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Research Payoff in an Imperfect Market: The Case of Animal Disease Vaccine in Australia

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A monopolistic market is developed for assessing research benefits in an input market. The model can be applied to the market for animal disease vaccine in Australia. Given a set of hypothetical data, the results with outcomes for a monopoly are compared with those for a competitive industry. The empirical results show that increases in net producer and societal gains are larger with a monopoly than with a competitive market. The paper argues that since the market for animal vaccine in Australia is probably not competitive, the use of a competitive model for assessing research benefits in that market could lead to underestimation of both producer and social benefits

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This paper arises from a project which was initiated and managed as one of several ex-post evaluations being undertaken by the Institute of Animal Production and Processing (IAPP) CSIRO, and its Division of Animal Health. The project is co-ordinated by Dr Jim Johnston, Manager (Policy, Planning and Evaluation) in CSIRO.

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Introduction

Market models have been widely used for measuring the size and the distribution of benefits from cost-reducing agricultural research. Research benefits are often assessed at the farm level using partial-equilibrium competitive frameworks. Appraisal of research benefits for an input market was first undertaken by Freebairn, Davis and Edwards (1982) and was further developed by Alston and Scobie (1983) and Holloway (1989). These models assume that the market for inputs is perfectly competitive.

It might be reasonable to treat commodity markets as perfectly competitive due to the atomistic nature of these markets. However, there are grounds for challenging the competitive assumption for the input supply and marketing sectors (see for examples: Barber, 1973; Breimyer, 1976; Parker and Connor, 1979). In the input-supply and marketing sectors, market imperfection arises as a result of market concentration, the effect of government-granted monopoly (e.g. the development of a system of patents), economies of size and the effects of uncertainty. The main form of competition may not be the extreme of a monopoly but rather imperfect competition and oligopoly. However, there is no generally accepted price formation model for either of these (Freebairn, Davis and Edwards, 1982). Many price markup rules exist for imperfect markets. A common procedure is to set output price at some percentage above variable costs. For a monopoly, market price may be determined at the profit-maximising level at which marginal revenue equals marginal cost.

In this paper, a closed-economy monopolistic model is developed for assessing the economic benefits from cost-reducing research. The model may be applied to the market for animal disease vaccine in Australia. Hypothetical data associated with this vaccine market are used for the empirical appraisal. The results with outcomes for a monopoly are compared with those for a competitive industry. The results and implications of this study are reported in the final section of this paper.

The Analytical Framework

In this section, welfare effects of research which shifts down the marginal cost curve for a monopolistic firm are examined (see Figure 1). The downward-sloping demand curve is represented by D, the marginal revenue curve by MR and the upward-sloping marginal cost curve by MC. The demand, the marginal revenue and the cost functions are assumed to be linear. In the absence of research, a linear inverse demand function can be represented by $P = a - \alpha Q$ and the marginal revenue function by $P = a - 2\alpha Q$, where P is price, Q is quantity, a is the price intercept and α is the demand price slope ($\alpha = P_m/\eta Q_m$ where η is demand price elasticity and the m subscript denotes a monopoly). The marginal cost curve is represented by $MC = b + \beta Q$ where MC denotes marginal cost, b is the 'cost' price intercept and β is the price slope ($\beta = k/eQ_m$ where e is 'cost' price elasticity). The marginal cost curve is not a supply curve for the monopolist. For empirical purposes, therefore we assume that e falls within a range of the supply price elasticity. A sensitivity test for this will be undertaken in the results section. The profit-maximising monopolist will set price at P_m (and quantity at Q_m) which corresponds to point e where marginal cost equals marginal revenue. Note that $P_m = (a + k)/2$. With research, the new technology reduces marginal cost by v per unit. This is depicted by a downward parallel shift in the marginal cost curve from MC to MC', where $MC' = c + \beta Q'$ where $c = b - v$ and the prime superscript denotes with research. The monopolist will reduce price to $P_m' = (a + k')/2$ (and quantity to Q_m'). It can be seen that the profit-maximising monopolist will pass on some but not all of the cost decrease. Compare this result with a competitive industry where price is set at the intersection of D and MC, the fall in product price is smaller for the monopolist because a smaller portion of the cost reduction is passed on to consumers.[1]

