

# **Achieving optimal value from publicly funded marine information resources**

by

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## EXECUTIVE SUMMARY

This paper was prepared with the objective of determining whether the UK achieves optimal value from secondary use of marine data and information obtained using public funds.

To address this question the paper considers the UK policy framework, proceeds from the sale of publicly funded marine data and the likely impact of different pricing regimes on take up and use for commercial purposes.

Recent European legislation demands that all environmental information should be freely available to the general public. This framework mandates the UK to create the infrastructure and tools that permit such access. Despite this policy framework a number of UK public sector organisations continue to differentiate between public and commercial use. Where data or information is to be used commercially a charge in excess of marginal cost is levied.

The revenue generated from such sales is a small proportion (less than 1%) of the operating costs of public sector organisations involved with marine data and information. The low level of revenue from commercial sales indicates that there is either a very low demand for the information they hold or that present pricing policies severely inhibit take up by potential commercial users.

A simple economic screening model has been used to determine the impact of different pricing regimes on commercial use of publicly funded data. The conclusion of this economic modelling is that marginal cost availability would enhance secondary use by UK commercial companies. This greater use would generate corporation tax revenue (from increased corporate profits) exceeding the existing revenue generated by public sector bodies.

The overall consequences of the recommended move to marginal cost pricing, in conjunction with adequate funding for public sector bodies, is increased revenue to the Treasury, through increased competitiveness of the UK marine sec-

tor both in the UK and overseas, and more effective maintenance of data and information in the interest of future public good.

The UK Marine Information Council Working Group on Data Access strongly supports present Government moves towards marginal cost access to publicly funded data and recommends that this policy should extend to all marine information funded from tax revenue. It further strongly supports better funding of data and information custodianship.

## 1. INTRODUCTION

- 1.1 This paper sets out to determine whether the UK presently achieves optimal value from marine data and information obtained using public funds.
- 1.2 Access to marine information was one of the issues considered by the Foresight Marine Panel Task Force on managing the marine environment and marine resources. The Task Force's report, 'The Greenwich Project – Realising the potential of the UK's marine information business'<sup>1</sup> made two key recommendations in relation to access to marine information:
- Adoption of an 'at retrieval cost' policy for access to all publicly funded marine information.
  - A strengthening of national facilities for data archiving and retrieval of public and private sector data and data products.
- 1.3 The UK Marine Information Council (UKMIC) was formed in early 2000 with the objective of implementing the recommendations of the Foresight Marine Panel Task Force's report. The UKMIC comprises representation from government departments, agencies and industry groups concerned with the generation and use of marine information. Further details of the composition and terms of reference of the UKMIC are provided in Appendix A.
- 1.4 A Data Access Working Group was established within the UKMIC in 2001 to support the implementation of the recommendations on access to marine information. One of the objectives set for this Working Group was to conduct a review of present policy on access to marine information derived from public funds. The terms of reference for the UKMIC Data Access Working Group are provided in Appendix B.
- 1.5 At the heart of the access issue is the question of whether policies being followed in the UK optimise the value of publicly funded marine information in terms of wealth creation, employment and quality of life.
- 1.6 This report sets out to examine this question through a review of the present legislative and policy framework, an appraisal of the returns from commercial sales of publicly funded marine information and comment on the impact of present policies on effective use of publicly funded marine information for public good. An economic model is presented as a means for evaluating the impact of different policies in terms of their return to the UK Exchequer.
- 1.7 The report concludes by drawing together the outcome of the review into a single coherent recommendation for achieving the optimal value from publicly funded marine information resources.
- 1.8 Whilst this report deals specifically with publicly funded marine information, the case presented may be equally applied to other information collected using public funds.

## 2. THE LEGISLATIVE AND POLICY FRAMEWORK

- 2.1 Before considering the UK legislative and policy framework in respect of information in general and marine information in particular, it is useful to provide an international context. Of particular relevance to this report is the contrast between policy in the United States and that in certain European countries, including the UK.
- 2.2 United States domestic federal information policy is based on the premise that government information is a valuable national resource and that the economic benefits to society are maximised when government information is available in a timely and equitable manner to all. Policies such as charging no more than the cost of dissemination and prohibitions against restrictions on the reuse and re-dissemination of government information are aimed at achieving this goal.
- 2.3 The US Copyright Act<sup>2</sup> provides that copyright protection is not available for any work of the United States Government.
- 2.4 US policy has the effect of actively encouraging the secondary use of federal information under a legislative regime that places no legal constraint on commercial use. In certain limited instances there may be constraints on the timing of release. For example, principal research investigators may, under certain circumstances, retain exclusive access rights to data for up to two years.
- 2.5 In Europe and within European nations the legislative and policy situation is far more complex. In the absence of any unifying fundamental legislation a wide range of policies are pursued both at a European Union level and within individual European countries. In general, there has been a trend towards 'government commercialisation' of public information sometimes in the form of monopoly controls over certain types of publicly funded information in order to generate revenues.
- 2.6 In the UK Her Majesty's Stationery Office (HMSO) deals with all matters of Crown Copyright<sup>3</sup> with responsibility sometimes being delegated to individual government departments or agencies. The legislative framework for publicly funded marine information is a combination of Crown Copyright and the Environmental Information Regulations 1992<sup>4</sup> (which transposes into law EU Directive 90/313 of 1990<sup>5</sup> on freedom of access to information on the environment).
- 2.7 In the UK there has been a general trend towards policies that encourage public sector establishments to commercially exploit intellectual property and these policies have often been extended to include exploitation of copyright material such as data and information as well as ideas and inventions.
- 2.8 Where public bodies have been established as trading funds there is an explicit expectation that they will generate at least part of their revenue from commercial activity, including the sale of Crown Copyright material, often in competition with private companies.
- 2.9 The Baker Report 'Creating knowledge creating wealth'<sup>6</sup> examined the role of public sector research establishments (PSREs) in commercial activities and generally concluded that PSREs should be encouraged to commercially exploit intellectual property. The report is non-committal on the subject of exploitation of copyright information:
- 'Free dissemination of information is particularly relevant for PSREs where the demand pull is weak or where there is a strong public interest in the wide dissemination of results'*
- 2.10 The Government response to the Baker Report<sup>7</sup> stresses that the rationale for encouraging better exploitation of research conducted in Government laboratories is:
- '...not about making money for the government but about maximising the contribution to the nation's jobs, prosperity and quality of life, without compromising the vital independent advice that these laboratories provide'*

