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ORIGINAL ARTICLE

Optimal pricing and grant policies for museums

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Abstract The "free access" policy designed by the British Government has encouraged interest in museum financial issues. We define a principal-agent model for museum administration where there are two income sources: public grants and ticket revenues. This model allows us to define the optimal contract determining public grants, ticket prices, budget and managerial effort. We find a theoretical explanation for the inelastic pricing strategy commonly adopted in cultural economics. We further find that museum manager should never have any control over the price of tickets. The model can also be applied to other institutions, such as schools or NGOs, which are able to raise funds directly from private (e.g., ticket revenues or membership fees) or public sources.

Keywords Grants · Public valuation · Public prices · Museums · Principal-agent model

JEL Classification number H20, H42,C70, D80, Z10

1. Introduction

Over recent years, the economics of museums has experienced remarkable development (e.g., Johnson and Thomas, 1998; Frey and Meier, 2003) and the problem of funding has been one of its most important issues. In this area, two main strands stand out, namely the impact of charges and the public funding of museums. In the first case, the advantages and disadvantages of charging have been widely discussed. Anderson (1998) defends free entry, O'Hagan (1995) and Bailey and Falconer (1998) provide some arguments in favour of a policy of charging, while Frey (1994) and Maddison and Foster (2003) defend a price discrimination policy. Moreover, O'Hagan (1995), Goudriaan and Van't Eind (1985), Darnell (1998) and Luksetich and Partridge (1997) analyse the impact of admission charges on access. They conclude that, in general, museum demand is price inelastic, so access is weakly responsive to increases

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in admissions charges. Applying the "Ramsey rule" for optimal taxation, this argument can be considered a reason to establish prices for museums. Inelastic goods and services will generate small excess burdens and the excess burden can be considered an additional cost to society beyond the amount of money collected by the museum. Furthermore, Maddison (2004) has recently found that an increase in non-grant income produces an equivalent reduction in government grants. This can be viewed as an incentive problem for museums but, in efficiency terms, is a new argument to *privatize* the budgets of museums.

On the other hand, Duffy (1992) and Frey and Meier (2003) provide some specific reasons to defend public funding,[1] although other authors (Feldstein, 1991; Di Maggio, 1991; Dickenson, 1992) have pointed out the presence of some regressive redistributional effects. In this field some research has been oriented towards determining the optimal quantity of grants, using the social valuation of museums (Asworth and Johnson, 1996; Barros, 1997; Santagata and Signorelli, 1998). Other studies have defined the instruments and procedures that public agencies have used to assign public aid to different kinds of institutions (Schuster, 1989; O'Hagan, 1998; Heilbrun and Gray, 2001). Both approaches have a common methodological assumption: the relations between the public agency and the manager of the museum are framed within an environment of certainty.

These theoretical studies are an expression of the social and political concern over museum funding, and this issue is receiving even more attention these days due to the recent Labour Party admission fee cuts for the main national collections in Great Britain. Moreover, from our point of view these relations can and should be considered in a framework of uncertainty, using principal-agent models as a methodological approach.[2] These models permit the design of optimal contracts under conditions of imperfect information, and this is the aim of this paper. Although the focus of this paper is on museum administration, the model that we have developed can be easily generalized and applied to other institutions, such as schools, sport facilities or NGOs, which are able to raise funds directly from private (e.g., ticket revenues or membership fees) or public sources (e.g., public grants).

We present a theoretical principal-agent model where the public agency, which is risk neutral, plays the role of the principal, and the manager of the museum, who is risk-averse, plays the role of the agent. As a starting point, the model is developed under symmetric information; that is to say, the principal and the agent have the same information and the former knows and is able to control the effort made by the latter. Next, we relax these assumptions and discuss the model under asymmetric information. In both cases, we assume that the museum operates with zero marginal costs.

We also try to provide an answer to another widely-debated question in cultural economics:[3] why are museums located on the inelastic segment of the demand curve (for performing arts, see Heilbrun and Gray, 2001, pp. 99–104; and for museums, Goudriaan and Van't Eind, 1985; Johnson and Thomas, 1992; Luksetich and Partridge, 1997; Darnell, 1998; Bailey and Falconer, 1998 and Been *et al.*, 2002)? Being located on the inelastic section of the demand curve causes a theoretical problem since the economic behaviour of a profit-maximizing firm should be to increase prices in order to maximise revenues and profits. However, this is not the observed behaviour of museums. There are some alternative explanations for this contradiction. First, the ticket price is a relatively small proportion of the total

[1] Beyond the economics of museums, Schuster (1989), Fullerton (1991), Netzer (1992) or Baumol (1997) analyse the determinants of grants to culture.

[2] A good example of a principal agent approach to analyse firm behavior is Guesnerie and Laffont (1984).