The conventional producer and consumer surplus measures are used in this paper to quantify the size and distribution of research benefits.[2] In Figure 1, consumer surplus increases by area $P_m fg P_m'$. As shown by Wisecarver (1974), this area under the derived demand curve for farm inputs represents the social value to consumers of the fall in price of these inputs induced by a research-caused downward shift of the marginal cost curve. The actual division of these benefits between farmers, middlemen, and final consumers remains to be determined. Producer surplus is represented by area above the marginal cost curve and below the price line. In Figure 1, producers' quasi-rent increases by area $P_m' gdc$ less area $P_m feb$ (which is area $(bedc + fgde - P_m fj P_m'))$. Algebraically, the gain in consumer surplus, CS_m, the gain in producer surplus, PS_m, and the aggregate (societal) gain, TS_m can be specified as follows:

$$CS_m = 0.5(P_m - P_m')(Q_m + Q_m') \tag{1}$$

$$PS_m = 0.5[(P'_m - c) + (P'_m - k')]Q'_m - 0.5[(P_m - b) + (P_m - k)]Q_m \quad (2)$$

$$TS_m = CS_m + PS_m. \quad (3)$$

Substituting $P'_m = P_m - \alpha v/(2\alpha+\beta)$, $Q'_m = Q_m + v/(2\alpha+\beta)$, $k = 2P_m - a$, and $k' = 2P'_m - a$, into equations 1 through 3 (derivations are available from the authors):

$$CS_m = \alpha v Q_m/(2\alpha + \beta) + \alpha v^2/[(2(2\alpha + \beta)^2)] \quad (4)$$

$$PS_m = vQ_m + v^2/[2(2\alpha + \beta)] \quad (5)$$

$$TS_m = CS_m + PS_m. \quad (6)$$

An Application and The Data

The model developed may be applied to the market for animal disease vaccine in Australia. There are at least three reasons why the animal disease vaccine market in Australia is probably non-competitive. First, there are only a few large animal disease vaccine companies in Australia. Second, animal disease vaccine producers engage in private research and a patent right is conferred on the firm after the research. Third, a research-induced cost reduction for firm A to whom an exclusive right for using the low-cost production method is given would constrain other producers from entering the market because they might not achieve a lower cost-effectiveness than firm A.

For the empirical analysis, hypothetical price, quantity and unit cost reduction (size of shift in supply) data are used for comparing the outcomes for both the monopolistic and competitive market structures. The demand elasticity for animal disease vaccine in Australia is likely to be price inelastic due to the small number of substitutes for animal disease vaccine. The supply of inputs (i.e. animal vaccine) in Australia, on the other hand, was reported to be very price elastic (Freebairn, Davis and Edwards 1982). The range of demand and supply price elasticities used for the analysis is shown in Table 1.

Results and Conclusion

The size and the distribution of research benefits for the two market structures assumed in this paper are calculated using a set of hypothetical data, and the results of the evaluation are tabulated in Table 1. It is shown that the increase in social benefits, holding other parameter constant, is larger with monopoly than with perfect competition. The bulk of the total benefits (67-91%) accrue to consumers in the case of a perfect competition, reflecting the larger values for supply price elasticity relative to that for demand. The aggregate benefits are little affected by variation in supply and demand elasticities. In contrast, about 68-73% of the gains from research accrues to producers rather than consumers in the case of a monopoly. It is of interest that both the size and distribution of research benefits are not very responsive to price elasticities of demand and supply in the case of monopoly.