It further states:

*'It agrees that giving greater emphasis to the knowledge transfer effort need not – and indeed must not – conflict with the primary research and advisory roles of PSREs'*

- 2.11 Like the Baker Report itself the Government response makes scant reference to the exploitation of data or information. It does however recognise the clear distinction between intellectual property and data and information:

*'The Government's primary interest here is in commercialisable and in particular patentable intellectual property. The Government recognises that different arrangements will apply to research outputs such as data sets, which are not discoveries or inventions.'*

A further clause stresses the need for not being prescriptive in this area:

*'The Government also endorses John Baker's conclusion that the large variety of PSREs and of knowledge transfer routes mean that government cannot be over-prescriptive about the methodology for ensuring the practical application of PSRE research outputs. The Government recognises that the nature of research output itself has an important bearing on decisions whether or not to pursue commercial routes for exploiting knowledge. For example, while a commercial route might be clearly indicated for potentially valuable discoveries and inventions open dissemination might be more appropriate for certain classes of data set.'*

- 2.12 In its final report under the 2000 spending review<sup>8</sup> HM Treasury makes specific reference to improving the availability of information subject to Crown Copyright for reproduction and use by the information industry. This report generally concludes that marginal cost pricing for information has merit in relation to the majority of departments and agencies but that the case for marginal cost pricing is weakest in the government's trading funds:

*'The recommendation of the review is that Government trading funds which trade information should improve their*

*pricing and dissemination policies; but elsewhere (in departments and agencies other than trading funds) that there should be a move to an immediate policy of marginal cost pricing (unless, in any specific case, a statutory enactment indicates otherwise).*

- 2.13 The distinction between trading funds and other departments and agencies is drawn on the basis that:

*'in some cases the public sector's role is highly developed, stretching considerably beyond the collection and dissemination of the material the government needs for its own purposes.'*

- 2.14 The present basis upon which individual public sector bodies make marine information available varies from one body to another. This variation is sometimes under the influence of policy guidelines specific to an individual body and sometimes on an *ad hoc* basis. For example, the Environment Agency has a general policy of open at retrieval cost only access whilst the Natural Environment Research Council has a data policy<sup>9</sup> that requires that unspecified charges be levied for commercial use consistent with the perceived commercial value of information in a particular application.

- 2.15 In the case of Trading Funds dealing with marine information, present policy is to charge for information at rates determined by perceived commercial value.

- 2.16 The desire to protect the commercial trading activities of trading funds has a significant impact on the national and international exchange of data and information for public good purposes such as improved marine forecasting, global climate studies and maritime safety. For example, public information perceived to be of commercial value is often only exchanged for public good purposes subject to constraints on subsequent use. This is exemplified by present exchange policy in respect of meteorological data where the so-called Resolution 40 of the World Meteorological Organisation<sup>10</sup> provides the framework for international exchange subject to confidentiality. In practise, these constraints are increasingly difficult to apply and enforce.

2.17 The UK has actively supported the adoption of international data exchange policies that contain constraints on subsequent use. One example is the policy adopted by EuroGOOS<sup>11</sup> (the European contribution to the Global Ocean Observing System). This policy requires that certain types of public information are restricted in their use following exchange; this uses a similar model to Resolution 40 of the World Meteorological Organisation.

2.18 UK signature of the Aarhus Convention<sup>12</sup>, which entered into force in October 2001, has significant implications for UK policies on access to publicly funded environmental information resources. This convention governs public rights of access to environmental information and requires that public authorities:

*'in response to a request for environmental information make such information available to the public'*

Whilst the Convention cites a number of reasons why a request for environmental information may be refused, the Convention is silent on issues relating to commercial use. It does however cite a basis for making a charge for supplying information:

*'Each party may allow its public authorities to make a charge for supplying information, but such charge shall not exceed a reasonable amount. It shall not exceed the actual cost of reproducing the information requested and shall not include the costs of staff time spent on searches.'*

2.19 The Aarhus Convention will require that the UK move to a position where publicly funded environmental information is publicly accessible at reasonable cost. Under such a regime placing specific restrictions on commercial use of publicly funded information will become considerably more difficult to implement both in terms of restricting initial access and constraining subsequent use.

2.20 Implementation of the Aarhus Convention in UK law will be via a revision to the Environmental Information Regulations 1992 (revised 1998)<sup>13</sup>. The proposed revision has been the subject of recent consultation and is due to be considered

by Parliament as soon as possible (as at 24 February 2003).

