TECHNOLOGY CLUBS: EFFICIENT PRICING IN BUSINESS-UNIVERSITY COLLABORATIONS

GAVIN CAMERON AND CHRIS WALLACE

April 2003

Address for Correspondence:
GAVIN CAMERON, DEPARTMENT OF ECONOMICS, MANOR ROAD,
OXFORD UNIVERSITY, OXFORD OX1 3UQ, UK

Abstract. Recently, business-university collaborations have become the subject of much interest. It is important to distinguish between ‘blue-sky’ research and more directly commercially applicable research. This paper provides a framework in which to think about the latter. A simple screening model is proposed to study the ways in which a university might sell its research to the private sector. It demonstrates that ‘technology clubs’, where firms pay a fixed fee to join and a relatively low marginal cost for each piece of research, would increase the amount of research commercially developed and would be beneficial to all parties.

1. Introduction

There is currently a great deal of interest in business-university collaborations among both academics and (Hall 2001, Poyago-Theotoky, Beath, and Siegel 2002) and policymakers. It is also well-known that a significant proportion of university R&D is funded by such collaborations. In 2000, of the £3633m of Higher Education...
R&D (HERD) spending in the UK, £1139m (31 per cent) was funded by the business enterprise, private non-profit, and foreign sectors. This is represents a significant increase over the past decade from about 22 per cent (Office of Science and Technology 2000, Lawton Smith 2000) in 1990. The amount funded by business enterprise itself is more modest, at around 7 per cent.

However, while the academic literature contains a great deal of discussion of how collaborations are organized (Siegel, Waldman, and Link 2003), what factors determine their success (Mansfield and Lee 1996, Goldfard and Henrekson 2003), and what are their effects (Bozeman 2000, Salter and Martin 2001, Guellec and van Pottelsberghe de la Potterie 2001), there has been little theoretical interest in how collaborations might be designed. Nonetheless, authors have at least recognised that design is problematic, since too much emphasis on commercial pricing may lead to under-provision of research or possibly the monopolisation of research results (Feller 1990).

This paper is an initial attempt to fill that lacuna. Section 2 discusses some conceptual issues. Section 3 presents a theoretical model of business-university collaborations that focuses on situations where businesses are well informed about the prospects and benefits of the collaboration - this is most likely to be the case for applied technology collaborations. Section 4 discusses the implications of the model and Section 5 concludes.

2. BUSINESS-UNIVERSITY COLLABORATIONS

The knowledge generated by university research is a public good, in that it is non-rival and non-excludable, although of course when an Intellectual Property Right (IPR) is assigned, it may become excludable. Such goods are typically underprovided by the market because firms find it difficult to make profits from providing them. Moreover, although IPRs lead to strong incentives to create knowledge, they also turn the inventor into a monopolist. This is not efficient since once the knowledge is created the marginal cost of disseminating the idea is very low.

In addition, a further problem arises because any regime for technology transfer must provide incentives for four groups of agents: firms, universities, researchers, and the

2The model we describe is therefore not well-suited for the analysis of business-university collaboration in ‘blue-sky’ research projects, for example, the US Advanced Technology Program, see Hall, Link, and Scott (2002).

3Non-rival goods are those that can be consumed/used by one person without reducing the amount of the good available to others. Non-excludable goods are those where there is no way to prevent the good being consumed by any person.
taxpayer. Once an IPR has been granted, it is clear that all these interests conflict, that is, any group cannot do better without making another group worse off.

It is also the case that research can vary from being very applied to being very basic. In what follows we assume that there are only two kinds of business-university collaboration: applied, which is sufficiently close to the market and specific to each firm that an IPR cannot be assigned; and basic, which is sufficiently far from the market and general that an IPR can be assigned.

In the case of ‘applied’ business-university collaborations, we envisage a typical scenario being that a firm has an applied technological problem that it would like to solve and not much uncertainty about how difficult (costly) that will be, and also that the firm knows the value to itself of success. The university possesses expertise in the general area and is able to supply qualified scientists and engineers (QSEs) to solve the problem.

The current approach in the UK appears to be to allow universities discretion in how much they charge for such work, and the typical solution appears to involve charging a commercial fee (which includes both the marginal cost of the QSEs’ time as well as an element of fixed cost recovery for the university). This deters many firms from entering such collaborations and reduces use of collaborations even by the firms that do. This is economically inefficient compared with the alternative of charging simply the marginal cost of QSE time.

