EDUCATIONAL PLANNING AND VOUCHER SYSTEMS: IMPLICATIONS FOR AGRICULTURAL ECONOMICS

T.G. MacAULAY

Department of Agricultural Economics
University of Sydney, NSW, 2060

Invited Paper presented to the
Annual Conference of the Australian Agricultural Economics Society,
University of Sydney, NSW, 2006
9 - 11 February 1993

EDUCATIONAL PLANNING AND VOUCHER SYSTEMS: IMPLICATIONS FOR AGRICULTURAL ECONOMICS

T.G. MacAULAY
Department of Agricultural Economics
*University of Sydney, NSW, 2066**

Introduction

The development of human capital for agriculture is a vital contribution that the educational sector makes to the agricultural sector. There are many aspects to this contribution including primary, secondary and tertiary level education, the development of research skills, research output, maintenance of the stock of knowledge and extension activities in relation to that knowledge. How the components of the educational system function is therefore important for agriculture in general and also for the participants in the educational sector related to agriculture. To place some bounds on the discussion in this paper it has been focused on agricultural economics education. The issue under consideration is what will be some of the impacts on a small university department, such as a typical department of agricultural economics, of a change from a 'regulated' system to a 'voucher' system. Some of the implications for agricultural economics training at university level will also be considered.

The economics of education is a difficult subject, education being neither a pure public good nor a purely private good. It might best be referred to as a quasi-public good. As Blaug (1968, p. 249) points out, '... the economic benefits are largely personal and divisible: below the statutory leaving age, it is possible to buy more education and above the statutory age the number of places in higher education are rationed out in accordance with examination results. It follows that there is nothing in the nature of education as an economic service that prevents meaningful comparison of its financial costs and benefits'. Thus, a very difficult and substantive economic planning issue is the extent to which the public should fund education and the extent to which the individual should fund their own education. Brennan (1988) has pointed out that in an ideal world in the absence of other relevant distortions, fees should be structured to take into account the marginal cost of providing the education minus any net marginal 'spill over benefit'. By this he meant benefits not accruing to the student. The difficulty, of course, is how to measure the benefits to the individual and to the public or how to set up a suitable pricing system. Voucher systems have been seen as one means of getting closer to this ideal and as a means of having a more competitive education sector.

* Thanks are due to Bob Batterham, John Brakey, Ross Drynan, Ross Harrold, Gupareet Singh and Alexander MacAulay for assistance in various ways in the development of this paper.

Fees are not a recent innovation to the Australian tertiary education sector. Prior to the election of the Whitlam government in 1972, fees of about 20 per cent of recurrent teaching costs were charged by State governments. In 1972, with the election of the Whitlam Labour government, tertiary education was made essentially free by the elimination of fees. With the defeat of the Whitlam government in 1975, then followed a period of what Smart has called 'tertiary neglect' with the share of tertiary education funding of total federal budgetary outlays shrinking from 4.5 per cent to less than 3 per cent by 1989 (Smart 1990). Then followed the Dawkin's era with a Green Paper and a White Paper (Dawkins 1987), the Wran Committee report (Wran 1988) on the funding of education and the recommendation for a Higher Education Contribution Scheme (HECS) and an associated income contingent loans scheme bas'd on future taxable income. By January 1989, virtually all university students were subject to a fee of $900 per full-time semester.

It is clear that recent trends in educational policy in Australia would suggest a move away from the idea that the public should fund almost entirely the cost of the public education system to an approach where the individual funds part and the government part, through the use of tax revenue. The HECS charge was a break with the previous 15 year experiment in free tertiary education. The HECS fee is a fixed per course charge for every student who is in the publicly funded tertiary education system and over a period of time the dollar value has been increased. A further step in the student funding of public education has been proposed by the Coalition parties in the 'Fightback' (1992) policy proposals. The proposal involves the provision of publicly funded National Education Awards or 'vouchers' available to students who can successfully compete for such a voucher through examination results. The HECS charge will continue but Universities and possibly University Faculties and Departments will be able to rebate or impose a surcharge on the HECS fee. In addition, the income contingent loans scheme will also continue and could potentially be used as a means for students to borrow the difference between the value of the vouchers and the fees actually charged by universities. These changes then make possible price discrimination on the basis of the demand by individuals for a particular degree program. It is a change which moves the system a little closer to a market based pricing system. Significant, however, is the fact that the government contribution through the voucher is not proposed to be based on the value of a particular educational program to the public or the country as a whole but rather it is likely to be based on what is known as the 'relative funding model' or more simply the national average cost of production at a historical point in time for various sets of degree programs (Dr David Kemp, presentation to Heads of Department, University of Sydney, North Head, 3 November 1992).

The objective of this paper is to identify some of the implications for the operation of a University Department of the introduction of a voucher system for the funding of education. The particular focus is on the area of agricultural economics education and therefore on what may happen to small sized departments. In the case of agricultural economics departments they are usually small, require considerable input from other department's teaching programs and are producing graduates who enter a very wide range of professional areas on graduation. In some cases, they are in effect supplying the educational needs for a segment of the market in which the students with the higher tertiary entrance ranks enter the areas of agricultural science, economics and accounting and a portion of those who cannot meet the quotas for these disciplines enter agricultural economics programs. In addition, agricultural economics education is in some cases linked to degree programs in agricultural science rather than specific degrees in agricultural economics. Agricultural economics as a discipline therefore fills a rather special niche in the market for educational opportunities.

In a broader context, the issue of the nature of the training provided is considered in the context of a university product which is not professionally based in the same way as medicine, veterinary science or accounting but is discipline based and founded in the two areas of agriculture and economics and with a strong orientation toward applied economics.

The Current Tertiary Funding System

As indicated above, the tertiary education sector has been subject to a major policy shift with the re-introduction of fees and in the future may be subject to further development concerning the way in which the government contribution to the funding of education is paid. These shifts would seem to be toward trying to develop a better balance between what the individual student contributes in relation to the private and public benefits of education. In this section the nature of the current system will be considered. The proposed voucher system will be discussed in the next section.

The key elements of interest in the current tertiary educational funding system are as follows.

- Allocation of resources to universities on a 'relative funding model'.
- Negotiation of student and staff profiles in return for negotiated funding.
- Restriction of student intake into degree programs through the use of quotas related to the student profile.
- A fixed student charge (HECS) of $2 328 in 1993 for a standard program (Australian Taxation Office and Department of Employment Education and Training 1992).
- Restrictions on additional fees for domestic undergraduate students.
- Negotiation of salaries and terms and conditions of employment through a national wage system.

- A variety of formulae and systems of negotiation for transmitting funds from the central administration of a university to its departments.

This system provides for centralised control over both the fees paid by students and the number of students that can enter a particular university. Control over the number of students entering a particular university is through the limitation to funding based on the negotiated profile so that over-enrolments by universities are not funded by the government. When demand for the number of funded places exceeds the supply it becomes incumbent on universities to introduce some form of quantitative restrictions on enrolments, usually in the form of quotas. The key management variable remaining for department managers within such a system is the number of staff employed, and as a consequence, the teaching loads (students per staff member or equivalent full-time student units or EFTSU per staff member). This assumes that department managers do not see gains in under fulfilling the student quotas or downgrading the quality of the education through reduced teaching input and restructured degree programs. Given that staff promotion criteria and, to some extent, the earning of additional funds which can be used in more flexible ways are based on research reputation and output there may be an incentive to gradually downgrade the effort put into teaching.

The Voucher Proposal

Early voucher systems for the funding of education were proposed by Milton Friedman (1962) and others. The focus has been largely on primary and secondary education (Mecklenburger and Hostrop 1972). A review of proposals discussed in the Australian context has been provided by Blandy, Hayles and Woodfield (1979). Much of the literature on the question of vouchers for education has been related to concerns about equity and access and analysis designed to overcome some of the perceived problems. A number of modifications and adjustments to the basic scheme have been proposed. Suggestions include vouchers of different value depending on income and levels of disadvantage. These issues will not be considered in detail in this paper.