2.21 As a result of Government acceptance of the Cross Cutting Review of the Knowledge Economy<sup>8</sup> HMSO was established as the regulatory body to oversee Crown Copyright licensing and to promote the policy objectives identified in the Review. As a result, HMSO embarked on a consultation exercise<sup>14</sup> to determine the role and scope of the repositioned HMSO as a regulatory body. This consultation dealt specifically with the following recommendations of the Review:

*'An Advisory Panel of representatives from the public and private sectors should be appointed, to work closely with the Controller in her regulatory capacity;*

*Licenses to reuse core information from Government Departments and Agencies, except Trading Funds, should normally be granted at no more than marginal cost;*

*Departments should normally grant licenses to reuse information not core to their responsibilities, called 'value added information', for a fee to be determined in accordance with Treasury rules on charging for Government services;*

*Trading funds should improve their dissemination and pricing policies.'*

2.22 The outcome of the consultation confirmed the commitment to provision of core government information for reuse at no more than marginal costs. This does not apply to Trading Funds. The consultation also confirmed that a repositioned HMSO should regulate the licensing decisions of Trading Funds, whose pricing and dissemination policies should be improved. At the time of writing the basis for the regulation and the specific improvements to be made are unknown.

### 3. SALES OF PUBLICLY FUNDED MARINE DATA

3.1 In this section we examine the revenue generated by different UK public sector bodies from the commercial sale (i.e. excluding inter-departmental sales) of marine information. This revenue is placed within the context of the estimated total funding of each body.

3.2 These revenue estimates have been obtained by asking each public sector body concerned with marine information the following question:

*“What was your revenue in Financial Year 2000/2001 and 1999/2000 from sales of data to commercial customers, i.e. not to government departments? In this context data means archived information sold to a customer without further manipulation other than the process of retrieval. This definition would include:*

- *Instrumental data and observations which are gathered, stored and archived,*
- *Stored model output,*
- *Any other archived data resulting from your routine activities.”*

3.3. The revenue figures from data sales provided by each of the public sector bodies are presented in Table 1. Table 1 also includes estimated total funding for each of these bodies, taken from their published accounts, and a summary of their pricing policy (Table 2).

3.4. It should be noted that the figures provided for data sales are revenue (i.e. income) rather than profit; no account is taken of the cost of data sales in terms of salaries or associated overheads, which are met by public sector funds.

3.5. The commercial revenue generated from the sale of publicly funded marine information, with the exception of the UK Hydrographic Office is small. For each of the public sector bodies the revenue is a small proportion (<1%) of the overall operating costs.

3.6. The low levels of revenue from commercial sales by organisations

operating in a regime of market pricing or differential pricing indicates that there is either a very low demand for the information they hold or that present pricing policies severely inhibit take up by potential users.

3.7. The UK Meteorological Office and UK Hydrographic Office are both Trading Funds established under the Trading Funds Act 1973. Their “funding” is not through money voted directly by Parliament but from charges made to both the public and private sector for their services. The £49 million funding for the UKHO represents revenue from the sale of charts, publications and expertise.

| Body  | Pricing policy | Financial year | Revenue from data sales <sup>†</sup> | Total funding* |
|---|----------------|----------------|--------------------------------------|----------------|
| Centre for Environment, Fisheries & Aquaculture (CEFAS)                   | Marginal       | 1999/2000      | Nil                                  | £28 million    |
|   |                | 2000/2001      | Nil                                  | £29 million    |
| Department of Agriculture and Rural Development Northern Ireland (DARDNI) | Marginal       | 1999/2000      | Nil                                  | £5 million     |
|   |                | 2000/2001      | Nil                                  | not available  |
| Environment Agency (EA)   | Marginal       | 1999/2000      | Nil                                  | £640 million   |
|   |                | 2000/2001      | Nil                                  | £655 million   |
| Fisheries Research Service (FRS)  | Differential   | 1999/2000      | £3,000                               | £2 million     |
|   |                | 2000/2001      | £3,000                               | £2 million     |
| UK Meteorological Office (UKMO) <sup>1</sup>                              | Market         | 1999/2000      | £6,000                               | £15 million    |
|   |                | 2000/2001      | £30,000                              | £15 million    |
| Natural Environment Research Council (NERC) <sup>2</sup>                  | Differential   | 1999/2000      | £27,000                              | £234 million   |
|   |                | 2000/2001      | £29,000                              | £252 million   |
| Scottish Environmental Protection Agency (SEPA)                           | Marginal       | 1999/2000      | Nil                                  | £33 million    |
|   |                | 2000/2001      | Nil                                  | £34 million    |
| UK Hydrographic Office (UKHO)   | Market         | 1999/2000      | <£20,000                             | £45 million    |
|   |                | 2000/2001      | <£20,000                             | £49 million    |

**Table 1 UK public sector bodies – Revenue from data sales**

\* To nearest £ million

† To nearest £000

Notes for clarification:

1. The UK Meteorological Office (UKMO) has provided figures relating to ‘wholesaling revenue from the provision of data products for marine service providers, other than government agencies or departments’.
2. The Natural Environment Research Council (NERC) has provided figures relating to ‘licensing of data (marine) to commercial organisations’. In 2001/02 its total income from sale/licensing of environmental data/information was £1.9 million.

|                              |  |
|------------------------------|--|
| <b>Differential pricing</b>  | Different customers are charged different prices. Often differentiation is made between “academic use” and “commercial use” of the data. |
| <b>Marginal cost pricing</b> | Data is priced to recover the additional costs of making the data available.   |
| <b>Market pricing</b>        | Data is priced at the level customers are willing to pay (which may be less than the marginal cost associated with data supply).         |