At present, there is a great number of different practices when it comes to the charging of overheads on research (where an overhead is usually expressed as some percentage of the salary cost of researcher). Some funding bodies are generous, some are not. Those that are not are sometimes accused of ‘free-riding’ on universities to achieve their own research agendas. We consider that there is a misperception of the role of overheads. We do not think that overheads should be thought of as making a contribution to the fixed costs of a university. However, it is clearly reasonable for a university to reclaim all the marginal costs associated with a researcher, and these include both salary and the marginal cost of office/laboratory space, computing, and other resources. In practice, rules of thumb (for example, a ‘45 per cent overhead’) may well be appropriate, with different rules of thumb for research that is more or less intensive in other marginal costs. What this certainly means is that the government should forbid universities from accepting contracts that do not include at least some overhead (that is, payment above the marginal salary cost of the researcher).
In the case of ‘basic’ business-university collaborations, the situation is rather different. We envisage a typical scenario being the discovery of a genuinely new piece of knowledge that is not specific to a particular firm, whose discovery is an uncertain process, and that can be written down in such a way that the current legal system would award an Intellectual Property Right for the discovery. In this situation, incentives must be provided to all four sets of agents (firms, universities, researchers, and the taxpayer) to participate in such collaborations. The most efficient solution once the IPR has been discovered is for the university to publish the IPR and to encourage its free use by firms. But this hardly gives incentives to universities and researchers to make discoveries. Equally, a system whereby the government takes control of the IPR and charges firms its full value does nothing for those incentives either. Rather than consider the difficulties associated with providing such incentives, this paper focuses on case of ‘applied’ business-university collaborations.

3. A Simple Model of business-university Collaborations

This section provides a simple model of business-university collaborations. In particular, a university department conducts research which is of value to the business world. The firm considering whether or not to purchase the research is better informed about the likely commercial success of the venture, the university department is less so. Both firm and university are interested in maximising their profits from the transaction.

A university might sell its research output to the firm in many different ways. As has been argued, the current method usually involves the payment of a commercial fixed price to the university. This price might involve both an ‘overhead’ charge along with a component to cover the ‘marginal’ cost of the researchers involved in production. In this section, a comparison is made between this method and the use of a ‘technology club’, where firms pay a fixed fee to join, and pay relatively low marginal costs on each piece of research they purchase subsequently. This latter mechanism is shown to be beneficial to all concerned. The amount of research purchased increases, potentially raising profits for both businesses and university departments. From the government’s perspective, welfare is unambiguously increased.

3.1. The Framework. First, the current system is analysed within the framework. Firms are charged a commercial price for each unit of research they wish to purchase.

---

*4The model is an application of the contracts literature derived from Mussa and Rosen (1978) and Maskin and Riley (1984). For a recent textbook discussion, see Salanié (1997), Chapter 2.*
3.1.1. Charging a Fixed Commercial Price. Suppose the firm interested in buying the research has valuation $\theta v(q)$ where $q$ is the quantity of research 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 university department does not and believes that the research is high valuation with probability $\alpha$. This is to reflect the idea that the business world is better informed about the commercial potential of a given piece of research. The department charges a fixed commercial fee $p$ for the research. The firm’s profits are therefore:

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

The department wishes to maximise its profit, given by:

$$R = pq - cq$$

where $c$ is the constant marginal cost of research production. The fixed costs of the university are irrelevant for the analysis. Of course, a university will choose not to sell any research if this sale does not make a contribution toward its fixed costs.\(^5\)

For concreteness, assume throughout that $v(q) = 2\sqrt{q}$. The important feature of this function is that the revenue to the firm increases in the amount of research it purchases, but does so at a decreasing rate. The firm will choose $q$ to maximise $\pi$:

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

Which implies $q^* = (\theta/p)^2$ and hence $\pi^* = \theta^2/p$. Given that the firm demands this quantity, the department sets prices to maximise:

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

Which implies that $p = 2c$. Price is set at twice marginal cost. As a result the firm purchases $q_c = (\theta_H/2c)^2$ if the research has high commercial value and $q_c = (\theta_L/2c)^2$ if not. Firm profits are given by $\theta^2_H/2c$ and $\theta^2_L/2c$ respectively. The expected profits to the university are:

$$R_c = \frac{1}{4c} \left\{\alpha \theta^2_H + (1 - \alpha) \theta^2_L\right\}$$

