minimum level of quality tolerated by the first type of consumer, they will visit, otherwise they will not. Furthermore, they will enjoy consumer surplus only if the quality is above this level.

In this case, it is clear that the sorting mechanism through which the types of visitors are assigned consumption, does not depend on the price. Visitors do not make their decision on whether or not to attend based on the price of the visit, but on their preference of quality. In the cases above, the decisions have been made on both quality and price.

6. Problematization of the Application

The model relies on the assumption that the museum can guarantee a certain level of congestion on each type of day (high or low quality). However, this is not as straightforward as has been implied.

The museum is bound to sell a certain amount of visits in order to supply a given quality. Low levels of congestion require low attendance. High levels of congestion require high attendance. Therefore, in case the museum wants to supply different qualities, there must be more visitors of the second type than visitors of the first type attending. This is due to the nature of the museum product.

If not enough visitors attend on a low-quality day, it becomes high quality. If too many visitors attend on a high-quality day, it becomes low quality. In effect, the calculated profit-maximizing qualities may not be reasonable, in particular in the cases where the museum supplies a product of the highest quality possible. Such a product can only be supplied when it is sold to only one visitor.

In the case of both charged and free days, for the strategy of supplying each charged day to only one visitor to be the most profitable, it is required that the person with the highest willingnessto-pay has a valuation of quality that is more than twice that of the person with the secondhighest willingness-to-pay within the second group of consumers, which is not the case since it has been assumed that every individual within each group of consumers has an equal valuation of quality. The same is the case when the museum sells priced days of different qualities.

In the case of only charged days, with one level of congestion, supplying to only one visitor is profit-maximizing only if that visitor has a willingness to pay which is higher than the sum of all other visitors, which is not the case since the method requires that the product is sold to all consumers.

As a result of the two cases above, it is in reality more profitable to sell visits of a lower quality than the highest one. At the same time, the museum is constrained in its quality choice since it wants consumers to self-select into their respective assigned days. Thus, there is a minimum level of visitation present under which the first type of consumer will choose to visit on a free day. Where the profit-maximizing price is within the range is unclear from the model.

There are however methods to impact the quality for a given level of visitation during a given period of time. One method is to set an upper limit on congestion. By supplying only a limited amount of tickets, the museum can guarantee a certain interval of quality. The museum has an incentive to supply a maximum amount of tickets that is below the level of attendance on free days, in order to create lower congestion on those days and thus be able to profitably charge for admission. Furthermore, the museum has an incentive to on free days supply an amount of

$\frac{M_1 q_1}{M_1 - M_2}$ tickets that, if all sold, correspond to a congestion level of. In setting a limit on $M_1 - M_2$ attendance, the museum needs to take into account incentive compatibility constraints.

Another method through which the museum can impact the level of congestion, given a certain level of visitation during a given period of time, is by changing the high-low quantity ratio. In other words, it can decide how many days of high quality to supply for each day of low quality with the effect of achieving a certain level of congestion on each day. The more high-quality days are supplied within the period of time, the more can the first group of visitors spread out on those different days, which increases their quality. At the same time, the second group of visitors is more comprised on fewer low-quality days, which decreases their quality. Similarly, the more low-quality days are supplied within the period of time, the more can the second group of visitors spread out on those different days, which increases their quality. At the same time, the first group of visitors is more comprised on fewer high-quality days, which decreases their quality. However, this method changes the quality of both types of days simultaneously. There is a negative relationship between quality on charged days and quality on free days. Thus, it is only appropriate for the cases where the museum both types of days.

One third method, which allows the museum to impact the quality on a given type of day, without impacting the quality on the other type of day, is available. This is to alternate the length of the daily opening hours. Assuming for simplicity that the opening hours on high-quality days are the same across all of those days, and that the opening hours on low-quality days are the same across all of those days, the museum can change the opening hours on a given type of day in order to influence quality of that type of day. For a given schedule of opening hours on low and high quality days, respectively, ceteris paribus increasing the opening hours on high-quality days, increases the quality of those days. The visitors can then spread out over a longer period of time, which decreases congestion. For the same schedule, increasing the opening hours for on low-quality days, ceteris paribus, increases the quality of those days. The visitors are similarly able to spread out over a longer period of time, which decreases congestion. Following the same logic, decreasing the opening hours on high-quality days results in lower quality on those days. Similarly, decreasing the opening hours on low-quality days results in lower quality on those days. However, this assumes that consumers are available all opening hours.