**Table 2 Pricing policy terminology<sup>15</sup>**

## 4. THE ECONOMIC ARGUMENT

- 4.1 It is evident from the information presented in Sections 2 and 3 that there is a lack of clarity and consistency in the application of the legislative framework to the sale of publicly funded marine information by public sector bodies. In addition, the revenue generated from the sale of publicly funded marine information is a small part of the income of these organisations.
- 4.2 Private sector companies are currently often required to pay commercial fees for access to publicly funded data and information in the UK. Some public sector bodies have moved towards market pricing, while others have maintained marginal cost pricing. Table 1 shows the wide variability in pricing policy for a subset of the public sector bodies that hold marine information.
- 4.3 Within the private sector, there is considerable frustration at the widely differing charging policies for the acquisition of publicly funded marine information. In the situation where the charges made for supply of information are significantly higher than retrieval cost, this frustration is manifested in the following ways:
- Private sector organisations purchase the minimum quantity of data to meet their requirements; clearly this is not making best use of data collected using public funds.
  - Private sector organisations go elsewhere, often outside the UK, for data; again this is not making best use of data collected using public funds.
  - Private sector organisations withdraw from doing business in the sector; their income is then lost to the UK economy.
- 4.4 Many public sector bodies are required by their funding Government Department to generate a proportion of their income from the private sector. A convenient means for achieving this income is to sell the data that they have historically collected using public funds. The income that is generated is then used to part fund the activities of public sector bodies. It will however be demonstrated that the impact of this approach is to deny a much greater potential income to the Treasury via taxation, which could be used to properly fund the public sector bodies.
- 4.5 A further issue that results from this approach is one of unfair competition. Some of the organisations that hold publicly funded marine information compete directly with commercial organisations in providing 'value added' data products. These public sector bodies have blanket access to publicly funded information within their own organisations at no net cost. Public sector organisations holding the information effectively have free access whereas commercial organisations must pay for the source information.
- 4.6 The lack of a consistent and appropriate policy places the UK's marine information sector at a disadvantage relative to its overseas competitors.
- 4.7 There is a requirement for a clear policy for the sale of publicly funded marine information that provides optimum revenue to the UK within the prevailing legislation.
- 4.8 A simple screening model has been developed to provide a framework within which the economic issues relating to the sale of publicly funded marine information can be considered. This model is described in full in the paper presented in Appendix C.
- 4.9 The conclusion of this paper is that the increased corporation tax revenue that would accrue from a move to marginal-cost pricing, (from increased corporate profits from using the information) would greatly exceed the existing revenue generated by public sector bodies through sale of information to commercial organisations. A move to marginal-cost pricing will therefore provide the optimum value to the UK within the prevailing legislation.
- 4.10 The findings of this paper strongly support Government moves towards a marginal cost basis for commercial access

to publicly funded marine information and suggests that a marginal cost basis should be extended to all marine information obtained using public funds. In parallel with the move to marginal cost pricing, adequate funding should also be made available to public sector bodies for the collection and maintenance of data that is required for the public good.

- 4.11 The overall consequences of the recommended move to marginal cost pricing in conjunction with adequate funding for public sector bodies, is increased revenue to the Treasury through increased competitiveness of the UK marine sector both in the UK and overseas.

## 5. CONCLUSIONS

- 5.1 It is clear that the UK does not presently achieve optimal value from its publicly funded marine information:
- There is a lack of clarity in the underlying economic principles and their legislative framework.
  - Different agencies and bodies of government apply different principles when making information available sometimes with inconsistency between user groups.
  - Public sector bodies with preferential access to publicly funded data sometimes compete directly with commercial organisations when selling derived data products.
  - The revenue generated by public sector sales of marine data is small, in all cases less than 1% of their income.
- 5.2 The economic argument presented shows that the optimum benefit to the nation is achieved from a policy of open access at retrieval cost (marginal cost pricing).
- 5.3 The European legislative framework within which the UK operates demands that all environmental information is available to the general public. This framework mandates the UK to create the infrastructure and tools that permit such access at no more than marginal cost. It follows that the UK Government should improve support for adequate and effective custodianship of and access to publicly funded marine information through improved funding of those organisations responsible for this task.
- 5.4 Marginal cost access has the benefit of streamlining and improving global information exchange for public good since it is no longer necessary to place restrictions on commercial end use. It also helps to ensure better custodianship of information and better public understanding and scrutiny related to environmental issues.
- 5.5 The UK Marine Information Council Working Group on Data Access strongly supports present Government moves towards marginal cost access to publicly funded data and recommends that this policy should extend to all marine information funded from tax revenue.

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## APPENDIX A UK MARINE INFORMATION COUNCIL – COMPOSITION AND TERMS OF REFERENCE

### Composition

The UK Marine Information Council had the following organisations as members at the time of commission of this report:

- The Association of Marine Scientific Industries (AMSI)
- The British Geological Society (BGS)
- The Centre for Environment, Fisheries & Aquaculture (CEFAS)
- The Department of Agriculture and Rural Development Northern Ireland (DARDNI)
- The Department of the Environment Northern Ireland (DOENI)
- The Environment Agency
- HR Wallingford
- The Health & Safety Executive (HSE)
- The United Kingdom Hydrographic Office (UKHO)
- The Marine Biological Association (MBA)
- The United Kingdom Meteorological Office (UKMO)
- The Plymouth Marine Laboratory (PML)
- The Proudman Oceanographic Laboratory (POL)
- The Southampton Oceanography Centre (SOC)
- The Scottish Association for Marine Science (SAMS)
- The United Kingdom Oil Operators Association (UKOOA)

### Extract from Memorandum of Association of the UK MIC

1. The name of the Association (hereinafter called UKMIC) is the UNITED KINGDOM MARINE INFORMATION COUNCIL.
2. The UKMIC was established on 1 Jan 2000.
3. The UKMIC has the following mission statement:

*The UKMIC is established to implement a coherent UK strategy for the marine informatics sector. Within the marine informatics sector the UKMIC aims to assist the exchange of information between practitioners, to bring together practitioners for the promotion of scientific discussion and co-operation, and to develop links with similar organisations in a European and global setting.*

### Objectives

4. The UKMIC has the following objectives:
  - To foster effective partnerships between academia, industry and government,
  - To support the development of the nation's marine information industry,
  - To promote the development of UK capability in operational ocean monitoring and forecasts,
  - To ensure that there is an adequate skill base to support the growth of the sector.