3.1.2. Technology Clubs. Now suppose that the university sets up a technology club. That is, they charge a fixed subscription fee $f$ and a price-per-use $p$. Profits to the

\(^5\)As will be shown, the university always makes positive profits from the transaction and these increase unambiguously when they sell the research through a technology club. This means that in the presence of fixed costs, technology clubs have a further beneficial effect. Research which would otherwise have been too costly is now produced and sold.
firm and to the university are now respectively:

\[ \pi = \theta v(q) - pq - f \quad \text{and} \quad R = pq + f - cq \]

The addition of a constant to firms profits does not change their maximisation problem. However, the university can now offer a menu of contracts: \((p_L, f_L)\) and \((p_H, f_H)\) to separate the two types. Substituting for \(q^*\) in the expected revenue equation yields the following maximisation problem:

\[
\max_{p_L, f_L, p_H, f_H} \alpha \left\{ \frac{\theta_H^2}{p_H} + f_H - c \left( \frac{\theta_H}{p_H} \right)^2 \right\} + (1 - \alpha) \left\{ \frac{\theta_L^2}{p_L} + f_L - c \left( \frac{\theta_L}{p_L} \right)^2 \right\} \quad \text{s.t.}
\]

\[
\begin{align*}
\text{IC}_H & : \quad \theta_H^2 / p_H - f_H \geq \theta_H^2 / p_L - f_L \\
\text{IC}_L & : \quad \theta_L^2 / p_L - f_L \geq \theta_L^2 / p_H - f_H \\
\text{PC}_H & : \quad \theta_H^2 / p_H - f_H \geq 0 \\
\text{PC}_L & : \quad \theta_L^2 / p_L - f_L \geq 0
\end{align*}
\]

These are respectively the incentive compatibility (IC\(_H\) and IC\(_L\)) constraints and the participation (PC\(_H\) and PC\(_L\)) constraints.

The first two are critical for the universities problem when it wishes to offer different contracts for the different types of research. Since it does not know whether the research is of high or low valuation, it must ensure that, when the research is of high value, the firm will select the contract designed for this case (IC\(_H\)), and vice-versa (IC\(_L\)). The latter two constraints ensure that both high and low valuation research is purchased. The next section describes the various solutions to this problem.

3.2. **Analysis.** There is a number of different cases to consider. (i) Full information (simply for comparison), (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).

3.2.1. **Full Information.** If the university knew the commercial potential of the research (its type) this would be a straight-forward problem. The two incentive compatibility constraints IC\(_H\) and IC\(_L\) can be ignored. Revenue is strictly increasing in \(f_H\) and \(f_L\) so the university would wish to set them as high as possible. That is, by PC\(_H\) and 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 university prices efficiently — and then extracts all the profits from the firms with the subscription fee. Expected profit 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. Notice that this revenue is four times as great as when they are unable to charge a subscription fee. Indeed, it is larger than the sum of firm and university profits in the absence of \( f \) — under perfect information there is no doubt that all could benefit from the introduction of technology clubs (given a suitable redistribution by the government). Of course, this is simply a benchmark case. In reality, there is asymmetric information.

### 3.2.2. Pooling.

The university 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 — hence the constraints \( IC_L \) and \( IC_H \) can be ignored. The best it can do is to offer \( f = \theta_L^2/p \). Substituting this back into university profit and after maximisation and some manipulation, optimal price is given by:

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

This is not efficient relative to full information. Again, after some manipulation, university profit 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 \( R_f \). It is also possible to calculate \( q_p \), the quantity sold under pooling. Note that \( p < 2c \), hence \( q_p > q_c \). The quantity sold unambiguously rises relative to the case when a single commercial price is charged. Finally, consider total expected profits from this type of contract (the sum of university and firm profits). Again, there is an unambiguous rise in total profits. Technology clubs (given a suitable redistribution by the government) results in a welfare benefit for all. However, this is not the only candidate equilibrium — the university could offer a single contract to exclude the low type.