[3] This is also an important issue in sports economics. See for instance Noll (1974) for an empirial study and Salant (1992) for theoretical work on pricing policy in this field.

effective visiting cost of museums (which includes, for instance, transportation costs) with the consequence that, although the ticket price elasticity could be small, demand is effectively price elastic. Second, the inelastic pricing strategy to maximize profits is appropriate when the firm receives revenues from other complementary goods (Marburger, 1997). Finally, the museum can follow an objective other than profit-maximisation; for example, it can accept a compromise between profits (or revenues) and number of visitors (Darnell, 1998). Our paper can therefore be thought of as providing theoretical foundations for inelastic pricing as an optimal strategy when there is a public agency which cares about the number of visitors and which provides a grant to complement the museum revenues.

The paper is organised as follows. In Section 2 we summarise the stylised characteristics of the principal-agent approach. Section 3 develops our theoretical model with symmetric information; Section 4 describes the new equilibrium when the manager can hide his effort to the public agency (moral hazard). Finally, in Section 5 we summarise the main conclusions of this paper.

2. Principal-agent models

Principal-agent models can be applied to any bilateral relationship, or contract, where one of the participants, called the agent, carries out an action that provides some benefit to the other participant, called the principal. In this section, we have followed Macho Stadler and Pérez Castrillo (1997). Although we have used their notation and structure, our theoretical model incorporates prices and government valuation for museum attendance, both of which are cornerstones of our analysis.

The principal designs a contract that ties him to the agent and which sets down the payments corresponding to each possible result. The agent chooses his action among a set $\{E\}$ of possible actions. The results of this action depend on the agent's efforts and on some non-controllable environmental conditions, usually denominated the "state of nature," which imposes uncertainty on the relationship.

The main purpose of principal-agent theory is to characterise the optimal contracts under diverse assumptions about the information available to the principal and the agent. A contract can be defined as a credible commitment for both parties, which specifies the obligations of each party and all the possible contingencies of the relationship. That is to say, it should establish the mechanism of payments to remunerate the agent under different circumstances. Moreover, these payments should be a function of verifiable and measurable variables, known by both participants or by a third party that can guarantee the fulfilment of the contract (i.e., a court). If the contract is based on non-verifiable variables, arbitration is impossible and both parties will have incentives to violate the agreements. Foreseeing this behaviour, nobody will therefore be willing to sign non-verifiable contracts.

As the principal is responsible for designing the contract, he will choose those terms that allow him to reach his objectives at the lowest possible cost and to try to correct for, as much as possible, the problems that will be present in his relationship with the agent. The terms of the contract must be, in turn, beneficial for the agent because otherwise he would not sign it. In short, the utility of not signing the contract, denominated the reservation utility, $\underline{U}$, should be equal to or smaller than the utility of signing and accepting the terms of the contract.

The development of the relationship is as follows. First, the principal (P) designs the contract. Second, the agent (A) decides whether or not to accept it. Third, the agent chooses which action to take, i.e., he decides the level of effort he chooses to put in to carry out the task for which he has been hired by the principal. Simultaneously, the state of nature – a set of non-controllable environmental variables (N) – comes into play; that is to say, these variables will influence the development of the relationship between the principal and the agent. Consequently, the actual outcome of the relationship between the principal and the agent will depend on the level of effort chosen by the agent and on a random variable that represents the state of nature faced by the agent, and therefore the result will also be a random variable. Finally, the agent will receive some payment in exchange for his effort.

When we apply this model to museum management, the results can be defined as the number of museum visitors, n_i, which is a discrete variable going from zero to the congestion level. The probability of getting a certain number of visitors, n_i, will be denoted as $p_i(e)$ and is always strictly greater than zero. Since this condition makes any result possible, whatever the agent's effort, e, it ensures that the principal cannot infer the effort of the agent by observing a certain result. However, it is assumed that the greater the effort, the higher the probability of obtaining good results and, consequently, the lower the probability of them being bad. That is, the effort shifts the probability distribution for attendance.[4] We will assume as well that the expected number of visitors will increase at a decreasing rate with effort. In other words, there is a limit to the expected number of visitors that can be achieved by intensifying the effort.

Given that one of the main characteristics of these models is the existence of uncertainty, we will assume that the objective functions of the principal and the agent are Von Neumann-Morgenstern functions. We will assume that the principal wants to maximize a profit function that includes as arguments the number of visitors, n_i, and the grant to the museum, s, which can depend on the number of visitors. We will denote this function as $B[\theta n_i - s(n_i)]$, where $B' > 0$ and $B'' \leq 0$. The quasi-concavity of B implies that the principal can be risk neutral or risk averse. In our case, we assume that the public sector (the principal) is risk neutral, so $B'' = 0$. θ is a positive constant that represents the public sector's valuation of any visitor.[5] As Frey (1994, p. 330) has pointed out, this public valuation "consists mainly of option, existence and prestige values."

The museum manager's behaviour can be considered within the terms of a bureaucratic model (Niskanen, 1968). Following this author, a bureau has the following critical characteristics:

– It is a non-profit organization.
– It exchanges a specific output for a specific budget.
– The bureaucrat maximizes his utility.