### Membership

5. Membership of the UKMIC is open to organisations who have an involvement in marine informatics whether in operations, administration or research.

## APPENDIX B UK MARINE INFORMATION COUNCIL – TERMS OF REFERENCE FOR THE UKMIC DATA ACCESS WORKING GROUP

### Background

The Foresight Marine Information Task Force report (DTI 1999) identified a number of actions required to improve the effectiveness of the UK in the Marine Information Sector. The UK Marine Information Council was formed to implement the recommendations and has established working groups in specific areas. The following sections define the policy principles, agreed objectives and plan of the working group formed to address the recommendations on access to data.

### Principles agreed by the Foresight Marine Information Task Force:

- An 'at retrieval cost' policy for access to all publicly funded marine information.
- A strengthening of national facilities for data archiving and retrieval of public and private sector data and data products.

### Objectives of the working group on access to data as agreed by the UKMIC:

- Identify a clear policy on access to data.
- Identify effective mechanisms to facilitate access to data.
- Lobby for change to a more effective UK policy.

### Policy principles:

- Publicly funded data available to the general public as widely as possible free of copyright and other restrictions and to everyone without discrimination.
- To ensure that national facilities are properly equipped and funded to archive public and privately funded data, and to service the dissemination of data widely and efficiently.

### Working group plan:

- Review existing national and international legal framework.
- Research and document the implications of current UK policy for government, academia and industry.
- Produce an inventory of existing national facilities for data and data product archival and retrieval.
- Produce policy recommendations.
- Conduct a quantitative comparison of cost and wealth creation implications of current and proposed access policies.
- Promotion and lobbying.

**APPENDIX C    A SIMPLE SCREENING MODEL BY GAVIN CAMERON AND CHRIS WALLACE. PAPER COMMISSIONED BY THE UKMIC DATA ACCESS WORKING GROUP, OCTOBER 2001**

# A SIMPLE SCREENING MODEL

GAVIN CAMERON AND CHRIS WALLACE

October 2001

## 1. THE PROBLEM

The government collects data at some large fixed cost. The government gives the rights to sell the data to various departments. The departments are interested in raising revenue, perhaps in order to cover the costs of collecting the data. The firms and institutions interested in buying the data have potentially different marginal valuations for the data. The department does not know the valuations but can offer a menu of contracts to the firms and ensure they self select. Alternatively, the department can offer a single contract and either exclude low-valuation types or pool and include all valuation types. The model below is a very simple framework within which to think about these issues and is very easily generalised. A general model of this sort is undoubtedly available in the existant screening literature.

## 2. A SIMPLE FRAMEWORK

Suppose the firms interested in buying the data have valuation  $\theta v(q)$  where  $q$  is the quantity of data they purchase and  $\theta$  is a scaling factor.  $\theta \in \{\theta_L, \theta_H\}$  with  $\theta_H > \theta_L$ . The firm knows if it is high- or low-valuation, but the department does not and believes that the firm is high valuation with probability  $\alpha$ . The department can set a subscription fee to the data:  $f$  and a price-per-use  $p$ . The firms profits are therefore:

$$\pi = \theta v(q) - pq - f$$

The department wishes to maximise revenue, given by:

$$R = pq + f - cq$$

$c$  is a constant marginal cost. For concreteness assume that  $v(q) = 2q^{\frac{1}{2}}$ . The results do not alter in spirit for the general case.<sup>1</sup> The firm will choose  $q$  to maximise  $\pi$ :

$$\pi = 2\theta q^{\frac{1}{2}} - pq - f \quad \text{hence} \quad \frac{d\pi}{dq} = \theta q^{-\frac{1}{2}} - p$$

Which implies  $q^* = (\theta/p)^2$  and hence  $\pi^* = \theta^2/p - f$ . The department can offer a menu of contracts:  $(p_L, f_L)$  and  $(p_H, f_H)$  to separate the two types. Substituting for  $q^*$  in the revenue

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*Date Printed.* This Version Printed October 22, 2001.

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<sup>1</sup>The standard assumptions would be that  $v$  is an increasing concave function ( $v(0) = 0$ ,  $v'(q) > 0$  and  $v''(q) < 0$ ). In other words, additional units of data are always valued but at a decreasing rate.

equation and taking account of the uncertainty yields the following maximisation problem for the department:<sup>2</sup>

$$\begin{aligned} \max_{p_L, f_L; p_H, f_H} \quad & \alpha \left\{ \frac{\theta_H^2}{p_H} + f_H - c \left( \frac{\theta_H}{p_H} \right)^2 \right\} + (1 - \alpha) \left\{ \frac{\theta_L^2}{p_L} + f_L - c \left( \frac{\theta_L}{p_L} \right)^2 \right\} \quad \text{s.t.} \\ \text{IC}_H : \quad & \theta_H^2/p_H - f_H \geq \theta_H^2/p_L - f_L \\ \text{IC}_L : \quad & \theta_L^2/p_L - f_L \geq \theta_L^2/p_H - f_H \\ \text{PC}_H : \quad & \theta_H^2/p_H - f_H \geq 0 \\ \text{PC}_L : \quad & \theta_L^2/p_L - f_L \geq 0 \end{aligned}$$

The rest of this note describes the solutions to this problem.