### 3.2.3. Exclusion.

Again, the university cannot observe \( \theta \). It chooses to set a single contract \((p, f)\) with a high subscription fee so that the low-valuation research will not be bought. Since only the high-valuation research is purchased, \( f \) can be set to
extract all the profit of the firm, by \( PC_H : f = \frac{\theta_H^2}{p} \). Substituting into university profit and noting \( q_L = 0 \) and \( q_H = (\theta_H/p)^2 \), maximisation occurs at \( p = c \). The other constraints can be ignored. This is not efficient relative to the full information world since \( (1 - \alpha) \) of the market is not served at all. University profit is given by:

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

Naturally again, lower than \( R_f \). Comparing with \( R_p \), it is possible to show that:

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

Under this condition, it is also the case that \( R_e > R_c \), the profit in the case of no fixed fee. In addition, the expected quantity of research traded unambiguously increases under this condition[6] If, in addition \( \alpha \geq 1/2 \) the expected profit of the university exceeds total profits for firm and university when \( f = 0 \).

Of course, a separating contract is also possible. 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 profit to the university than either \( R_p \) or \( R_c \). The next section deals with this case.

3.2.4. Separation. In the standard way, first consider \( PC_H \). 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 it can be ignored. Now \( f_H \) and \( f_L \) are raised together until \( PC_L \) is satisfied as an equality. Both incentive compatibility constraints continue to hold. Now \( f_H \) can be raised further until \( IC_H \) is satisfied as an equality. \( IC_L \) gets slacker when this occurs and will continue to hold. Ignoring this final constraint and substituting the values for \( f_H \) and \( f_L \) (given by \( IC_H \) and \( PC_L \)) into the profit equation, expected university profit is maximised with respect to \( p_H \) and \( p_L \). This yields a solution as

\[6\]This occurs even though low-valuation research is never sold in the exclusionary equilibrium — to see this, compare \( q_e = \alpha(\theta_H/2c)^2 + (1 - \alpha)(\theta_L/2c)^2 \) with \( q_e = \alpha(\theta_H/c)^2 \).
the profit equation is concave local to the optimum. Optimal values are given by:

\[ p_H = c \]

\[ p_L = c \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right] \right)^{-1} \]

\[ f_H = \frac{\theta^2_L}{c} \left( 1 + \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right]^2 \right) \]

\[ f_L = \frac{\theta^2_L}{c} \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right] \right) \]

This is a solution as long as all the constraints hold. IC \_L can be shown to hold. In addition, the firm’s profit when the research is of high commercial value (\( \pi_L = 0 \) of course) is:

\[ \pi_H = \frac{1}{c} \left( \theta^2_H - \theta^2_L \right) \left( 1 - \frac{\alpha}{2(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right] \right) \]

This is greater than zero if and only if \( \alpha < \frac{2\theta^2_L}{\theta^2_H + \theta^2_L} \). Profit for the university in this candidate for a separating equilibrium is:

\[ R_s = \frac{\theta^2_L}{c} \left\{ 1 + \frac{\alpha^2}{4(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right]^2 \right\} \]

It remains to check whether \( R_s > R_e \) and \( R_s > R_p \). The second inequality always holds. This is to be expected. 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:

\[ \alpha < \frac{2\theta^2_L}{\theta^2_H + \theta^2_L} \implies R_s > R_e \]

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 university sells only high-valuation research. Again, it is possible to conclude that the expected quantity sold increases relative to the case when no fixed fee is charged. Note that the expected quantity of research sold under separation is:

\[ q_s = \left( \frac{\theta_L}{c} \right)^2 \left\{ 1 + \frac{\alpha^2}{4(1-\alpha)} \left[ \frac{\theta^2_H}{\theta^2_L} - 1 \right]^2 \right\} \]

Comparing this with \( q_e \) yields this result. The sum of expected profits for the firm and university can be compared with the case when \( f = 0 \). If (in addition to the above equilibrium condition) \( \alpha \leq 1/2 \) then the sum of expected profits is larger under separation than when there is no fixed fee.
3.3. Welfare. So far the government has had no interest in the process. Suppose that the government is interested in maximising social welfare. This section makes welfare comparisons for the solutions presented in Sections 3.1 and 3.2 before discussing the implications of the model for government policy.