According to Niskanen (1968, pp. 293, 294), the bureaucrat's utility function depends on "salary, perquisites of the office, public reputation, power patronage, ease of managing the bureau and ease of making changes. All these variables (...) are positive, monotonic functions of the total budget of the bureau." Hence, we will consider the arguments of the agent's utility function to be the museum budget and the effort (e) exerted. The budget includes ticket income, $n_i t$ – where t is the ticket price – and the grant, $s(n_i)$ where we let the grant be a function of the number of visitors. For simplicity, we will assume that the utility function is

[4] If this assumption does not hold then the principal and the agent would always agree on the minimum effort since greater effort would not imply better expected results, rather a lower utility to the agent. In this case, the minimum effort would assure the best expected result and payments to compensate the effort would be relatively low. Thus, the principal would obtain the highest profits in expected terms.

[5] A declining θ could represent decreasing marginal utility of visitors, even for a risk neutral principal. If the public sector had different valuations for different visitors, θ would vary with the visitors' characteristics. This assumption could be used to analyse a special case of discrimination.

additively separable and we will denote it as $U[n_i t + s(n_i), e] = u[n_i t + s(n_i)] - v(e)$, where $u' > 0$, $u'' \leq 0$, $v' > 0$ and $v'' \geq 0$.

These objective functions tell us that there are conflicts of interest between the principal and the agent. On the one hand, greater levels of effort will help to assure a better result for the principal but will reduce the agent's utility. On the other hand, bigger payments will reduce the principal's profit but will increase the agent's utility. The terms of the contract will match (i.e. serve to make compatible) the interests of both participants.

3. The optimal contract under symmetric information

In this section we develop a model where both participants have the same, but imperfect, information. In particular, the public sector (principal) knows the effort put in by the museum manager (agent). Under this assumption, effort must be included in the contract clauses. In later sections we will relax this assumption so that the agent is able to conceal his effort from the principal.

When designing the contract, the principal will try to maximise his expected profit under the restriction that the agent agrees to sign the contract. With symmetric information, the principal will be able to design a contract, acceptable to the agent, in which the effort demanded by the agent is specified. When the result is a discrete random variable, the following constrained maximisation program can represent the principal's problem:

$$\begin{aligned} &\underset{e,s(n_i),t_{i=0,1,2,\ldots,N}}{\text{Max}} \sum_{i=0}^{N} p_i(e)B[\theta n_i - s(n_i)] \\ &\text{s.t.} \sum_{i=0}^{N} p_i(e)u[n_i t + s(n_i)] - v(e) \geq \underline{U} \end{aligned} \tag{1}$$

The restriction is known as the participation restriction and implies that the principal should take into consideration the contracts that the agent is willing to sign, given the level of effort that will be demanded.

The characteristics of an efficient contract can be found by solving this maximisation program. Moreover, with symmetric information the principal can, at the beginning of the relationship, determine the effort level compatible with his maximum expected profit, and the agent will not be able to hide this from him. Also, the contract can include clauses that give the agent incentives to put in this level of effort.

The solution to this problem will be a Pareto optimum. Since the principal tries to maximise his profit by giving the agent the minimum needed to accept the contract, $\underline{U}$, at the maximum of the program (1), he/she will not be able to improve without the agent losing utility, and vice versa.

The Lagrange function associated with this problem is:

$$L(s(n_i), t, \lambda) = \sum_{i=0}^{N} p_i(e)B[\theta_{n_i} - s(n_i)] + \lambda\left[\sum_{i=0}^{N} p_i(e)u(n_i t + s(n_i)) - v(e) - \underline{U}\right] \tag{2}$$

with the control variables being the level of effort, e; the ticket price, t; and the grant, $s(n_i)$.

The first order conditions of this programme are:

$$\frac{\partial L}{\partial s(n_i)} = -p_i(e)B'(\theta n_i - s(n_i)) + \lambda p_i(e)u'(n_i t + s(n_i)) = 0 \quad \forall i \in \{0, 1, 2, \ldots, N\} \tag{3}$$

$$\frac{\partial L}{\partial t}=\sum_{i=0}^{N}p_i(e)B'\left[\frac{\partial n_i}{\partial t}\left(\theta-\frac{\partial s}{\partial n_i}\right)\right]+\sum_{i=0}^{N}p_i(e)\lambda u'\left[n_i+\frac{\partial n_i}{\partial t}\left(t+\frac{\partial s}{\partial n_i}\right)\right]=0 \quad (4)$$

$$\frac{\partial L}{\partial e}=\sum_{i=1}^{N}p_i'(e)B(\theta n_i-s(n_i))+\lambda\left[\sum_{i=1}^{N}p_i'(e)u(n_i t+s(n_i))-v'(e)\right]=0 \quad (5)$$

Since we incorporate the ticket price as a control variable, these first order conditions take into account the cross effects between this variable and optimal subsidies and effort. We now analyse these conditions. First, we analyse the optimal grant under symmetric information; second, we derive the optimal ticket price; and finally, we obtain the optimal level of effort.