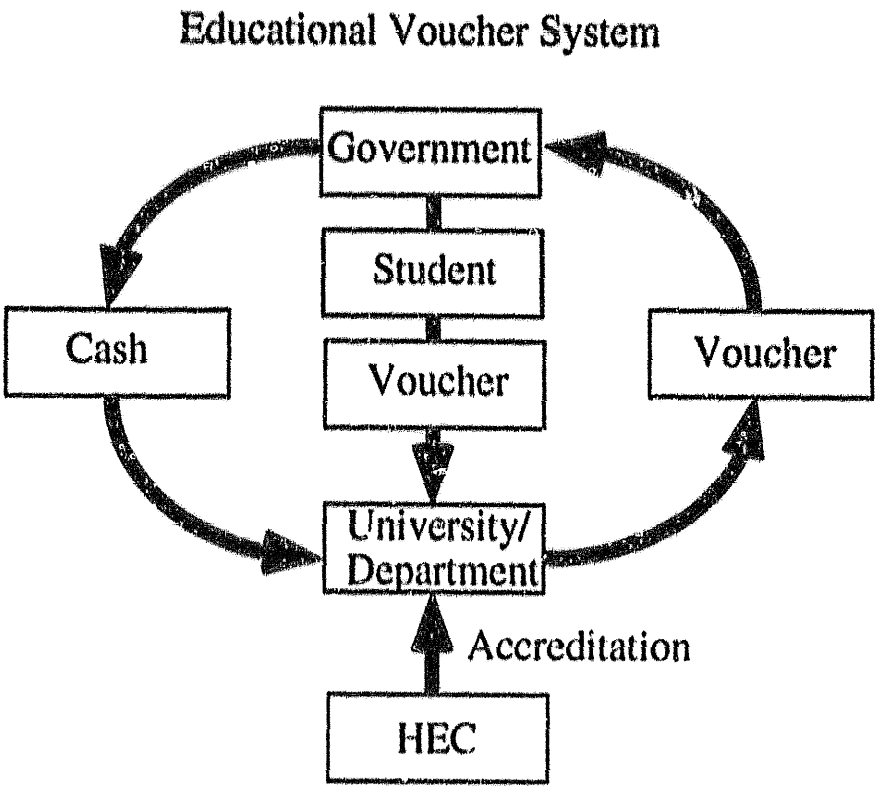

Figure 1 — Stylised Representation of a Voucher System

The basic design of the voucher system proposed by the Coalition Parties in the 'Fightback' policy proposals is of interest. National Education Awards, as the vouchers have been termed, will become the major source of funding for the university system should the Coalition's policy be adopted. The basic proposals are as follows (Liberal and National Parties, 1992).

- National Education Awards will be awarded to individual students on merit within States but tenable at any accredited institution in Australia.
- Awards will be available for part-time and full-time study.
- Awards will be tenable for their full value at accredited institutions.
- Institutions may offer places to students not in receipt of awards.
- Institutions will have the right to vary the student charge by setting course and institutional fees.
- HECS, with a discount rate of 25 per cent for up-front payment, and loan arrangements will be available.
- Institutions will be free to offer places in courses as they choose (controls will be placed on medical places).
- Enterprise bargaining and voluntary agreements will be restored to universities.

- Scholarships will be made available to accredited institutions.
- The value of a voucher will be determined by the relative funding model with different values for different degree programs.
- Vouchers may be either of value for the approved length of a degree program or for six years (which alternative might be adopted seems unclear at this stage).
- Establishment of a Higher Education Commission to advise the government on university accreditation and funding.

A number of issues relating to some of the finer details of the proposal appear to be unresolved. These include details on the funding of postgraduate study, although there would seem to be a clear intention that postgraduate funding also be included in the voucher system. Nor has the length of the life of the voucher been clearly specified, although it has been suggested that it could be for the period of the recognised degree program or possibly for a maximum of six years. Capital funding is also not entirely clear but a component of the voucher will be designed to provide for capital funding. The funding of over quota student enrolments already in the system at the time of the change is also a significant financial issue.

University Management of Vouchers

The implications of such a scheme for departmental managers will depend to some extent on how the vouchers are managed within universities themselves. It would seem possible to deal with vouchers within a university in a number of ways. Possible alternatives include the following:

- Centralised formula allocation;
- Central taxing of revenues with either a common or differential tax rate; and
- Central fee for service with charges based on student numbers.

A number of Australia's universities have formulae based on full-time student equivalents for allocating recurrent funding. Centrally collecting the vouchers and retaining the existing fund allocation arrangements for Departments and Faculties is one possibility under vouchers. The central administration would collect a fixed sum for the cost of the central administration and distribute the rest by formula. A disadvantage of this method is that the signals implied by students exercising their choice of degree will be reflected at the university level but not fully at the Department or degree program level. The difficulty is that changes in student numbers for the Department concerned will be blended with changes in other departments elsewhere in the university. There is thus the possibility of very significant cross-subsidisation between departments and a tendency for inappropriate expenditure decisions. This can be shown mathematically as in Appendix A. The advantage for the University administration is that it will share little of the risk of variation in student numbers.

A second major possibility is the imposition of a tax on voucher income set so that sufficient funds are generated to fund the central administrative operations of the university. Such a tax may vary between departments or categories of departments depending on criteria relating to the extent of use of the central administrative service. The advantage of such a system, as reflected in Appendix A, is that the marginal revenue from vouchers less the marginal effect of the tax is reflected directly to the managers of the degree program in which the students have chosen to use their voucher. This should lead to much more efficient decision making than in the case of the formula approach. In addition, the central administration will be subject to changes in the student numbers and will have to explicitly justify changes to the tax rate.

A third possibility which has similar consequences to that of a tax system is to charge departments for the services provided by the central administration on a fee-for-service basis or as a close approximation to a cost per full-time student equivalent basis. As reflected in Appendix A this approach also has the effect of directly transmitting the marginal return less the marginal cost of central administration on a student basis.

A Department as a Not-for-Profit Organisation

A considerable literature has arisen in recent years on what has become known as non-profit organisations. Hansmann (1980, p. 838) concludes that the essential characteristic of a non-profit enterprise is that it is '... barred from distributing its net earnings, if any, to individuals who exercise control over it ...'. Hansmann refers to this as the 'non-distribution constraint' and suggests that it is a reasonable response to a particular kind of market failure as a result of the inability to police producers of goods and services by ordinary contractual devices so that there is 'contract failure'. In reflecting on the object of a non-profit organisation Hansmann also suggests that such organisations are there primarily to protect the interests of the organisations 'patrons' from those who control the organisation.

With the recognition of the role of non-profit organisations such as hospitals and public broadcasters came a recognition that educational organisations such as universities and publicly funded schools also have some of the characteristics of non-profit organisations. As James and Neuberger (1981, p. 586) suggest a university department can be considered to be a non-profit organisation producing multiple outputs and managed as a labour cooperative. They suggest that staff in a department are typically engaged in a mixture of production (of undergraduate training) and consumption (research and postgraduate training) activities so that both the theory of the firm and the household are relevant. They also suggest that faculty members teach large and profitable undergraduate classes to '... obtain the resources for costly utility-maximising activities that society will not fully and directly subsidise, i.e.

research and the teaching of small classes.' James and Neuberger also point out that a collective non-profit organisation faces various difficulties in decision making including intransitivities and free-rider problems which are not encountered in bureaucratic non-profit organisations because they tend to have a sing' .nanager in direct control.

A university department might be considered to operate with a variety of different objectives. That proposed by James and Neuberger (1981) includes both the number of undergraduate and postgraduate students, the quality of these studens, the value of research which is also a function of teaching load and the overall teaching load. The objective proposed was additive in these terms. In the current Australian educational environment of quotas and government funding, the financial survival of a department would seem to be very important. This implies that the department would place a high priority on continuing to receive its budget allocation. Amalgamating with other departments to form a larger entity would not be excluded as a possibility in this context. In trying to translate this objective into more measurable terms this would seem to imply maximisation of next year's budget allocation to the department from the faculty or the university administration given that this year's allocation has already been made. Since student commencements are generally limited by some form of quota the means to increase student numbers entering the degree programs of a department are generally limited, except for the possibility of full-fee domestic or overseas post-graduate programs. Thus, the revenue side of a department is largely out of the control of a department manager so that in attempting to reach a budget target cost minimisation will be the focus of attention and this will largely be directed toward staffing costs.

As James and Neuberger (1981) reflect, and what is also consistent with the literature for non-profit organisations, departments may also have other goals such as the intake and graduation of high quality students, the graduation of the maximum number of students possible, the production of an expanding volume of high quality research and possibly simply a goal of getting bigger in terms of staff numbers. All of these goals can be directly or indirectly linked to the budget because they imply a cost and therefore the goal of maximising next year's budget allocation has been chosen as a reasonable proxy for expressing the goal of a university department in the current educational environment. It is recognised that, in choosing to make use of budget allocation as an objective, this implies a set of weights on certain inputs and outputs which may not properly reflect the goals of a department. For example, the way in which the quality factor is reflected in the budget will only be through the gains to the budget of higher graduation ratios and improved progression rates and possibly through an ability to reduce costs of teaching through attracting higher quality students. The additional satisfaction that staff in a department gain by working with higher quality students is not reflected in a budget based objective function. As will be examined later it is quite likely that under a voucher system the objective for a university department will be different.