### 3. SOLUTIONS

There are a number of different cases to consider. (*i*) Full information, (*ii*) asymmetric information with a single contract (pooling), (*iii*) asymmetric information with a single contract (exclusion) and (*iv*) asymmetric information with a menu of contracts (separation).

**3.1. Full Information.** If the department could observe the firm's type this would be a straight-forward problem. The two incentive compatibility constraints  $\text{IC}_H$  and  $\text{IC}_L$  can be ignored. Revenue is strictly increasing in  $f_H$  and  $f_L$  so the department sets them as high as possible. That is, by  $\text{PC}_H$  and  $\text{PC}_L$ :

$$f_H = \theta_H^2/p_H \quad \text{and} \quad f_L = \theta_L^2/p_L$$

Hence, substituting into the revenue equation and differentiating with respect to prices for both types yields:  $p_H = p_L = c$ . The department prices efficiently — and then extracts all the profits from the firms with the subscription fee. Expected revenue raised under full information is:

$$R_f = \alpha \frac{\theta_H^2}{c} + (1 - \alpha) \frac{\theta_L^2}{c}$$

Clearly firms receive zero profits and purchase  $(\theta/c)^2$  units of data. Of course, this is simply a benchmark case. In fact, there is asymmetric information.

**3.2. Pooling.** The department cannot observe  $\theta$ . It chooses to set a single contract  $(p, f)$  with a low subscription fee so that both types will choose to purchase data. The best it can do is to offer  $f = \theta_L^2/p$ . Substituting this back into revenue and after maximisation and some manipulation, optimal price is given by:

$$p = c \left\{ \frac{2(\alpha\theta_H^2 + (1 - \alpha)\theta_L^2)}{\alpha\theta_H^2 + (1 - \alpha)\theta_L^2 + \theta_L^2} \right\} > c$$

<sup>2</sup>The constraints  $\text{PC}_H$  and  $\text{PC}_L$  are “participation constraints” which are required to enable both types of firm to participate; it must be possible for firms to make a profit when choosing the appropriate contract.  $\text{IC}_H$  and  $\text{IC}_L$  are “incentive compatibility” constraints; both firms must find it profitable to select the contract that is designed for them and not the other type's contract.

This is not efficient relative to full information. Again, after some deal of algebra, revenue in this candidate for equilibrium is:

$$R_p = \frac{1}{c} \left\{ \frac{(\alpha\theta_H^2 + (1-\alpha)\theta_L^2 + \theta_L^2)^2}{4(\alpha\theta_H^2 + (1-\alpha)\theta_L^2)} \right\}$$

Naturally this is lower than  $R_f$ . The department could offer a single contract to exclude the low type however.

**3.3. Exclusion.** The department cannot observe  $\theta$ . It chooses to set a single contract  $(p, f)$  with a high subscription fee so that the low-valuation type will choose not to purchase data. Since only high valuation types will purchase,  $f$  can be set to extract all their profit, by  $PC_H$ :  $f = \theta_H^2/p$ . Substituting into revenue and noting  $q_L = 0$  and  $q_H = (\theta_H/p)^2$ , revenue is maximised when  $p = c$ . This is not efficient relative to the full information world since  $(1-\alpha)$  of the market is not served at all. Revenue is given by:

$$R_e = \alpha \left( \frac{\theta_H^2}{c} \right)$$

Naturally again, lower than  $R_f$ . But how does it compare with  $R_p$ ? It is possible to show that:

$$\alpha \geq \frac{2\theta_L^2}{\theta_H^2 + \theta_L^2} \quad \implies \quad R_e \geq R_p$$

Of course, primary interest lies in a separating contract. For any  $\alpha$  below the above value it is possible to show that (i) there exists a separating equilibrium contract and (ii) it yields more revenue than either  $R_p$  or  $R_e$ . The next section deals with this case.

**3.4. Separation.** In the standard way, first consider  $PC_H$ .<sup>3</sup> Since  $\theta_H > \theta_L$  if both  $IC_H$  and  $PC_L$  are satisfied then  $PC_H$  will always be satisfied (as a strict inequality). Hence ignore it. Now raise  $f_H$  and  $f_L$  together until  $PC_L$  is satisfied as an equality. Both incentive compatibility constraints continue to hold. Now raise  $f_H$  alone until  $IC_H$  is satisfied as an equality.  $IC_L$  gets slacker when this occurs and will continue to hold. Ignore this final constraint and, substituting the values for  $f_H$  and  $f_L$  (given by  $IC_H$  and  $PC_L$ ) into the revenue equation maximise with respect to  $p_H$  and  $p_L$ . Return to  $IC_L$  to check it holds (it does). This yields a solution as the revenue equation is concave local to the optimum. The algebra is tedious and is omitted here. Finally, the optimum values are:

$$p_H = c \quad \text{and} \quad p_L = c \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right] \right)^{-1}$$

$$f_H = \frac{\theta_L^2}{c} \left( 1 + \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right]^2 \right) \quad \text{and} \quad f_L = \frac{\theta_L^2}{c} \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right] \right)$$

<sup>3</sup>This solution technique is a standard one in the screening literature. Essentially, it is possible to ignore the  $IC_L$  constraint as the problem will not lie with a low-type masquerading as a high-type but rather in the opposite case. The high-type must always be allowed to retain some of the rent as they must be given an incentive to choose the correct contract, and the low-type's rent can always be fully extracted.