3.3.1. Welfare Comparisons. Welfare in this simple model is assumed to be some weighted sum of the university’s and the firm’s profits. That is, the government wishes to maximise:

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

\( t \in [0,1] \) is a weighting factor (which might be thought of as a tax rate). It is assumed that the government taxes the firm’s profits at some rate less than 100 per cent and values the university’s profits at their face value (simply because universities are generally part of the public sector).
The two extreme cases are when the government does not care about the firm’s profits at all \((t = 0)\) and when the government cares about firm and university profits equally \((t = 1)\). This latter case has been discussed throughout Section 3.2 when comparing total university and firm profits to the situation when there is no fixed fee (denoted \(W_c\) subsequently). It is straightforward to observe that:

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

Since introducing a fixed fee always resulted in a higher profit level for the university, and it was found that welfare under pooling with \(t = 1\) was unambiguously larger than welfare without a fixed fee, it must be the case that \(W_p(t) > W_c(t)\) for all \(t \in [0, 1]\) (where \(W_p\) is welfare under pooling). Hence, \(W_p\) can be used as a benchmark throughout the following.

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

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

Now consider pooling and separating candidates. Calculating firm profits when they purchase high-valuation research, and noting \(\pi_L = 0\) in both cases, yields:

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

For the separating candidate the previous calculations can be used to obtain:

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

First, comparing \(W_s\) and \(W_p\). Some algebraic manipulation yields the following expression:

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

When \(t \leq 1/2\) then the welfare from separation is always larger than the welfare from pooling (and hence larger than welfare when there is no fixed fee). The extra profits that the firm makes when pooling (profits are always larger since the university is not optimally extracting them) do not compensate the government for the lower profits of the university. However, when \(t > 1/2\), the government values profits in the private sector enough to outweigh the extra revenues (optimally) extracted by the university. University profits are always higher under separation but firm profits are always lower.
The comparison of pooling and exclusion is not so straightforward. Consider $t = 1/2$. In this case $W_e = W_s$ and hence $W_e > W_p \iff W_e > W_s$. $W_e - W_p$ is thus:

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

So that $W_e > W_p$ for all $t \leq 1/2$ if and only if $\alpha > 2 \theta_L^2 / (\theta_H^2 + \theta_L^2)$. This is precisely the condition for exclusion to be the equilibrium. This leaves the case $t > 1/2$. Consider $t = 1$. Setting $x = \theta_H^2 / \theta_L^2 > 1$, it can be shown that $W_e > W_p$ if and only if:

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

![Figure 2. Welfare optima and equilibria when $t = 1$.](image)

These values of $\alpha$ can be calculated and plotted on the diagram (see Figure 2). The area above the dashed line is where separation is an equilibrium, for the area below the dashed line exclusion is an equilibrium. Neither are welfare optimal, however, until reaching the region below the solid line — where exclusion is welfare optimal. In the region above the solid line pooling is welfare optimal but does not constitute an equilibrium (in the sense that it does not maximise revenue for the university).

3.3.2. Summary and Discussion. Figure 3 summarises the welfare and equilibrium results for various values of $t$. 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 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 $t \to 1/2$ (for example, to the dotted line which illustrates some $t \in (1/2, 1)$, and eventually...
Figure 3. Optimal welfare and equilibrium for $t \in [0, 1]$. 

to the dashed line when $t \approx 1/2$). For any point above this line pooling is welfare optimal but is not an equilibrium, the university can do better by separating or excluding (regions $S$ and $E$ respectively).

It is in the government’s interest to enforce pooling contracts if it values the firm’s profits highly enough ($t > 1/2$). Even if the government were to do so, notice that the ability to charge a fixed fee is still beneficial for all involved. Technology clubs are welfare improving regardless of the value of $t$. On the other hand, when the government does not value private profits too much ($t \leq 1/2$) the separation and exclusion equilibria are also welfare optimal.

4. Discussion

The model presented above is essentially one where universities create knowledge which is then disseminated to firms through business-university collaborations. Since the marginal cost of disseminating research results is very low, the results should be made available for only a very low fee (the marginal cost) since this maximises the value to society of the research. By pricing at marginal cost, universities will not be able to cover their (fairly large) fixed costs. However, since the knowledge is created for a variety of publicly-worthwhile purposes, one solution is for the government to pay for these fixed costs through general taxation.

If subsidies on this scale are not politically acceptable, the government needs to create a common and coherent pricing regime for business-university collaborations that can recoup some of these fixed costs. If all the potential users of the knowledge (that is, commercial firms) have similar valuations of the research and if the demand for access to the research is not price-sensitive, the best solution is to charge marginal cost for
each research project and to levy a ‘subscription’ fee for access to the research that covers the fixed cost.