Single-Period Model of a University Department with Quotas

Departments within a University have a number of the characteristics of a central planning system. The budget is usually allocated on the basis of some formula which may be explicit or implicit, usually according to student numbers, and then this money is spent largely on salaries for the provision of teaching services, administration and the carrying out of research. The department manager has very few options except to adjust the number of students allowed into the program up to a quota and to change the teaching load by having the given group of staff teach more or less students. It is unlikely that a manager would not fill the quota places. For the moment, it is assumed that research activities can be treated separately from the activities of teaching and that a separate budget allocation can be made for this purpose. This is purely a simplifying assumption at this stage. It is also assumed that changing teaching load in relation to the teaching program does not necessarily mean that staff numbers are reduced, given the possibility of deploying staff on research activities funded or supported from research fund sources.

A simple model of this process can be expressed in terms of three equations which can be manipulated in a recursive fashion. The equations relate to income for next year, teaching resources and student load. Let R_{t+1} be the revenue from student fees in the following year, β the fee per student, x_t the number of students, τ the student to staff ratio, s the average salary and l_t the number of teaching staff in year t. In algebraic form the model is as follows.

(1) $R_{t+1} = \beta x_t$.

(2) $x_t = \tau l_t$

(3) $l_t = B_t/\sigma$

If some approximate numbers were given to the parameters of the model, so that β is \$5000 per student, the budget allocation B for teaching is say, \$750,000, the average salary, σ, is \$80,000 and the teaching load τ, is 20, then the model becomes:

Problem 1:

(4) $R_{t+1} = 5000.0\, x_t$

(5) $x_t = 20\, l_t$

(6) $l_t = 750000/80000$.

The solution to the three simple equations is for an income for next year of \$937,500, a total of 9.38 teaching staff and an intake of 187.5 students. There is no maximisation of an objective function in this process, simply a recursive calculation given the budget allocation, the average salary, the specified teaching load and the earnings per student. Of course, the Department may be subject to the additional restriction of a quota on student intake and therefore implicitly on the total students. In the case of this solution being within quota the Department is teaching sufficient students per staff member to earn enough in student payments to expand the budget for the following year by \$187,500 or the equivalent of 37.5 students or 1.88 staff positions.

If the teaching load were to be reduced to 16 then this year's budget would be equivalent to next year's budget with 150 students and 9.375 staff positions. The pivotal number in this system is the teaching load and the consequent effect on the number of staff required to teach the current number of students who can be taught within the current budget. An increase of 1.0 in the student teaching load brings \$46,875 to the budget in the following year because it allows both a decrease in the staff and an increase in the student numbers on which next year's budget is based.

If the problem is now transformed into a constrained maximisation problem rather than a set of simultaneous equations some further insights into the operation of a department can be obtained. It is now assumed that the objective function is to maximise the budget allocation for next year and that this budget allocation is based on the student numbers enroled this year. Also it is possible that not all of the budget will be used and that not all of the staff resources will be used. Using linear programming the problem may be formulated as:

Problem 2:

(7) $\quad \text{Max } R_{t+1} = 5000\, x_t$

subject to

(8) $\quad x_t - 20\, I_t \leq 0$

(9) $\quad 80000\, I_t \leq 750000$

(10) $\quad x_t,\ I_t \geq 0$

The solution to this single period problem is identical to that for problem 1 and this is true for other student to staff ratios as well.

If the objective for the Department is now changed to one of net return maximisation so that the Department manager is assumed to behave in a way analogous to a competitive firm then the following problem is formulated:

Problem 3:

(11) $\quad \text{Max } 5000\, x_t - 80000\, I_t$

subject to

(12) $x_t - 20\, l_t \leq 0$

(13) $80000\, l_t \leq 750000$

(14) $x_t, l_t \geq 0$.

At a teaching load of 20 the net return from operation of the department is $187,500 with the same student numbers and teaching staff as in problem 1. If the teaching load is changed to 15 then the optimum solution is to shut the department down with $x_t = 0$ and $l_t = 0$.

Although in net terms a loss may be being made it may still pay to stay in operation in terms of maximising next year's budget. Even if managers of departments within universities only partially maximise next year's budget and are concerned about budget overruns there is an incentive to either increase the teaching load (with all the issues of quality involved) or to run a net loss in the hope that some case can be made to alleviate the loss (the soft budget constraint of the central planning systems).

Single-Period Model of a University Department with Vouchers

Consider next, the possibility that a voucher system of payment is introduced. A number of difficulties arise with the formulation given above. To include a voucher system it is necessary to make a number of assumptions about the way in which the voucher system will operate. First, it is assumed that with the introduction of the voucher system a department or university will be free to add to or rebate the funds provided in the voucher. Thus, in effect, the student will pay part of the total fee and the government another part which is made available to universities through the cashing of the voucher. The term 'fee' in subsequent parts of the paper refers to the student's contribution.

Given that the central administration of the university must be funded it is thus assumed that either a revenue tax or a fee-for-service type tax will be imposed on the revenue of the system. Thus the revenue gained by the department will be subject to these taxes but the number of students commencing will be determined by the fee actually charged by the university over and above the value of the voucher. It has been suggested that the voucher will be worth about 75 per cent of the standard fee and that the HECS system yment with its loan arrangements will be used for the remainder. It is assumed also, that the fee must be set and adhered to for the given year. The department thus has a considerable degree of uncertainty to resolve as to the nature and position of the demand curve it faces for commencing students. It will be assumed that the department manager has complete knowledge of the demand function and that it is reasonably approximated by a linear function. It will also be assumed that the fees charged in a given year will be applied to all students in the degree program (assumed to be four years long) and that the level of the fee charged does not change the number of students already in the degree program—it only affects those entering the program.

Once it is assumed that the department faces a demand relationship and a split source of revenue from vouchers and fees the management objective of the department must change from that of maximising next year's budget allocation by adjusting teaching load, through changes in staffing or commencing students to, in addition, attempting to set fees so as to maximise its objective function. This is a rather fundamental change in the nature of the management of a university department. It will involve managing an additional variable which affects the income available to hire staff. It also implies that the budget for the department cannot be determined until the additional variable factor of the fee has been determined.

A simple, single period model maximising the net income position of a department can be written as follows:

Problem 4:

(15) Maximise $[(V_t + F_t)(1-t)]x_t + [(V_t + F_t)(1-t)]K_{t-1} - \sigma I_t$

subject to

Student numbers balance constraint

(16) $K_t + q_t = K_{t-1} + x_t$,

Graduation numbers constraint

(17) $q_t = \gamma(K_{t-1} + x_t)$,

Commencing numbers demand

(18) $x_t = \alpha - \beta F_t$,

Student/staff ratio constraint

(19) $K_{t-1} + x_t = \tau I_t$.

where V_t is the cash value per student of the voucher, F_t is the cash value of the fees charged over and above the value of the voucher, t is the revenue tax rate for central administration costs, K_{t-1} is the number of students in the degree program at the beginning of the year, σ is the average salary rate, I_t is the number of staff, x_t is the number of commencing students, q_t is the number of completing or graduating students, γ is the graduation ratio (that is proportion of the total number of students who graduate), α and β are the usual coefficients on the demand for commencing student places, and τ is the student to staff ratio.

The first term of the objective function for the model is the revenue obtained from the fees charged and the voucher income less the central administration tax from the commencing students, the second term is the income from vouchers and fees obtained from the existing students. The final term is the salary costs for teaching staff. Other fixed overheads might have been included but they do not affect the solution and must be covered from the net cash income earned.

The first identity is the stock flow balance for student numbers relating the closing numbers still in the program and the graduating students to the opening numbers in the program and commencing students. It will be noted that such an identity introduces an inevitable set of dynamic factors into the model. It also means that optimization over a single time period is likely to be unsatisfactory and that to have such a model operate, starting and closing values will be required which reflect the size of the operation. Therefore, one consequence of the voucher scheme may well be a need for much longer term planning and the strategic setting of a time path for fees in relation to specific disciplines. The second constraint can be considered a grossly simplified form of the educational production function where students are the inputs and graduates are the output. To keep the model very simple it is assumed that a fixed proportion of the total number of students in the program graduate. The third relationship is the demand relationship for commencing places and the final relationship is also part of the educational production function, again in a very simplistic form in specifying the fixed ratio, τ, between students and staff. The model is a very rigid model but sets the basic structure for more sophisticated models and also permits some insights to be obtained into some of the consequences of a voucher system.