This is a solution as long as all the constraints hold. In particular check the profits of the two types ( $\pi_L = 0$  of course):

$$\pi_H = \frac{1}{c}(\theta_H^2 - \theta_L^2) \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right] \right)$$

This is greater than zero if and only if  $\alpha < 2\theta_L^2/(\theta_H^2 + \theta_L^2)$ . Revenue in this candidate for a separating equilibrium is:

$$R_s = \frac{\theta_L^2}{c} \left\{ 1 + \frac{\alpha^2}{4(1-\alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right]^2 \right\}$$

It remains to check whether  $R_s > R_e$  and  $R_s > R_p$ . It turns out that the second inequality always holds. This is natural. It is better to separate the two types than offer a pooling contract which includes them both. After some algebraic manipulation it is possible to show that:

$$\alpha < \frac{2\theta_L^2}{\theta_H^2 + \theta_L^2} \quad \implies \quad R_s > R_e$$

Hence there is an optimal separating equilibrium for low values of  $\alpha$ . As  $\alpha$  rises beyond the level indicated above, there is an optimal *exclusion* equilibrium where the department sells only to the high-valuation type.

#### 4. EQUILIBRIUM DESCRIPTION

It is straight-forward to check that  $R_s < R_f$  for the appropriate values of  $\alpha$ . Full information allows higher revenues to be made. There is plenty to be said about the solution however. No distortion at the top (as usual). Charge the high-valuation customer marginal cost and some high subscription fee. Charge the low-valuation customer above marginal cost and a low subscription fee. If there are lots of high-valuation firms out there (high  $\alpha$ ), only serve them and exclude the low-valuation firms. Never pool.

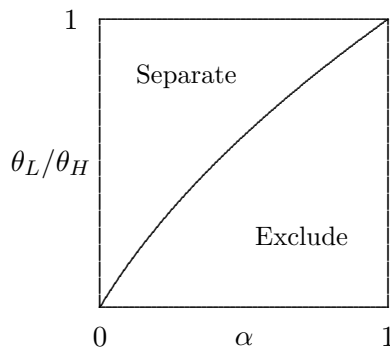


FIGURE 1. Optimal contracts for values of  $\alpha$  and  $\theta_L/\theta_H$ .

## 5. WELFARE

So far the government has had no interest in the process. Is the government happy with the outcome? Suppose the government is interested in maximising welfare. Welfare in this simple problem is assumed to be some weighted sum of the department's revenue and the firms' profits. That is, the government wishes to maximise:

$$W = t \{ \alpha \pi_H + (1 - \alpha) \pi_L \} + R$$

$t \in [0, 1]$  is the weighting factor or tax rate. It is assumed the government taxes profits at some rate less than 100% and values revenues at their face value. The two extreme case are when the government doesn't care about profits at all ( $t = 0$ ) and the government cares about profits equally to department revenues ( $t = 1$ ).

Consider first the case of exclusion. Firms make no profits and hence:

$$W_e = R_e = \alpha \left( \frac{\theta_H^2}{c} \right)$$

Now consider pooling and separating candidates. Calculating profits for the high type pooling firm and noting  $\pi_L = 0$  in both cases yields:

$$W_p = \frac{t\alpha}{c} (\theta_H^2 - \theta_L^2) \left\{ \frac{\alpha\theta_H^2 + (1 - \alpha)\theta_L^2 + \theta_L^2}{2(\alpha\theta_H^2 + (1 - \alpha)\theta_L^2)} \right\} + \frac{1}{c} \left\{ \frac{(\alpha\theta_H^2 + (1 - \alpha)\theta_L^2 + \theta_L^2)^2}{4(\alpha\theta_H^2 + (1 - \alpha)\theta_L^2)} \right\}$$

For the separating candidate use the previous calculations to obtain:

$$W_s = \frac{t\alpha}{c} (\theta_H^2 - \theta_L^2) \left\{ 1 - \frac{\alpha}{2(1 - \alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right] \right\} + \frac{\theta_L^2}{c} \left\{ 1 + \frac{\alpha^2}{4(1 - \alpha)} \left[ \frac{\theta_H^2}{\theta_L^2} - 1 \right]^2 \right\}$$

Comparing  $W_s$  and  $W_p$  first. Algebraic manipulation yields the following expression:

$$W_s - W_p = \frac{1}{2c} \frac{\alpha^3}{(1 - \alpha)} \frac{\theta_H^2}{\theta_L^2} \frac{(\theta_H^2 - \theta_L^2)^2}{(\alpha\theta_H^2 + (1 - \alpha)\theta_L^2)} \left( \frac{1}{2} - t \right)$$

This is not at all pretty, but it is easy to interpret. When  $t \leq 1/2$  then the welfare from separation is always larger than the welfare from pooling. The extra profits that the private firms make when pooling (profits are always larger since the department is not optimally extracting them) do not compensate the government for the lower revenues. However, when  $t > 1/2$ , the government values profits in the private sector enough to outweigh the extra revenues (optimally) extracted by the department. Revenues are always higher under separation but profits are always lower.