However, if research users have very different valuations and if those valuations are not known to the university (this is the realistic case), the best solution is often to offer a number of different tariffs. For example, a high subscription fee coupled with a low per-project charge would be attractive to high-valuation research users, while a lower subscription fee coupled with a slightly higher per-project charge would be attractive to low-valuation research users.

As noted above, the most realistic case is where each research user has a different valuation, unknown to the university. For simplicity consider two different kinds of research user, those with high valuations and those with low valuations. The discussion can easily be generalised for the case when there are more than two kinds.

The university can set a subscription fee and a price-per-project for the research. The particular menu of options that it offers will depend upon the probability of the research being high valuation and upon the ratio of the high valuation to the low valuation. There are four different cases.

**Full Information.** There is no problem if the university can observe the project’s valuation. The university should set a price-per-project equal to the marginal cost of the research project and then charge a different subscription fee for each project.

**Pooling.** If the university cannot observe the project’s valuation it can set a contract such that even the low-valuation research is purchased. Therefore it will charge a low subscription fee and a low price-per-project, but that price-per-project will be greater than marginal cost.

**Exclusion.** An alternative if the university cannot observe the project’s valuation is to set a contract such that only the high-valuation research will be purchased. This will involve setting price-per-project equal to marginal cost and then charging a fee large enough to make the low-valuation research unprofitable for the firm. In general, it will be worth excluding the low-valuation research (that is, choosing exclusion rather than pooling) when the probability that a given project is of high valuation is high, or when there is a big difference between the high and low valuations.

**Separation.** The most interesting case is when the university offers two different menus (with different subscription fees and prices-per-use) such that the different types of project are sold for different prices. A contract with a high subscription fee and a price-per-project set equal to marginal cost will be attractive to firms
purchasing high-valuation projects. A contract with a low subscription fee and a price-per-project set above marginal cost will be attractive to the firms purchasing low-valuation projects. This set of contracts will always raise more revenue than the pooling contract discussed above, and will raise more revenue than the exclusion contract when the probability that a given project is of high valuation is not too high, or when there is little difference between the high and low valuations.

**Welfare.** The contracts discussed above maximise the revenue of the university. But is the government happy with the outcome? The government should be concerned with some weighted average of university revenue and firm profits. The analysis shows that as long as the government does not value firm profits too much, separation and exclusion are as good for welfare as they are for university revenues. But when the government starts to value firm profits by nearly as much as it values university revenue, the government prefers the pooling solution even though this produces less revenue for the university.

5. **Conclusion**

Interestingly, the United Kingdom government has recently conducted a review of pricing of government information (HM Treasury 2000), having in mind the pricing of data produced by agencies such as the Metereological Office and the Office of National Statistics. Although the report is equivocal on whether marginal cost pricing is always the best solution, it does make the point that

> "The current policy of average cost pricing creates a significant barrier to the re-use of information because its requires parts of government, where this is not a core business, to make assessments and attributions of relevant costs and negotiate individual contracts in an area where many departments and agencies are ill-placed to operate. Marginal cost pricing would remove this burden from both the department concerned and the private sector"

HM Treasury (2000)

In the light of the model presented in this paper, the common practice of commercial pricing for ‘applied’ business-university collaborations does nothing to address the economic issues raised by the particular nature of publicly-funded university research and is a positive deterrent to the efficient and profitable exploitation of such research by the private sector.
Instead this paper suggests that ‘technology clubs’ provide the best means to promote business-university collaborations. The model suggests that when all parties have full information, welfare is always higher when universities can charge a fixed fee. If the university knows the commercial value of its research then the government is always better off encouraging the university to price at marginal cost and extract profits through a fixed charge.

In all cases, the introduction of technology clubs improves welfare. The ability to charge a fixed subscription fee leads to a higher quantity of research traded between businesses and universities and lowers the price at which those transactions take place. The increased revenue accruing to the university allows it to cover fixed costs, which they might not have been able to do in the absence of fixed fees. It is likely that (if they were to be included formally in the model) consumers would benefit too, from the lower prices that firms pay for their research and the higher quantity of research being purchased.

The government would be well advised to encourage the formation of technology clubs by university departments interested in the commercial possibilities of their research. Given the existence of such technology clubs, however, a tension might remain. If the government values the profits of firms highly enough, the welfare optimum will not coincide with the optimal strategy of the university. As a result there may be a need to restrict the kinds of contracts universities are able to offer. Specifically, pooling contracts might be preferred to separating or exclusionary contracts.

REFERENCES