Some simplification can be achieved by substituting out q_t and x_t and then forming the Lagrangian function as follows:

$$\text{(20)} \quad \begin{aligned} L = {} & (1 - t)(F_t + V_t)(\alpha - \beta F_t) + (1 - t)(F_t + V_t) K_t - \sigma I_t + \\ & \lambda_1 (K_t - (1 - \gamma)(K_{t-1} + \alpha - \beta F_t)) + \\ & \lambda_2 (\tau I_t - K_{t-1} - \alpha + \beta F_t) \end{aligned}$$

$$\text{(21)} \quad \partial L/\partial F = (1 - \gamma)\beta \lambda_1 + \beta \lambda_2 + (1 - t)[(\alpha - \beta F_t) + K_{t-1} - \beta (F_t + V_t)] = 0$$

$$\text{(22)} \quad \partial L/\partial I = \tau \lambda_2 - \sigma = 0$$

$$\text{(23)} \quad \partial L/\partial \lambda_1 = - (1 - \gamma)(\alpha - \beta F_t + K_{t-1}) + K_t = 0$$

$$\text{(24)} \quad \partial L/\partial \lambda_2 = -\alpha + \beta F_t + \tau I_t - K_{t-1} = 0$$

The first order conditions for a maximum are given in equations (21) to (24). Essentially the problem with a linear demand relationship for commencing places is a quadratic maximisation problem subject to a set of linear constraints. Taking as given the values for the parameters and the starting number of students, K_{t-1}, and ending numbers, K_t, then the following solutions are obtained.

(25) $\bar{F}_t = (\alpha + K_{t-1} - K_t/(1-\gamma))/\beta$,

(26) $\bar{T}_t = K_t/\tau(1-\gamma)$,

(27) $\bar{\lambda}_1 = -2(-\alpha - K_{t-1} + K_t/(1-\gamma))(-1+t)/\beta(1-\gamma) - \sigma/((1-\gamma)\pi) + (1-t)(-\alpha - K_{t-1} + \beta V_t)/(\beta(1-\gamma)$,

(28) $\bar{\lambda}_2 = \sigma/\tau$.

Of most interest is the determination of the level of the fee over and above the value of the voucher. It is apparent that the optimum fee is not a function of the value of the voucher, V_t (equation (25)). It is a function of the demand function parameters and the starting and ending numbers of students. Possibly most important, it is also a function of the graduation ratio. The impact of investing resources to change the graduation ratio under a wide range of conditions will lead to the possibility of reducing the optimal fee. In a non-profit organisation this is one of the potential uses of the profits earned. Thus

(29) $\partial F/\partial\gamma = -(\alpha + K_{t-1})/\beta(1-\gamma) - (\alpha + K_{t-1} - K_t/(1-\gamma))/(1-\gamma) < 0$

when $K_t < \mu(K_{t-1} + \alpha)$ where $\mu = (1+\beta)/\beta(1-\gamma)$ which is always greater than 1.0, that is when the intercept of the demand function plus the opening numbers of students magnified by the term μ is greater than the closing number of students. This is generally likely to be the case unless the numbers in the department were planned to grow extremely rapidly. Even then the possibility exists that $\partial F/\partial\gamma$ could still be negative. It will always be true that when numbers are declining an increase in the graduation ratio will allow the optimal level of fee to be reduced. The important implication is that management of the graduation ratio and progression from one year to the next will be very important in an ability to set a competitive fee structure. This then leads to the conclusion that there will be significant pressures to lower standards to increase the graduation ratio. However, if commencing students become aware of lowered standards the demand function may be shifted to the left and α is reduced. The extent of this shift with a lowering in standards will be of considerable interest to departmental managers. The impact on the optimal fee of a change in α is given by:

(30) $\partial F/\partial\alpha = 1/\beta$

so that if $\beta > 0$ then $\partial F/\partial\alpha$ will be greater than zero and a shift outward in the demand makes possible an increase in the optimal fee and vice versa. An interesting side issue is the extent to which advertising and promotion should be used to shift the demand function outward. On of the implications of such a voucher system is that advertising and promotion will have a much direct impact on the operations of a department than previously. Advertising and promotion also become another possibility fore using earned profits.

Another implication to be drawn from the relationship determining the optimal fee is that it does not depend on the salary costs. Changes in the salary cost will only affect the final level of the cash surplus and not the optimal level of the fee. The determination of the optimal staffing level of the department is given in equation (26) and is a function of the opening number of students and an inverse function of the continuation rate and the student to staff ratio. Again, pressure will be put on continuation rates to be as low as possible so as to keep staffing costs to a minimum.

Next it is possible to explore the situation in which vouchers are not an alternative in the model and quotas are used along with fixed fees. In this case V= 0 and $\beta = 0$ so that the student commencing quota is reflected by the previous intercept of the demand function α. When this is done the variables in the system become the number of staff and the shadow value on the second constraint. If the number of graduating students is a constant proportion of the total number of students and there is a quota on commencing students then the identity (16) must hold and the shadow value disappears as there are no endogenous variables in the identity. The solution to the model in this case is as follows:

(31) $\quad l_t = (\alpha + K_{t-1}) / \tau$,

(32) $\quad \lambda_t = \sigma \cdot \tau$

The implication of this result is that with the fee given and fixed by the government, with student commencement quotas and a given number of students beginning a year then the only decision variable for a department manager is the level of staffing and the related student to staff ratio τ. This implies that the manager is cost minimising on salaries. Where it is also possible to adjust the graduation ratio downwards then this can be seen as increasing the number of students in the program for the following year and hence potentially increasing next year's budget allocation. With these changes the model collapses to something close to that of Problem 3 or a budget maximising model.

Another perspective on the model is given in diagrammatic form for a given time period in Figure 2. The heart of the model is the identity (16) which allows specification of the graduation rate of students and the graduation numbers. Panel a has, on the vertical axis, the opening number of students for period t, K_{t-1}, plus the commencing students represented by x_t. On the horizontal axis is represented the closing stock of students still in the degree program, K_t, and the number of graduating students, q_t. The graduation ratio, which is the ratio of the number of graduating students to the total stock of students and is reflected in the slope of the line bc. Using this line the total number of students in the degree program can be divided into graduating students, ed, and continuing students, ac. A graduation ratio of something less than 0.25 would be expected for a four year degree program after taking into account the failures that take place during the degree. In panel b, the demand by students for a place in the degree program is reflected. It is assumed that a department will set the fee scale, F_t, for a given year and that the number of students commencing at that fee will be x_t. The revenue from the commencing students and the continuing students is given in panel c. As a linear demand relationship is used the revenue from commencing students is a quadratic function of commencing student numbers and to this must be added the revenue from the students already enroled. The total revenue can be read off the horizontal axis of panel c.

The student to staff ratio used is reflected in the slope of the line in panel d, and this ratio can be used to determine the number of staff, l_t, required to teach the total student group, $K_t + q_t$. In panel e the trade-off between changes to the fee set by the department and the number of staff required at the given student to staff ratio. Finally, panel f contains the salary cost relationship from which the total salary cost can be read off the C_t axis. A comparison of the difference between the total costs and total revenue gives the net position of the department. It is easy to see that if the student to staff ratio is low then salary costs will be high and the possibility of a cash deficit is likely. As well, if the fee were to be set too high commencing student numbers would be low, total students would be low and so both revenue and costs would be down assuming the staff numbers could be adjusted to the given staff/student ratio. If the graduation ratio is increased this means it is possible to increase next year's commencing student numbers by setting lower fees while at the same time keeping total student numbers at a similar level. It is also apparent that with a linear demand function that revenue from commencing students plus continuing students will be a quadratic function of the total number of students (panel c).

As in the case of the algebraic model it is possible to reflect the situation of quotas and set per student payments to the department by dropping the panels b and e in Figure 2 and redrawing it with a linear revenue relationship because of the fixed per student amount paid to universities by the government (Figure 3). It is apparent from such a diagram that provided the student to staff ratio is appropriate, given the average salary cost then expanded numbers will generate a budget surplus. Thus, under a quota system where quotas are effective it is likely that there will be considerable incentives for expansion in student numbers. Whereas, in the case of Figure 2, there is a point where expanding numbers decrease revenue as a result of the demand function for commencing places.