The problem is not so straightforward for the comparison of pooling and exclusion. Consider  $t = 1/2$ . In this case  $W_p = W_s$  and hence  $W_e > W_p \iff W_e > W_s$ .  $W_e - W_p$  is thus:

$$W_e - W_p = \frac{1}{2c} (\alpha\theta_H^2 - (2 - \alpha)\theta_L^2)$$

So that  $W_e > W_p \iff \alpha > 2\theta_L^2/(\theta_H^2 + \theta_L^2)$ . But this is precisely the condition for exclusion to be an equilibrium. What about when  $t > 1/2$ ? Consider  $t = 1$ . Here, it can be shown that

$W_e > W_p$  if and only if:

$$\alpha > 2 \left\{ \frac{(x-2) + \sqrt{x^2 + (x-1)^2}}{(x-1)(x+3)} \right\}$$

With  $x = \theta_H^2/\theta_L^2 > 1$ . These values of  $\alpha$  can be calculated numerically and plotted on the diagram. The area above the dashed line is where separation is an equilibrium, below the dashed line exclusion is an equilibrium but neither are *welfare optimal* until reaching the region below the solid line — where exclusion *is* welfare optimal. Anywhere above this line, pooling is welfare optimal, but does not constitute an equilibrium.

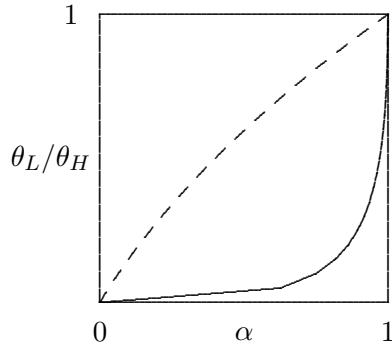


FIGURE 2. Welfare optima and equilibria when  $t = 1$ .

### 6. CONCLUSION

Summarising for various values of  $t$  (see diagram below): When  $t \in [0, 1/2]$  any point in region  $S^*$  is a welfare optimal separating equilibrium. Any point in  $E^*$  is a welfare optimal exclusion equilibrium. When  $t \in (1/2, 1]$  any point in  $S$  is a welfare sub-optimal separating equilibrium

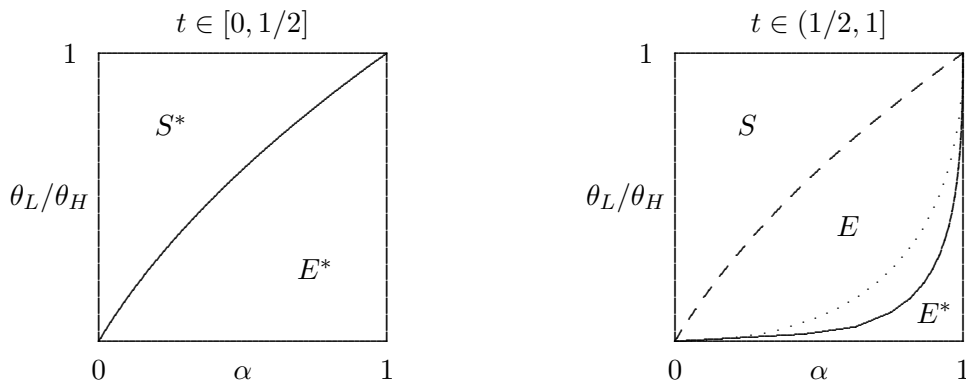


FIGURE 3. Optimal welfare and equilibrium for  $t \in [0, 1]$ .

and any point in  $E$  is a welfare sub-optimal exclusion equilibrium. Points in  $E^*$  remain welfare optimal exclusion equilibria.  $E^*$  is bounded by a line which rises as  $t \rightarrow 1/2$  (for example, to

the dotted line which illustrates some  $t \in (1/2, 1)$ ). For any point above this line pooling is welfare optimal but is *not* an equilibrium, the department can do better (regions  $S$  and  $E$ ).

Either the government would need to enforce pooling if it cares enough about profits or take the decision away from the department. However, the lower revenues this generates may not be enough to cover the fixed cost of collecting the data.

In any case, a  $t < 1/2$  seems much more reasonable and likely (tax rates on profits do not rise above 50%) and the whole point of the exercise is that governments are trying to raise revenue to cover fixed costs. Basically, though, the point is this: As long as the government does not value private profits too much, separation and exclusion equilibria are also welfare optimal. Of course, under full information welfare is always higher, regardless of the value of  $t$ . If the department knows the private valuations of the firms then the government is *always* better off allowing the department to price at marginal cost and extract profits through a fixed charge.

## 7. GLOSSARY OF TERMS

- $\theta \in \{\theta_L, \theta_H\}$  — The marginal valuation of data parameter for high and low value firms.
- $v(\cdot)$  — The firm's increasing and concave valuation of data, a function of...
- $q$  — The amount of data consumed.
- $q^*$  — The optimal amount of data consumed.
- $\alpha$  — The probability a given firm is high valuation.
- $p$  — The price of data, per unit used.
- $f$  — The fixed charge for use of data.
- $\pi$  — The firm's profits, and...
- $\pi^*$  — The optimal level of profits.
- $c$  — The department's (very small) marginal cost of data provision.
- $R$  — The department's revenue from data provision.
- $(p_H, f_H)$  — The contract offered for the high valuation firm.
- $(p_L, f_L)$  — The contract offered for the low valuation firm.
- $PC_H$  and  $PC_L$  — Participation constraints for the two types of firm.
- $IC_H$  and  $IC_L$  — Incentive compatibility constraints for the two types of firm.
- $R_f, R_e, R_p, R_s$  — Revenue under full information, exclusion, pooling, separation.
- $(q_L, q_H)$  — Quantity choices for the two types of firms and...
- $(\pi_L, \pi_H)$  — Optimal profits for the two types of firms.
- $W$  — Government welfare, their objective function.
- $t$  — The extent to which a government values profits relative to revenues.
- $W_f, W_e, W_p, W_s$  — Welfare under full information, exclusion, pooling and separation.
- $E, S, E^*, S^*$  — Regions where exclusion and separating equilibria respectively are optimal and their welfare optimal counterparts.