3.1. The optimal grant mechanism

From the first of these conditions it can be observed that:

$$\frac{B'(\theta n_i-s(n_i))}{u'(n_i t+s(n_i))}=\lambda \quad \forall i\in\{0,1,2,\ldots,N\} \quad (6)$$

This necessary condition implies that the ratio between the principal's marginal profit and the agent's marginal utility of income should equal the Lagrange multiplier for each of the possible results. Since B' and u' are always positive, λ will be strictly positive at the optimum, implying that the participation restriction is a binding constraint and the museum manager will get his reservation utility, $\underline{U}$, when he accepts the contract. λ can be interpreted as a shadow price which shows the value of a unit of the manager's additional utility in terms of public sector utility, that is to say, the exchange relationship among the units of utility (income) of the principal and the agent.

As this first order condition has to be fulfilled whatever the number of visitors, if the principal is risk neutral (B' being a positive constant) the manager's marginal utility of income has to be the same at the optimum for any possible result. However, if the agent is risk averse u' will be decreasing with income, so the budget has to be constant and independent of the number of visitors. In terms of our problem, this implies that the public agency (principal) has to fully insure the manager (i.e., the public agency has to fully guarantee the museum's budget). That implies, allocating him a subsidy that, given the optimal level of effort, allows the museum manager to obtain his reserve level of utility, $\underline{U}$. Hence, the subsidy has to be equal to:

$$s=u^{-1}[\underline{U}+v(e)]-n_i\,t \quad (7)$$

which will depend negatively on the number of visitors and will decrease in a one to one relationship with the box office income.[6] This solution implies that the public sector has to cover the shortfall in the museum budget in that it is not fully covered by ticket sales. It can be observed that if the museum has enough ticket income to obtain the required budget, then

[6] When the museum budget is independent of results, a new visitor will decrease the optimal grant by the amount of the ticket price.

$$\frac{\partial(tn_i+s(n_i))}{\partial n_i}=t+\frac{\partial s(n_i)}{\partial n_i}=0\Rightarrow\frac{\partial s(n_i)}{\partial n_i}=-t$$

it will not have any subsidy and the subsidy may even be negative, the latter implying that the museum is a positive source of finance for the public sector.

It can be observed that when the manager is risk neutral, all the payments that imply a similar expected budget for the museum would generate the same utility for its manager and u' would be constant. In this case, the manager will agree to fully insure the public agency in the sense that its net profits, $\theta n_i - s(n_i)$, will be independent of the number of visitors. However, the optimum contract will not imply a constant subsidy. Since $\theta n_i - s(n_i)$ has to be constant, it can be observed that, if there is one visitor more, the grant will increase in the amount of his/her political subjective valuation (θ). With both parties risk neutral there will not be a unique equilibrium. Any payment scheme that gave a museum the expected budget and yielded the reservation utility to its manager (and assured that the participation condition was satisfied) would be a possible equilibrium. Obviously, this set includes the solution represented by equation (7). In conclusion, with symmetric information the optimal revenue and risk allocation depends on the degree of risk aversion of both participants.

Condition (6) implies a Pareto-optimal allocation. For this to be achieved, the public agency and the manager should have the same information set (which includes the probability of obtaining the different results) when they sign the contract, and the manager should be able to require the manager to give his optimum effort. Under these conditions, the public agency has to compensate for the museum deficit but we will not observe a cost inflation process, as is the case for some festivals (Frey and Pommerehne, 1989).

3.2. Optimal ticket price

Using the equilibrium value of λ in equation (6) we can transform equation (4) as follows:

$$\sum_{i=0}^{N} p_i(e)B'\left[\frac{\partial n_i}{\partial t}\left(\theta - \frac{\partial s}{\partial n_i}\right)\right] + \sum_{i=0}^{N} p_i(e)\frac{B'}{u'}u'\left[n_i + \frac{\partial n_i}{\partial t}\left(t + \frac{\partial s}{\partial n_i}\right)\right] = 0 \qquad (8)$$

If the public agency is risk neutral, it is possible to get:

$$E\left[\left(n_i + \frac{\partial n_i}{\partial t}t\right) + \frac{\partial n_i}{\partial t}\theta\right] = 0 \qquad (9)$$

This implies that, with respect to t, the expected marginal social profit (expected marginal revenue plus the expected marginal social value) has to be equal to the marginal cost, in this case zero. Hence, the optimal ticket price obtained from this principal-agent model corresponds to a Pareto optimum equilibrium.