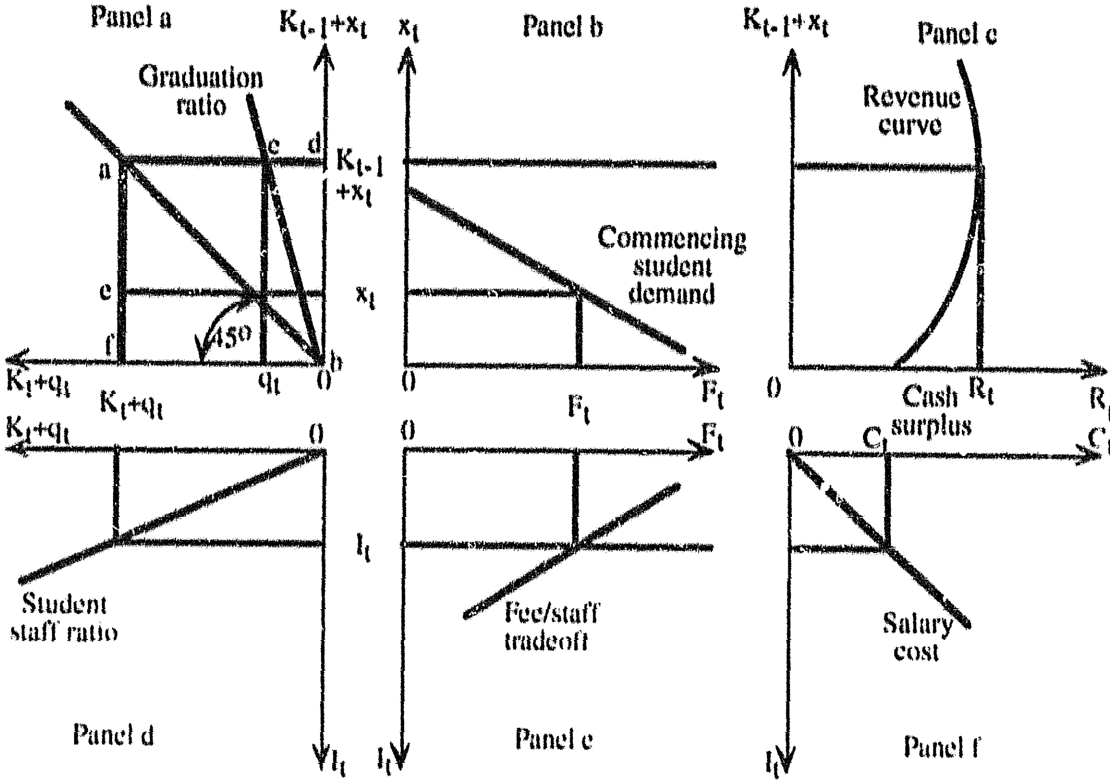

Figure 2 – Graphical Representation of a Department under Vouchers

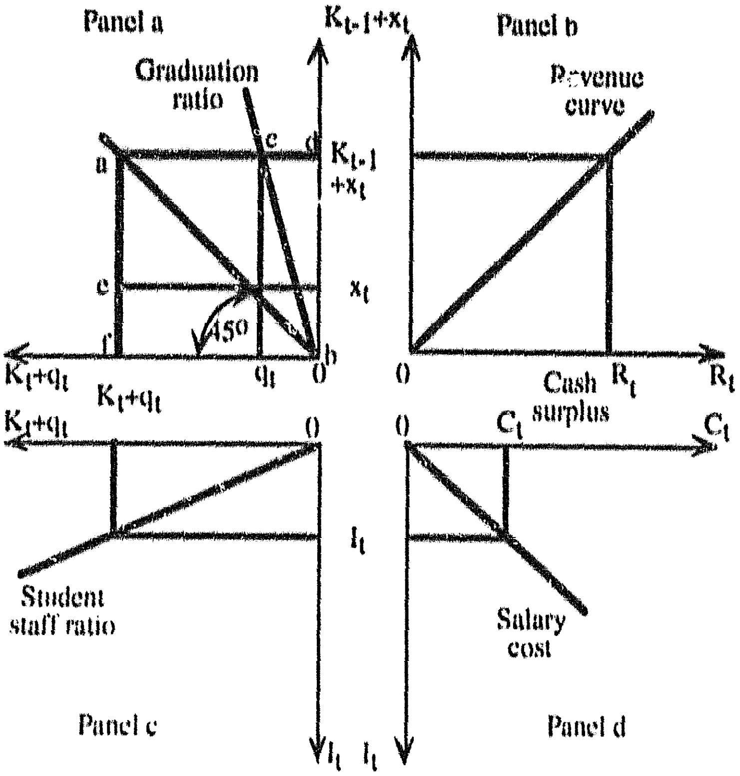

Figure 3—Graphical Representation of a Department under Quotas

A Multi-Period Optimization Model under Vouchers

The simple model illustrated above highlights the importance of teaching load and graduation ratios. In addition, the work by James and Neuberger (1980) highlights the significance of a university department as a non profit organisation. Essentially this means, as Jenkins and Austen-Smith (1987) note, that profits may be made but that they are not distributed as dividends to shareholders. If profits are made in a university department James and Neuberger argue that they will be used to subsidise 'consumption activities' such as research and teaching of post-graduate or senior level students. Thus, in developing a more realistic model of a department it is essential to include research as an activity which can use the surplus generated in the teaching program. It is also important to impose the constraint that at the end of the planning horizon any surplus income be completely spent. To illustrate this the following model is constructed.

Consider a department in which income is earned from both teaching and research but that the income earned from research does not effectively cover the salary cost of the time involved. The funds earned from teaching and research can be used to pay staff salaries and staff can either teach or carry out research. Under the current educational system the department can roughly take its earnings per student as given. It also, can largely take its average salary as given since the wage rates are determined outside the control of the department and the only way to change the cost of staff is to hire younger staff or use part-time and casual teaching staff.

To confirm the relationship between cost and the number of staff some simple graphical and regression analyses were carried out on 19 observations on departments in the Faculty of Agriculture in the University of Sydney over the period 1989 to 1992. The average cost per effective full-time student unit was related to the size of departments in terms of the reciprocal of the student to staff ratio and also the total cost was related to the total number of staff. Both sets of regressions and graphs were supportive of a linear relationship between cost and the number of staff. On the surface it would seem that economies related to the hiring of staff do not exist, even though the departments had varying numbers of staff. What may be much more important than the number of staff is the age distribution of the staff and the related salary profile. This could not be investigated with the data available. Although it seems plausible that the greater the number of staff the fewer senior staff are needed to run a department, it may be that there is too little flexibility and exchange in the staff of universities to allow such economies to be reflected in the data. This is an area in need of much more detailed analysis and modelling so that effective cost functions for university departments can be constructed. For the purposes of this paper a linear relationship between costs and number of staff has been assumed.

In a dynamic model context there is a similar set of stock flow balance relationships to be taken into account as in the single period model outlined above. These are the student balance, the staff balance and the budget carryover relationships and account is taken of the use of staff time for both teaching and research. Thus, the following maximisation problem is taken as a simple dynamic representation of a university department. The objective function is the discounted net return where the discount factor is $\delta = 1/(1+r)$ and it includes interest on the budget surplus B_t. The terminal value added to the objective function is the discounted value of the ending budget surplus.

(15) $$\text{Maximise} \sum_{t=1}^{n} \delta^{t-1} (s(V_t + F_t)(1-\upsilon)(K_{t-1} + x_t) - \sigma l_t + \rho R_t \, r B_t - H_t) + \delta^t B_t$$

Student balance

(16) $$K_t + q_t = K_{t-1} + x_t$$

Staff balance

(17) $$l_t = l_{t-1} + h_t$$

Cash flow

(18) $$P_t = s(V_t + F_t)(1-\upsilon)(K_{t-1} + x_t) - \sigma l_t + \rho R_t - H_t$$

Staff hiring

(19) $h_t = P_{t-1} / \sigma$

Student graduation

(20) $q_t = \gamma (K_{t-5} + x_{t-4})$

Total staff time

(21) $D_t = 260\, l_t$

Teaching time

(22) $T_t = \tau (K_{t-1} + x_t)$

Research time

(23) $R_t = D_t - T_t$

Budget balance

(24) $B_t = B_{t-1} + P_t$

Commencing student demand

(25) $x_t = \alpha - \beta F_t$

where s is the share of teaching done by the department (assumes service courses supplied from outside the department). V_t is the cash value of the government funded voucher. F_t is the fee per student paid to the department from the central administration in year t, υ is the tax rate applied to revenue to fund the central administration of the university, K_{t-1} is the number of students who are continuing in the degree program at the beginning of year t, x_t is the number of students who commence the degree in year t (currently set as a quota), l_t is the number of staff at the end of the year t and who are paid an average salary of σ, R_t is the number of days committed to research for which it is assumed that the department earns ρ per page published and that it takes on average one day to produce a published page (a rather arbitrary set of numbers), H_t is a set of overhead costs for year t, q_t is the number of students graduating from the degree program, h_t is the net number of staff hired or leaving in year t, P_t is the net cash earnings of the department in year t after allowance for overheads, γ is the average graduation ratio which for a four year degree will be somewhat less than 0.25, D_t is total staff working days available in year t, T_t is teaching time in days required for the specified teaching load of μ days per staff member. It is apparent that there are a number of non negativity restrictions implicit in such a model but it will be assumed that corner solutions are not encountered. The starting values for the number of students, the number of staff and the initial research output and the initial budget carryover must also be specified. In addition, a share of teaching, s, of 0.5 can be conveniently assumed and an arbitrary student teaching time, τ, of 8 days per student used. As well, a central tax rate, μ, of 10 per cent is used and the coefficients on the demand function are α = 100 and β = 10. To operate the model an interest rate of 5 per cent was used. The input data for the model are summarised in Table 1.