Even though the exact levels of quality and admission may be incompatible, the basic concepts concluded from the model remain. If the museum wants to supply two different types of days, it has incentives to maximize the quality difference between them. This is the case both if the museum wants to supply one free and one charged day, or only charged days, but with two different qualities. If the museum wants to supply only charged days, with the same quality, it will offer a maximized quality and price them low enough for both types of visitors to attend. If the museum wants to supply only free days, the second group of visitors will always attend, however the first group of visitors will only do it if the level of congestion is low enough. The museum is economically indifferent to the quality choice, however may have other incentives. For example, it can have a policy objective to maximize attendance. If it wishes to supply both groups of consumers, it wants to maximize the quality. In all cases, the museum will choose quality subject to incentive compatibility constraints and quality-quantity-relation constraints.

The same issue was discussed by Maddison and Foster (2003) in their study of the value of congestion costs in the British Museum. Although they concluded the marginal congestion cost per visitor to be £8.05, they were unable to find an optimal level of admission, because of the relationship between quality and quantity. The reason was that an imposition of a £8.05 charge, in this case, would much likely make attendance fall so that the congestion externality declines. The authors thus conclude that calculations of the optimal fee require knowledge of how attendance responds to changes in admission charges. However, they were able to graphically find that the optimal level of pricing is lower than the size of the externality, which, although an important insight, is insufficient at determining the optimal level in the model of museum visits as vertically differentiated products.

It should be noted that Maddison and Foster (2003) did however conclude that the presence of marginal congestion costs suggests that admission should be higher during periods of high demand than during periods of low demand. This is different from the conclusions of the analysis in this paper. However, it is important to note that their conclusion is made under a different premise. The research of Maddison and Foster was made to find a measure of the congestion externality in order to increase the value of the museum visit, whereas this paper allows for profit-maximizing strategies to find desired levels of congestion as an incentive for visitors to make given desired consumption decisions.

7. Conclusions

The model provides general conclusions about the level of attendance. The strategies are similar across all admission policies.

First, the case of both free and charged admission. In this case, the museum wants to maximize the difference in quality between the two types of days. The charged days will be supplied to visitors with relatively high valuation of quality and relatively low tolerance of congestion. The free days will be supplied to visitors with relatively low valuation of quality and high tolerance of congestion. Furthermore, the charged days will have higher quality than the free days. The quality of the charged days will however not be the highest possible and the quality of the free days will not be the lowest possible.

Second, the case of only charged days. Depending on the nature of demand, the museum will want to either supply both high-quality days and low-quality days, or only high-quality days. In the first case, the high-quality days will be supplied to the first group of visitors and the lowquality days will be supplied to the second type of visitor. The former type of day will have a high quality, but not the highest quality possible. The latter type of day will have a low quality, but not the lowest quality possible. Finally, the high-quality days will be more expensive than the low-quality days. In the second case, the quality will be high, but not as high as possible. Furthermore, the days will be supplied to both groups of visitors.

Third, the case of only free days. In this case, the second type of visitor will always attend. The first type of visitor will attend only if the level of congestion is tolerable. The museum has no economic incentives to impact the quality. However, it may have other incentives, for example policy incentives.

The museum will thus always supply museum visits to both types of consumers, except for in the case of only free admission where, with respect to economic incentives, the quality choice is ambiguous. As long as one consumer group pays for admission, a profit-maximizing museum will provide visits to both consumer groups.

It is clear from the analysis that the conclusions drawn rely heavily on the assumption that the museum can commit to a choice of quality. Without a clear model of the relationship between quality of visit and quantity sold, it will not be known what the final effect of a given admission fee is on the level of congestion and attendance, and thus on consumer surplus and profits. Therefore, the model is insufficient at evaluating the exact attendance under different admission policies. Further knowledge of the impact of quantity on quality is needed for this purpose. Without knowledge of the relationship between quality of visit and the quantity sold, the exact levels of quantity and quality under a given admission policy will be unknown. Thus, the amount of consumer surplus will also be unknown.

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