Equation (9) can be easily expressed in terms of the expected demand elasticity when we consider a linear demand function:

$$E[n_i] + \frac{\partial n_i}{\partial t}(t+\theta) = 0 \Rightarrow E[n_i]\left[1 + \frac{\partial n_i}{\partial t}\frac{t}{E[n_i]}\frac{(t+\theta)}{t}\right] = 0 \Rightarrow 1 + \frac{\partial n_i}{\partial t}\frac{t}{E[n_i]}\frac{(t+\theta)}{t} = 0$$
$$\Rightarrow \varepsilon_D \frac{(t+\theta)}{t} = 1 \Rightarrow \varepsilon_D = \frac{t}{(t+\theta)}$$

This implies that the demand elasticity will be equal to or less than one. Only when the public agency does not care about visitors ($\theta = 0$), and its profit function only includes the subsidy, will the optimum be at the point where demand elasticity is unitary. This is also the necessary condition to maximise ticket revenues and, if public sector is risk neutral, to minimise the subsidy.[7]

3.3. Optimal effort level

The first order condition with respect to effort (equation (5)) can be written as:

$$\sum_{i=1}^{N} p_i'(e)B(\theta n_i - s) + \lambda\left[\sum_{i=1}^{N} p_i'(e)\, u\,(t\; n_i + s)\right] = \lambda v' \tag{10}$$

So, when the effort is optimum, the loss of utility due to an increase in effort must be equal to the increase in the expected utility of the public sector plus the increase in the manager's expected income utility.[8]

The optimal level of effort, subsidy and ticket price must be chosen at the beginning of the relationship, so this condition can be expressed in expected terms as:

$$E\left[B'\frac{\partial(\theta n_i - s)}{\partial n_i}\frac{\partial n_i}{\partial e}\right] + \lambda E\left[u'\frac{\partial(n_i t + s)}{\partial n_i}\frac{\partial n_i}{\partial e}\right] = \lambda v' \tag{11}$$

Substituting λ for its equilibrium value (equation (6)), and rearranging terms:

$$E\left[B'\frac{\partial(\theta n_i + n_i)}{\partial n_i}\frac{\partial n_i}{\partial e}\right] = E\left[B'(\theta + t)\frac{\partial n_i}{\partial e}\right] = \frac{B'}{u'}\,v' \tag{12}$$

Hence, this first order condition requires that the expected marginal revenue product of effort equals the marginal cost, where both are evaluated in terms of the principal's utility. This is clearly a Pareto-optimal equilibrium.

If the public sector is risk neutral and B' is therefore constant, equation (12) may be expressed as:

$$E\left[\frac{\partial n_i}{\partial e}\right](\theta + t) = \frac{v'}{u'} \tag{13}$$

Hence, at the equilibrium the expected marginal revenue product of effort has to be equal to the manager's marginal rate of substitution between budget and effort, which increases at an increasing rate since we have assumed that v' and v'' are both positive. Since the participation condition has to be satisfied, the equilibrium will be the point that gives utility $\underline{U}$ to the manager and fulfils the first order condition represented by equations (3), (4) and (5).[9]

[7] If the public sector is risk averse and the manager is risk neutral then the optimal subsidy is constant when θ is zero.

[8] The manager's utility terms are multiplied by λ to value them in terms of principal's utility.

[9] It can be observed that the optimal effort level described by equation (13) will react to changes in the museum funding policy. For instance, if we assume that the expected number of visitors shows decreasing returns with respect to the effort, then if the ticket price is constrained to be zero the effort level will decrease for sufficiently high values.

4. The optimal contract under asymmetric information

In this section we develop a model in which the public sector (principal) does not know the effort put in by the museum manager (agent). Under this assumption, effort cannot be included in the contract clauses. As in Macho Stadler and Pérez Castrillo (1997, section 3.3), we will also assume that there are only two possible effort levels (high and low, denoted with superindexes H and L) and that the principal is interested only in the high effort. If the principal were interested in the low effort there would be no real incentive problem and he would simply offer the agent the symmetric information contract corresponding to this level of effort.

As this is not the usual case, the principal will generally need to include a new restriction in order to maximize his expected revenue when designing the contract. The new restriction is known as the incentive constraint and it implies that the principal has to include a payment schedule in the contract which gives the agent sufficient incentive to choose the high effort level:

$$\sum_{i=0}^{N} p_i(e^H)u[n_i t + s(n_i)] - v(e^H) \geq \sum_{i=0}^{N} p_i(e^L)u[n_i t + s(n_i)] - v(e^L)$$

that is to say, the expected utility of choosing the high effort has to be higher than the expected utility associated with the low effort.