TABLE 1

Selected Values for the Starting Values and Parameters

Variable	Value	Variable	Value
Starting values		Terminal values	
K_{-4} to K_0	150	K_T	150
I_0	7		
P_0	0		
B_0	0		
x_{-3} to x_0	50		
Parameter values			
r (interest rate)	0.05	s (department teaching share)	0.5
t (administration tax)	0.1	σ (\$000 average salary)	80.0
ρ (\$000 per page published)	0.3	γ (graduation ratio)	0.21
τ (teaching days/student)	8.0	V_t (\$000 voucher value)	2.0
H_t (\$000 overhead costs)	120.0		
a (demand intercept)	100.0	b (demand slope)	10.0

[a]Many of the values chosen are arbitrary and are not intended to reflect either a particular situation or a realistic situation but only to illustrate that such a model can be solved.

Solution of the model using the parameters and values given in Table 1 over 5 periods was obtained by using Mathematica (Wolfram1991). The objective function was maximised subject to the various constraints and with the key terminal condition that the number of students at the end of the period should equal 150. The preferred terminal condition which relates to the idea of a non-profit organisation would be that the cash surplus $B_T = 0$ but results for experiments with this condition could not easily be obtained because multiple solutions appeared to exist for each time period. The experiment reported therefore relates to a fixed final number of students. The charts in Figure 4 reflect the solution in which student and staff numbers are rapidly increased until the terminal condition starts to become effective and at this point research time, R_t, is greatly expanded. The pattern of fees, F_t, set reflect this growth path with fees initially decreased and then as student numbers must be limited fees are then increased.

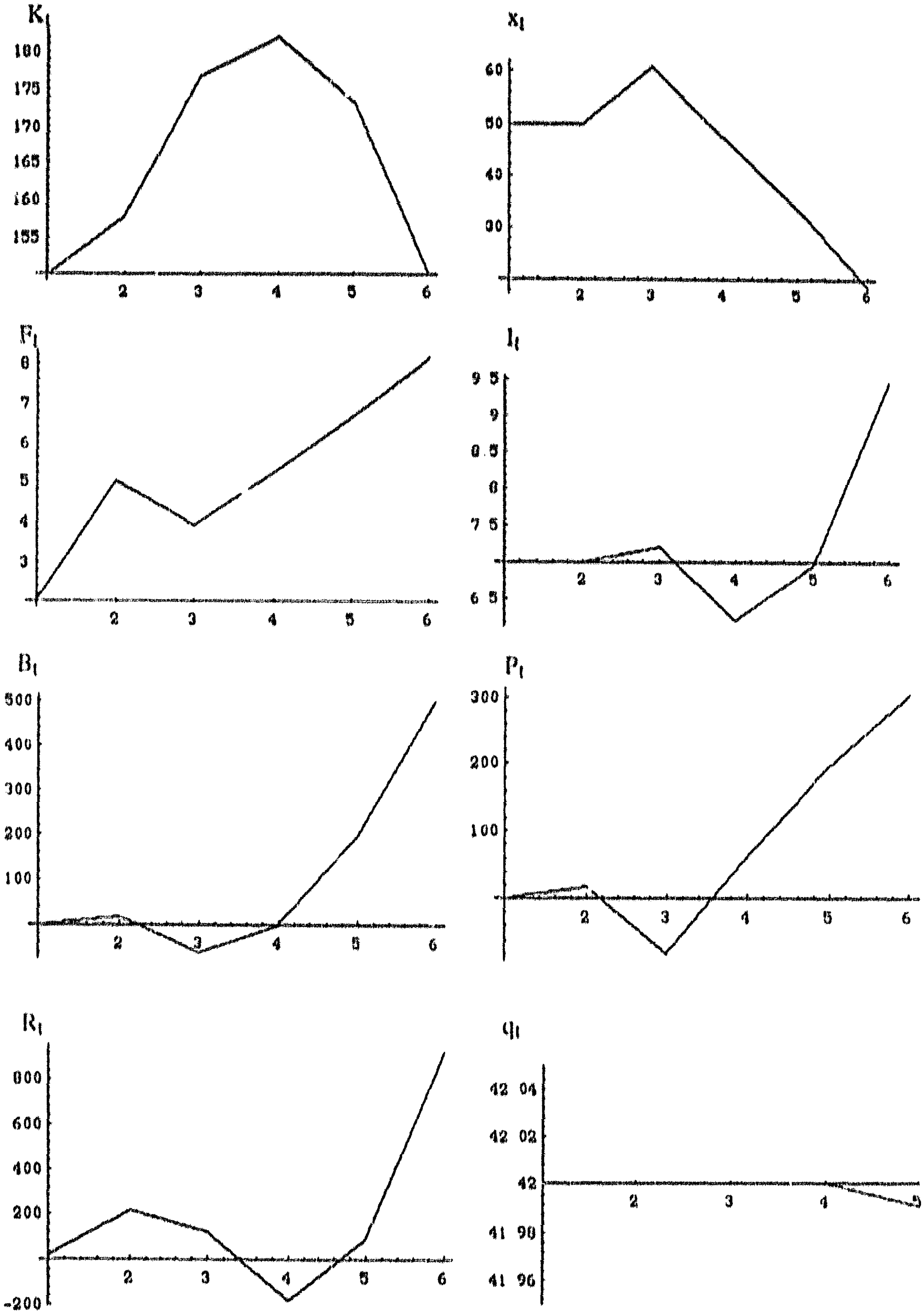

Figure 4—Results from a 5-Period Optimization of the Department Model with Vouchers

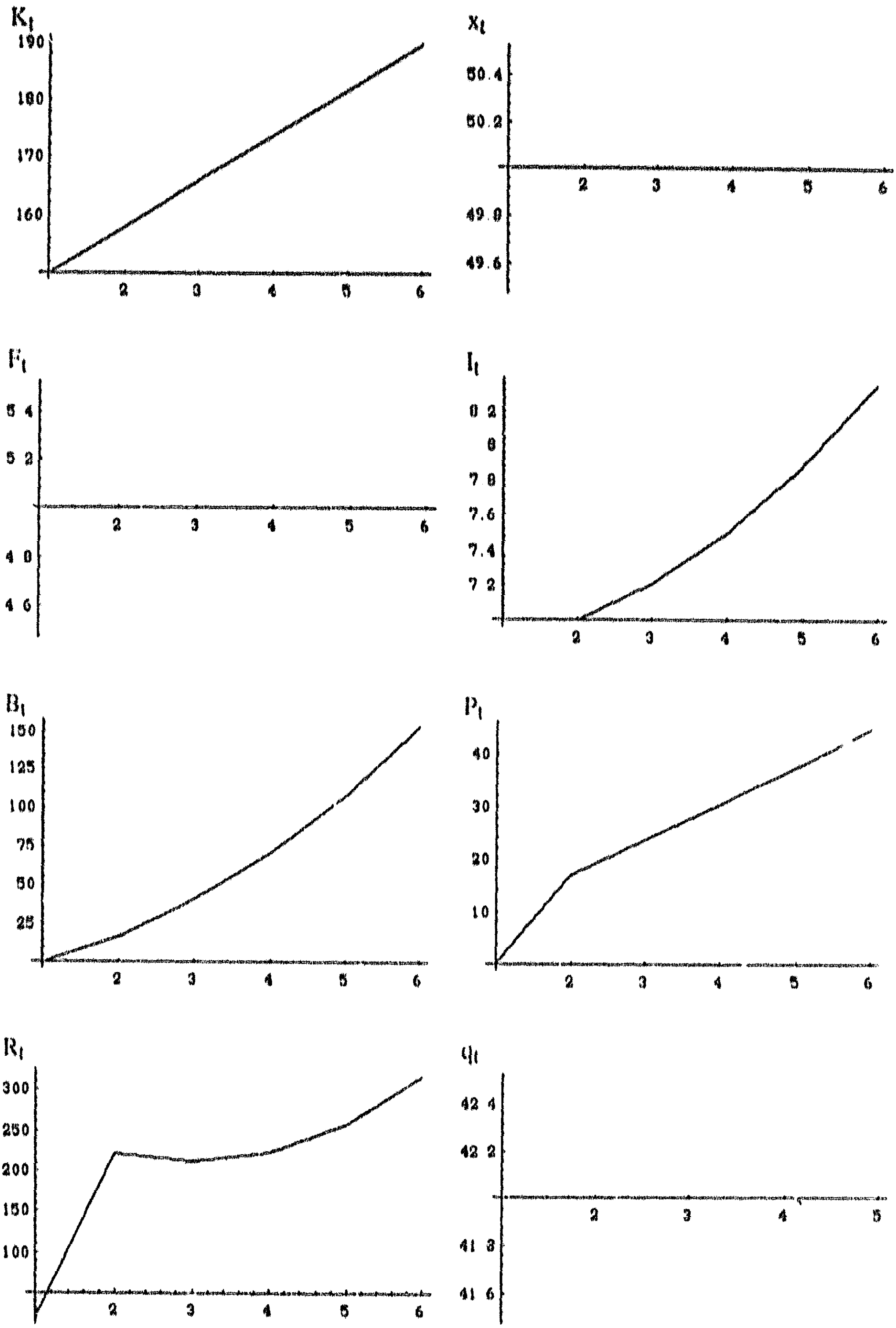

Figure 5—Results from a 5-Period Optimization of the Department Model without Vouchers