The following constrained maximisation program represents the principal's new problem:

$$\begin{aligned} &\underset{s(n_i),t_{i=0,1,2,\ldots,N}}{\text{Max}} \sum_{i=0}^{N} p_i(e^H)B[\theta_{n_i} - s(n_i)] \\ &\text{s.t} \sum_{i=0}^{N} p_i(e^H)u[n_i t + s(n_i)] - v(e^H) \geq \underline{U} \\ &\sum_{i=0}^{N}[p_i(e^H) - p_i(e^L)]u[n_i t + s(n_i)] \geq v(e^H) - v(e^L) \end{aligned} \tag{14}$$

The Lagrange function associated with this problem is:

$$\begin{aligned} L(s(n_i), t, \lambda, \mu) = &\sum_{i=0}^{N} p_i(e^H)B[\theta_{n_i} - s(n_i)] + \lambda\left[\sum_{i=0}^{N} p_i(e^H)u[n_i t + s(n_i)] - v(e^H)\right. \\ &\left. - \underline{U}\right] + \mu\left[\sum_{i=0}^{N}[p_i(e^H) - p_i(e^L)]u[n_i t + s(n_i)] - [v(e^H) - v(e^L)]\right] \end{aligned}$$

with the control variables being the ticket price, t; and the grant, $s(n_i)$. Since we have only two effort levels and the incentives restriction shows us that the manager will agree to choose the high level of effort, this is no longer a control variable.

The first order conditions of this programme are:

$$\begin{aligned} \frac{\partial L}{\partial s(n_i)} = &-p_i(e^H)B'(\theta n_i - s(n_i)) + \lambda p_i(e^H)u'(n_i t + s(n_i)) \\ &+ \mu[p_i(e^H) - p_i(e^L)]u'(n_i t + s(n_i)) = 0 \qquad \forall i \in \{0, 1, 2, \ldots, N\} \end{aligned} \tag{15}$$

$$\frac{\partial L}{\partial t} = \sum_{i=0}^{N} p_i(e^H)B'\left[\frac{\partial n_i}{\partial t}\left(\theta - \frac{\partial s}{\partial n_i}\right)\right] + \sum_{i=0}^{N}\left[\lambda p_i(e^H) + \mu\left[p_i(e^H) - p_i(e^L)\right]\right]u'\left[n_i + \frac{\partial n_i}{\partial t}\left(t + \frac{\partial s}{\partial n_i}\right)\right] = 0 \quad (16)$$

We now analyse these conditions. First, we analyse the optimal grant under asymmetric information and second, we derive the optimal ticket price.

4.1. Optimal grant mechanism

$$\frac{B'}{u'} = \lambda + \mu\left[\frac{p_i(e^H) - p_i(e^L)}{p_i(e^H)}\right] = \lambda + \mu\left[1 - \frac{p_i(e^L)}{p_i(e^H)}\right] \qquad \forall i \in \{0, 1, 2, \ldots, N\} \quad (17)$$

If $p_i(e^L) = p_i(e^H)$ this first order condition will be similar to equation (6) and the solution will imply a Pareto equilibrium, equivalent to the symmetric information solution. That is to say, there is no conflict between the principal and the agent since the probability of getting any result does not depend on the effort. Hence, the principal and the agent will agree on the agent choosing the low effort and the principal will pay a constant grant equal to $s = u^{-1}[\underline{U} + v(e^L)] - n_i$ t if the agent is risk averse.

However if $p_i(e^L) \neq p_i(e^H)$ then $\lambda \neq \frac{B'}{u'}$ and the optimal grant mechanism will not imply a Pareto optimal equilibrium since the museum budget will change with the results (as u' depends on n_i) even when the public agency is risk neutral and the manager risk averse. In this case, the value of $p_i(e^L)/p_i(e^H)$ can be considered as a signal about the effort realised by the agent given the observed result The higher the value for the observed result, the higher the probability that the museum manager had chosen the low effort level and the higher u'. Since u' is decreasing in income, bad results will imply small budgets and small grants for the museum.

If the public agency does not have perfect information, it should not use the grants to fully insure the manager because he has incentives to be inefficient by reducing his effort and, for example, making inefficient expenditures or not maximising alternative sources of revenue. The best choice for the public agency is to use grants to give adequate incentives to the manager in order to improve his effort level and thereby achieve more efficient museum management.

4.2. Optimal ticket price

We can rewrite equation (16) as:

$$\sum_{i=0}^{N} p_i(e^H)B'\left[\frac{\partial n_i}{\partial t}\left(\theta - \frac{\partial s}{\partial n_i}\right)\right] + \sum_{i=0}^{N} p_i(e^H)\left[\lambda + \mu\left[1 - \frac{p_i(e^L)}{p_i(e^H)}\right]\right]u'\left[n_i + \frac{\partial n_i}{\partial t}\left(t + \frac{\partial s}{\partial n_i}\right)\right] = 0$$

and using equation (17), this first order condition can be expressed as:

$$\sum_{i=0}^{N} p_i(e^H)B'\left[\frac{\partial n_i}{\partial t}\left(\theta - \frac{\partial s}{\partial n_i}\right)\right] + \sum_{i=0}^{N} p_i(e^H)\frac{B'}{u'}u'\left[n_i + \frac{\partial n_i}{\partial t}\left(t + \frac{\partial s}{\partial n_i}\right)\right] = 0$$

which is exactly equation (8). Hence, the existence of moral hazard does not affect the optimal ticket price. We have the same first order condition that we had under symmetric information with respect to the ticket price, and museum policy will fix the price on the inelastic part of the demand curve. The insight behind this result is that since ticket prices change the demand for museum attendance, the principal should not use them in the incentive mechanism and this mechanism should instead rely exclusively on the grants, even if there is a hidden effect problem (see equation (17)).

When the manager can hide his effort from the public agency, we have seen that the budget has to be linked to results because this will provide incentives for the manager to put more effort in. One possible way to link the budget to the results (and permit increments in the budget) would be to allow the manager to fix the ticket price and permit him to keep part of the total ticket revenue; we can call this the *market solution*. This solution, which could sometimes be considered efficient by the policymaker, is inefficient in that it implies fixing prices where private benefits (that is, marginal revenues) are equal to the marginal costs and that it does not take into account social benefits. This is the main reason why incentives have to be controlled using public grants, that as Frey proposed must be "based on the 'social value' or (in economic terms) in the 'external effects' produced" (Frey (1994) p. 330). However, to avoid other kinds of inefficiencies, grants associated with low results could even be negative.

5. Conclusions

In this paper we have developed a principal-agent model for museum financing. We have considered two potential sources of income: public grants and ticket revenues.

Using this framework, we can determine the optimal financing policy and the optimal managerial effort both when there is symmetric information (and where the public agency can control the manager's effort) and when the information is asymmetric (and the effort can not be controlled). Our principal-agent model justifies public funding of museums, especially when the manager can hide his effort from the public agency. In this case, the public grant has to be used by the public agency to provide adequate incentives to the manager to improve his effort level.

Analyzing the first order conditions of our model, and assuming that the principal is risk neutral and the agent risk averse, we can conclude that under symmetric information the museum budget has to be constant and independent of the number of visitors. This implies that the public agency has to fully insure the manager's museum budget, assigning him a subsidy that, given the optimal level of effort, allows the manager to obtain his reservation level of utility, $\underline{U}$. Hence, the public sector has to cover the deficit of the museum budget where it has not been covered by ticket sales. In this case, the public grant will decrease with the number of visitors and the box office income.

The manager's optimal effort level is Pareto-optimal with symmetric information. This implies that around this point the loss of utility due to an increment in effort must be equal to the increment in the expected social utility associated with the rise in the number of visitors. Therefore, at the equilibrium the expected marginal revenue product of effort has to be equal to the manager's marginal rate of substitution between budget and effort.

However, these conclusions do not hold under asymmetric information. When effort is difficult to control and we have a moral hazard problem, the budget has to be linked with results because the principal needs to provide some incentives to the manager in order to get high effort levels. Therefore, full insurance is inefficient in this situation. In this case, the equilibrium is no longer a Pareto optimum situation, at least with respect to the budget and the grant.

The existence of asymmetric information will have no effect on prices, which have to be fixed taking into account the public valuation of visits to the museum. Furthermore, we have found a theoretical reason to explain the inelastic pricing strategy that has been found in much empirical research, and which does not depend on the existence of asymmetric information. Moreover, the optimal ticket price is always Pareto optimal in the sense that it will equalize expected social marginal profit (expected marginal revenue plus expected marginal social value) with the marginal cost. However, public grants and museum budgets would be affected by the existence of this problem, moving the equilibrium away from the Pareto optimum situation. In this case, even with a risk averse manager and a risk neutral public agency, grants and budgets will depend on results because higher budgets related to good results provide the main incentives to increase the manager's level of effort.

Hence, transferring ticket pricing policy to the manager is not a correct way to introduce adequate incentives under any circumstances. The manager should not decide the ticket price. The public agency must regulate these prices in accordance with the social valuation and use grants as the incentive mechanism to achieve the optimal managerial effort.

These conclusions are in agreement with Labour's museums policy, characterised by prices fixed by the Government (first, the £1 policy and second, the free access policy), public grants depending on the public valuation and allowing managers to achive new ways of private funding that will link effort and financial resources.

We should point out that these results are based on the assumption that the principal can fix a public valuation for each visit to the museum. If this is not the case, the optimal policy could be different from the one proposed here. Moreover, we have assumed that museums operate below their congestion level and that marginal costs can be zero. Otherwise it can be easily observed that optimal prices will be set at a higher level, reducing the expected number of visitors.

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References

Anderson, R.G.W. (1998). "Is Charging Economic?" *Journal of Cultural Economics*, *22*, 179–187.

Asworth, J., and Johnson, P. (1996). "Sources of Value for Money for Museum Visitors: Some Survey Evidence." *Journal of Cultural Economics*, *20*, 67–83.

Bailey, S., Falconer, P. (1998). "Charging for Admission to Museums and Galleries: A Framework for Analysing the Impact on Access." *Journal of Cultural Economics*, *22*, 167–177.

Barros, C. (1998). "Museum Funding: Hyphotetical Philanthropy and Fair Price." Paper presented at the X$^{\underline{\text{th}}}$ International Conference on Cultural Economics, Barcelona.