If instead of a voucher system of payment the model is modified so as to operate with a fixed commencement quota for students and no terminal student number then a significantly different outcome is obtained as given in Figure 5. Student numbers are gradually expanded from 150 to close to 190 students since the quota intake of 50 was set somewhat higher than the number of students graduating in each year of 42. As the number of staff were gradually increased through use of the previous years cash surplus then the amount of time spent on research could also increase after the teaching requirements for time had been met. These results, as in the previous sets of results, reflect the close relationship between the inflow and outflow of students and the budgetary success of the department. Because of the fixed teaching load requirement then only residual time is available to be used on research.

In essence the model is a two output model using the paid input of staff which use their time to produce research and teaching. Although it is appealing to think that the graduation ratio, γ, is a function of teaching input in terms of say, hours, there is little evidence that this is the case. It seems that rates of progression through a degree program are more likely to be a function of the characteristics of the students rather than the teaching input (Chizmar and Zak 1983). Selection of students with characteristics which improve progression rates may, of course, be one important function of the staff.

In a similar way, the manner in which examination standards are set is likely to have an important bearing on progression rates. Some preliminary work on data from the Department of Agricultural Economics at the University of Sydney also seems to provide little or no support for the notion that teaching input has an effect on the graduation ratios and the progression of students from one year to the next. A larger group of staff did not seem to imply a lower average expenditure per equivalent full-time student (Figure B.1). This may be the result of the collected data being based on a period in which it was appropriate to spend all of the allocated budget and that staff age profiles were similar in the various departments considered and also were stable. This should not be taken as conclusive evidence that it is not possible, under the right incentives, to organise a staff age profile which is has a declining marginal cost as the size of the department increases. It would seem that in an environment in which it pays to spend the whole budget allocation and to organise the staff profile to do so the economies of size are not likely to be apparent.

The reasonably simple model outlined above, in a way, reflects the basic ideas of James and Neuberger (1981) in providing for the competition for the use of staff time between teaching and research and the possibility that teaching may subsidise the research activity depending on the relative return to research and teaching. However, little account has been taken of the issue of quality and the distinction between undergraduate and postgraduate classes and the distinction between production and consumption.

Further work is required on this model to expand its size, to develop more detailed relationships for some of the parameters such as the returns to research effort and the teaching time input which is likely to change as class size changes. It is likely that an improved model could be developed in a mathematical programming environment using such software as MINOS or GAMS.

The models presented in this paper all suffer a number of limitations. They have been designed to permit an understanding of some of the central relationships driving the outcomes for a small university department. One of the potential issues which bears on this issue is the scope for differentiation of fees by courses, year or by performance. As Brennan (1988) notes, that if marginal costs differ for different groups and that these differences in margina. cost are not outweighed by 'spillover effects' then fees should differ according to the various categories. He also makes the point that unless fees are higher for the high cost courses then such courses will wither in favour of the lower cost courses. Also, a further complicating factor is the possibility that failure rates may vary with the year in the program. An expanded version of the model, which includes each student cohort could take differences in fees by year into account and thus help with an examination of the question of what is the optimal fee structure across years for a degree program. It may be that a low entry fee with heavier downstream charges could be optimal for a small department. This would be likely to be particularly true if classes are smaller in the final years and costs typically higher.

The issue of time spent on administration and how this relates to the use of staff time was not included in the model. It would seem appropriate to include it in an expanded model so that the model would, in principle have three outputs of teaching, research and administration.

In relation to departments of agricultural economics the possibility of a voucher system will bring with it the challenge of setting fees appropriately and then adjusting those fees through time. For a department to survive financially with the voucher system it is clear that rapid adjustment of parameters such as staff teaching load, class sizes, and number of staff may be required. This will imply a higher level of management skill for departmental managers than previously expected. It will also imply a better collection of information on some of the parameters in the system such as response to promotion and advertising, the effects of quality improvement on reputation, the effects of student selection on progress and graduation ratios and the nature of the cost and demand functions. Finally, a fuller treatment of the problem for the university department manager should really involve a treatment with risk. This exercise will be left for further research work.

Concluding Comment

Significant changes are again proposed for the tertiary education system following the re-introduction of fees in 1989. The proposal for a voucher system extends the flexibility of the funding of university places and would create a competitive environment between universities. This will add to the riskiness of the environment in which university managers and departmental level managers operate but will also allow greater flexibility in determining and managing the income of a department. Agricultural economics is taught in a number of universities in Australia, typically in small departments or incorporated into agricultural science degree programs. Agricultural economics degree programs are competitive for students over a range of other areas including economics, agriculture, natural resource economics, agribusiness and to a lesser extent the broad range of degree programs. In being competitive with many other degree programs the supply of students wishing to take a training in agricultural economics becomes an issue when significant sums of money are to be charged for access to university. This, of course, is related to the perceived demand by employers for the particular set of skills offered in agricultural economics programs.

In developing a set of budget based models of a university it has be shown that the transition from the current profile funded system, which includes quotas on student places, to a voucher system, department managers would be likely to lead to a change from cost minimising and adjusting staffing to setting fees and adjusting staffing so as to maximise the present and future discounted net income stream. Because of the non-profit character of university departments any net income gains cannot be distributed as dividends but must be used by the department for cross-subsidising desirable but potentially unprofitable activities such as research.

The profession of agricultural economics currently would seem to be under significant threat. As members, we are facing the re-definition of our professional area by interests out side the Australian Agricultural Economics Society and outside the traditional departments of agricultural economics. The Australian Agribusiness Association has implicitly defined agricultural economists out of the area of the business management of the food system largely because we failed to understand the nature of the business involved. The Agricultural Consultants Association has performed a similar task at the farm level but has been assisted by the transformation of agricultural extension from a government funded activity to a privately funded activity. At an educational level agricultural economists have a major battle to fight in relation to the control of curriculum with the Australian Institute of Agricultural Science which is claiming authority over the area of agricultural economics in relation to competency standards. Unless as a professional group, agricultural economists start defining the boundaries of the profession it is likely that others will define the profession out of existence. This is an urgent task and not one on which it is easy to get agreement. However, the threats are real and of vital importance to the future management of academic departments. The frameworks, concepts and the professional view of the world communicated to agricultural economics students defines the future of our profession and to a very great extent its usefulness. I believe the founders of our profession laid a solid foundation but we cannot afford to stop building and re-shaping. I believe we have paused in the development of our profession and the world has been changing around us very rapidly.

The proposal to introduce vouchers or to further refine the private funding of tertiary education provides an opportunity for the agricultural economics profession to redefine what it is about. There will be the opportunity to compete with other professional areas for the attention of students. The management of this competition will be vital to the success of departments of agricultural economics. The setting of fees, the effectiveness of publicity and the clear definition of the product being offered and its quality will all be critical in the longer term success of the profession should the voucher proposal or something similar be implemented.

The development of a more market-oriented educational system should allow small departments such as those in agricultural economics to respond to the challenges of adjusting to the needs of a rapidly changing set of sectoral forces. The down-side risk is that unless they are managed as a business in which the staffing and fee setting variables can be flexibly managed there is a greater danger of departments 'going broke'.