Baumol, W. S. (1997) "Public Support for the Arts: Why and Wherefore?" Working Paper, President's Committee on the Arts and the Humanities.

Been, I., Visscher, K. and Goudriaan, R. (2002). "Fee or Free?" Working Paper Series (http://flyaquis.mov.vic.gov.au/been/Fee_ or_free.doc).

Darnell, A. (1998). "Some Simple Analytics of Access and Revenue Targets." *Journal of Cultural Economics*, *22*, 189–196.
Dickenson, V. (1992). "Museum Visitor Survey: An Overview, 1930–1990," in Ruth Towse, (ed.), *Cultural Economics: The Arts, The Heritage and the Media Industries*, vol. 1. Edward Elgar, Cheltenham.
DiMaggio, P. (1991). "The Museum and the Public," in Martin Feldstein, (ed.), *The Economics of Museums*. University of Chicago Press, Chicago.
Duffy, Ch.T. (1992). "The Rationale for Public Funding of a National Museum," in Ruth Towse and Abdul Khakee, (eds.), *Cultural Economics*, Springer Verlag, Heidelberg.
Feldstein. M. (ed.) (1991). *The Economics of Museums*. University of Chicago Press, Chicago.
Frey, B. and Meier, S. (2003). "The Economics of Museums." Working Paper, University of Zurich, Zurich.
Frey, B.S. (1994). "Cultural Economics and Museum Behaviour." *Scottish Journal of Political Economy*, *41*, 325–335.
Frey, B.S. and Pommerehne, W. (1989). *Muses and Markets: Explorations in the Economics of the Arts*. Basil Blackwell, Oxford.
Fullerton, D. (1991). "On Justifications for Public Support of the Arts." *Journal of Cultural Economics*, *15*, 67–82.
Goudriaan, R. and Van't Eind, G. (1985). "To Fee or Not to Fee: Some Effects of Introducing Admission Fees in Four Museums in Rotterdam," in V. Owen and W. Hendon, (eds.), *Managerial Economics for the Arts*. Association for Cultural Economics, Akron, Ohio.
Guesnerie, R. and Laffont, J.J. (1984). "A Complete Solution to a Class of Principal–Agent Problems with an Application to the Control of a Self–managed Firm." *Journal of Public Economics*, *25*, 329–69.
Heilbrun, J. and Gray, Ch. M. (2001). *The Economics of Art and Culture. An American Perspective*. Second edition. Cambridge University Press, Cambridge..
Johnson, P. and Thomas, B. (1998). "The Economics of Museums: A Research Perspective." *Journal of Cultural Economics*, *22*, 75–85.
Johnson, P.S. and Thomas, R.B. (1992). *Tourism, Museums and The Local Economy*. Mansell, London.
Luksetich, W. and Partridge, M. (1997). "Demand Functions for Museums Services." *Applied Economics*, *29*, 1553–1559.
Macho Stadler, I. and Pérez Castrillo, D. (1997). *An introduction to the economics of information: incentives and contracts*. Oxford University Press, Oxford.
Maddison, D. (2004). "Causality and Museum Subsidies" *Journal of Cultural Economics*, *28*, 89–108.
Maddison, D. and Foster, T. (2003). "Valuing Congestion Costs in the British Museum." *Oxford Economic Papers*, *55*, 173–190.
Marburger, D. (1997). "Optimal Ticket Pricing for Performance Goods." *Managerial and Decision Economics*, *18*, 375–381.
Netzer, D. (1992). "Cultural Policy in an Era of Budgetary Stringency and Fiscal Decentralization: The U.S. Experience," in Ruth Towse and Abdul Khakee, (eds.), *Cultural Economics*, Springer Verlag, Heidelberg.
Niskanen, W. (1968). "Nonmarket Decision Making the Peculiar Economics of Bureaucracy." *American Economic Review*, *58*, 293–305.
Noll, R.G. (1974). "Attendance and Price Setting," in R. G. Noll,. (ed), *Goverment and the Sports Business*, The Brookings Institution, Washington D. C.
O'Hagan, J.W. (1995). "National Museums: To Charge or Not To Charge?" *Journal of Cultural Economics*, *19*, 33–47.
O'Hagan, J.W. (1995). *The State and the Arts*. Edward Elgar, Chentelham.
Salant, D.J. (1992). "Price Setting in Professional Team Sports," in P. M. Sommers, (ed), *Diamonds Are Forever. The Business of Baseball*. The Brookings Institution, Washington D.C.
Santagata, W. and Signorello, G. (2000). "Contingent Valuation and Cultural Policy Design: The Case of Napoli Musei Aperti." *Journal of Cultural Economics*, *24*, 181–204.
Schuster, J.M. (1989). "Determinants and Correlates of Arts Support by States," in D. Shaw, *et al.*, (eds.), *Cultural Economics*. Association for Cultural Economics, Akron, Ohio.