Appendix A

Marginal Returns to a Department under Vouchers

Assume that there are two departments (assumed to be equivalent to two degree programs) in a university in which each is subject to payment under a voucher system. Students are free to take vouchers to other universities and departments and it is also assumed that the departments are able to independently set their fees at whatever level they deem appropriate (no central control on fees). It is also assumed that each department faces a downward sloping demand function which is independent of the demand function of the other department in the university. Thus the inverted demand functions may be represented by linear functions in the number of students x_i (i=1,2) and the fee charged the student, F_i, as:

(A.1) $$F_1=(\alpha_1 - x_1)/\beta_1 \;.$$

(A.2) $$F_2=(\alpha_2 - x_2)/\beta_2 \;.$$

where $\alpha_i > 0$ and $\beta_i > 0$. The revenue available for the departments after a proportion, k, has been allocated for the central administration may be written as (A.3).

(A.3) $$R = x_1F_1 + x_2F_2 - k(x_1F_1 + x_2F_2) \;.$$

If the administrative allocation of the remaining funds, R, is made to departments in proportion to the number of full-time equivalent students the department teaches then the funds allocated to each department, FC_i, may be expressed as:

Centralised formula (C)

(A.4) $$FC_1 = R\, x_1/(x_1 + x_2) \;.$$

(A.5) $$FC_2 = R\, x_2/(x_1 + x_2) \;.$$

In the case in which the value of the vouchers is transferred directly to departments and the cost of the central administration is covered by the levying of a tax on the revenue of the department then the revenue to each department, FT_i, may be written as:

Central taxing system (T)

(A.6) $$FT_1 = x_1\, F_1(1 - t_1)$$

(A.7) $$FT_2 = x_2\, F_2(1 - t_2)$$

where t_i is the tax rate which may or may not be common for all departments. If different departments require significantly different services from the central administration then the tax rate may be set for different groups of departments.

Finally, the third case is where the administration charges specific fees for the services rendered to each department. In this case it is assumed that the fees would largely be on a per student basis. So that the funds obtained in this case, FF_i, may be written as:

Central fee for service (F)

(A.8) $$FF_1 = x_1 F_1 - k_1 x_1 ,$$

(A.9) $$FF_2 = x_2 F_2 - k_2 x_2 .$$

Using the above relationships the marginal revenue for each funding system may be derived by taking the derivative with respect to the x_i variable.

Centralised formula (C)

(A.10) $$MR_{C1} = \frac{((1 - k)(\alpha_1 \beta_2 x_1^2 - 2 \beta_2 x_1^3 + 2\alpha_1 \beta_2 x_1 x_2 - 3 \beta_2 x_1^2 x_2 + \alpha_2 \beta_1 x_2^2 - \beta_1 x_2^3))}{(\beta_1 \beta_2 (x_1 + x_2)^2)}$$

(A.11) $$MR_{C2} = \frac{((1 - k)(\alpha_1 \beta_2 x_1^2 - \beta_2 x_1^3 + 2 \alpha_2 \beta_1 x_1 x_2 + \alpha_2 \beta_1 x_2^2 - 3 \beta_1 x_1 x_2^2 - 2 \beta_1 x_2^3))}{(\beta_1 \beta_2 (x_1 + x_2)^2)}$$

The marginal revenue under the centralised formula is clearly a complicated polynomial function of the number of students in both departments. Thus, at the margin with such a formula allocation a department manager will be receiving signals confused by the changes taking place in other departments.

In the case of a tax system the marginal revenue for a department is independent of the student numbers in other departments (provided the demand relationships are separable) and dependent only on the tax rate and the number of students taking a degree in the particular department.

Central tax system (T)

(A.12) $$MR_{T1} = (\alpha_1 - 2 x_1)/\beta_1 - t_1(\alpha_1 - 2 x_1)/\beta_1$$

(A.13) $$MR_{T2} = (\alpha_2 - 2 x_2)/\beta_2 - t_2(\alpha_2 - 2 x_2)/\beta_2$$

As with the case for the central tax system the fee for service system will also return a marginal return to the departmental decision maker which is independent of the actions of other departments.

Fee for service system (F)

(A.14) $$MR_{F1} = (\alpha_1 - 2\,x_1)/\beta_1 - k_1$$

(A.15) $$MR_{F2} = (\alpha_2 - 2\,x_2)/\beta_2 - k_2$$

It is worth noting that the marginal revenue for a department in which there was no requirement to fund a central administration would be equal to the first term in each of the equations (A.12) to (A.15).

Appendix B

Departmental Expenditure Per EFTSU in the Faculty of Agriculture, Sydney University

Data are regularly published by the University of Sydney on the expenditure per equivalent full time student unit, total staff numbers and the total expenditures of departments. These data were used to prepare Figure B.1 and the associated regression equations. It is worth noting that a plot of total expenditure versus staff numbers also reflect as reasonably straight line.

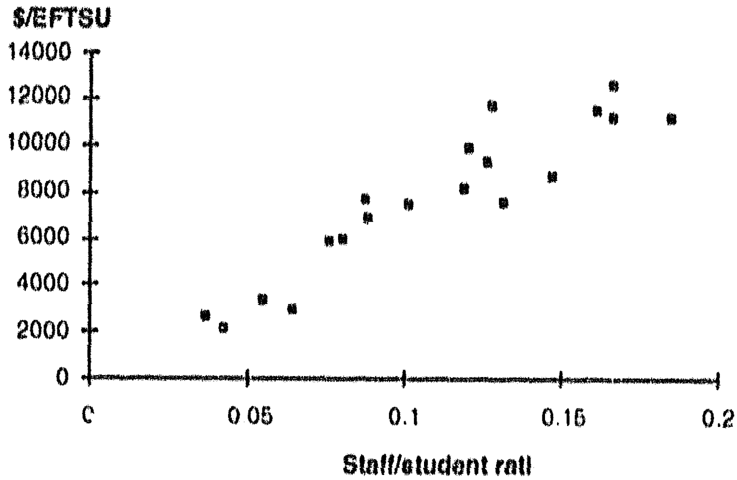

Figure B.1 Expenditure per EFTSU (real) for Departments in the Faculty of Agriculture, University of Sydney, 1989-92.

The regression relationship for the data used in Figure B.1 is as follows (t-values in parentheses):

$$C/E = 0.01196 + 1.268 \times 10^{-5} (1/SSR)$$
$$(1.18) \qquad (10.48) \qquad R^2 = 0.87 \qquad \bar{R}^2 = 0.86$$

A total of 19 observations of four each on five departments over the period 1989 to 1992 were used. C/E is the expenditure per equivalent full-time student (EFTSU) and SSR is the student/staff ratio.

References

Australian Bureau of Agricultural and Resource Economics (1992), *Commodity Statistical Bulletin*, Canberra.

Blandy, R., Hayles, J. and Woodfield, A. (1979), 'The economics of education in Australia, 1962-1977,' Ch 3 in Gruen, F.H. (ed), *Surveys of Australian Economics*, Vol. 2, George Allan & Unwin, Sydney.

Blaug, M. (1968), *The Economics of Education*, Vol. 1, Penguin Books, Baltimore.

Brennan, G. (1988), 'The structure of tertiary education fees', *Economic Analysis and Policy* 18(2), 149-170.

Australian Taxation Office and Department of Employment Education and Training (1992), *HECS: Your Questions Answered*, Australian Government Publishing Service, Canberra.

Chizmar, J.F. and Zak, T.A. (1983), 'Modeling multiple outputs in educational production functions', *American Economic Review* 73(2), 18-22.

Dawkins, J. (1987), *Higher Education: A Policy Discussion Paper* (the Green Paper), Australian Government Printing Service, Canberra.

Fox, K.A. (1972), *Economic Analysis for Educational Planning: Resource Allocation in Nonmarket Systems*, Johns Hopkins University Press, Baltimore.

Friedman, M. (1962), *Capitalism and Freedom*, Chicago University Press, Chicago.

Hansmann, H.B. (1980), 'The role of nonprofit enterprise', *The Yale Law Journal* 89(5), 835-901.

James, E. and Neuberger, E. (1981), 'The university department as a non-profit labor co-operative', *Public Choice* 36(3), 585-612.

Jenkins, S and Austen-Smith, D. (1987), 'Interdependent decision-making in non-profit industries: a simultaneous equation analysis of English provincial theatre', *International Journal of Industrial Organisation* 5(2), 149-74.

Liberal and National Parties (1992), *Fightback*, Supplementary Paper No. 4 Canberra

Mecklenburger, J.A. and Hostrop R.W. eds (1972), *Education Vouchers: from Theory to Alum Rock*, ETC Publications, Homewood, Illinois.

Smart, D. (1990), 'The Dawkins 'reconstruction' of higher education in Australia', *Education Research and Perspectives* 17(2), 11-22.

Wolfram, S. (1991), *Mathematica: A System for Doing Mathematics by Computer* (2nd edn), Addison-Wesley, Redwood City, California.

Wran, N. (1988), *Report of the Committee on Higher Education Funding*, Australian Government Printing Service, Canberra.