Two implications arise from the above analysis. First, we suggest that the market for animal disease vaccine in Australia may not be competitive. Therefore treating the market as competitive and using a competitive instead of a non-competitive framework for measuring research benefits could lead to an underestimation and hence underinvestment in this type of research. Second, the paper has implications for the distribution of society's gains from the conduct of research and a range of issues like research pricing if a publicly funded research organisation such as CSIRO is involved in conducting at least part of the research. Our analysis indicates that if an input market is non-competitive and a non-competitive model is used to measure research benefits, consumers' share of the research benefits will be substantially smaller, and producers' share larger, compared with the case where a competitive model is used. Thus, if a competitive market model is used for the appraisal, and research costs are shared in proportion to the distribution of benefits,[3] consumers (livestock farmers etc) may end up bearing a larger share of the research costs than they would if the actual non-competitive market is modelled correctly. Further research is therefore needed to develop appropriate non-competitive market models for assessing research benefits in imperfect markets.

Footnotes

1 Equations for calculating the size and the distribution of research benefits in a competitive industry are given in Appendix 1

2 Consumer surplus measures are widely used for analysing welfare effects of price changes for agricultural products. This is generally regarded as appropriate, largely because income effects caused by price changes are likely to be small since consumers spend a very small fraction of their income on a particular food item (Bigman and Shalit, 1983). Producer surplus, also used widely in welfare analysis, is open to more serious questioning. Use of producer surplus is most clearly appropriate when rents accruing to a single-fixed factor, all other factors in perfectly elastic supply (Mishan, 1968)

3 Australia's Industries Assistance Commission supported on equity grounds the principle of sharing the costs of research between producers and consumers in the same proportions as the benefits (IAC, 1976).

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Appendix 1

In a competitive market, consumer surplus increases by area $P_c hi P_c'$ and producers' quasi-rent increases by area $(bcih - P_c hi P_c')$ (refer Figure 1). These gains can be expressed as:

$$CS_c = 0.5(P_c - P_c')(Q_c + Q_c') \tag{8}$$

$$PS_c = 0.5[v - (P_c - P_c')](Q_c + Q_c')]. \tag{9}$$

For a linear specification of demand and supply and a parallel shift in supply, it can be shown that:

$$P_c' = P_c(1 - Z) \tag{10}$$

$$Q_c' = Q_c(1 + \eta Z) \tag{11}$$

where $Z = ke/(e + \eta)$ and the subscript c denotes a competitive market. By substituting equations 10 and 11 into equations 8 and 9:

$$CS_c = P_c Q_c Z(1 + 0.5\eta Z) \tag{12}$$

$$PS_c = 0.5 P_c Q_c (k - Z)(2 + \eta Z) \tag{13}$$

The total (societal) surplus equals the sum of the producer and consumer surplus.

Table 1: Gains to Australian producers, consumers and aggregate gains from the Animal vaccine research (values in A$ million per year)

1. Gains when MC curve shifts down for a competitive industry

Price Elasticities	Producer[a]	Consumer[b]	Total	Producer Share
	A$m			(%)
$\eta = -0.5$, $e = 2.0$	4.73	18.94	23.68	20
$\eta = -0.5$, $e = 5$	2.17	21.67	23.84	9
$\eta = -1.0$, $e = 2$	8.15	16.29	24.44	33
$\eta = -1.0$, $e = 5$	4.15	20.76	24.91	17

2. Gains when MC curve shifts down for a monopolistic Industry

Price Elasticities[c]	Producer	Consumer	Total	Producer Share
	A$m			(%)
$\eta = -0.5$, $e = 2.0$	25.12	9.14	34.25	73
$\eta = -0.5$, $e = 5$	25.62	11.14	36.76	70
$\eta = -1.0$, $e = 2.0$	25.38	9.96	35.33	72
$\eta = -1.0$, $e = 5$	26.08	12.75	38.82	68

[a] Gains to input suppliers (i.e. vaccine producers).
[b] Gains to farmers, marketers and final consumers combined.
[c] Note that a monopolist always produces at the elastic region of the demand curve. For $\eta_c = -0.5$ (point h), $\eta_m = -2.0$ (point f, see Figure 1).

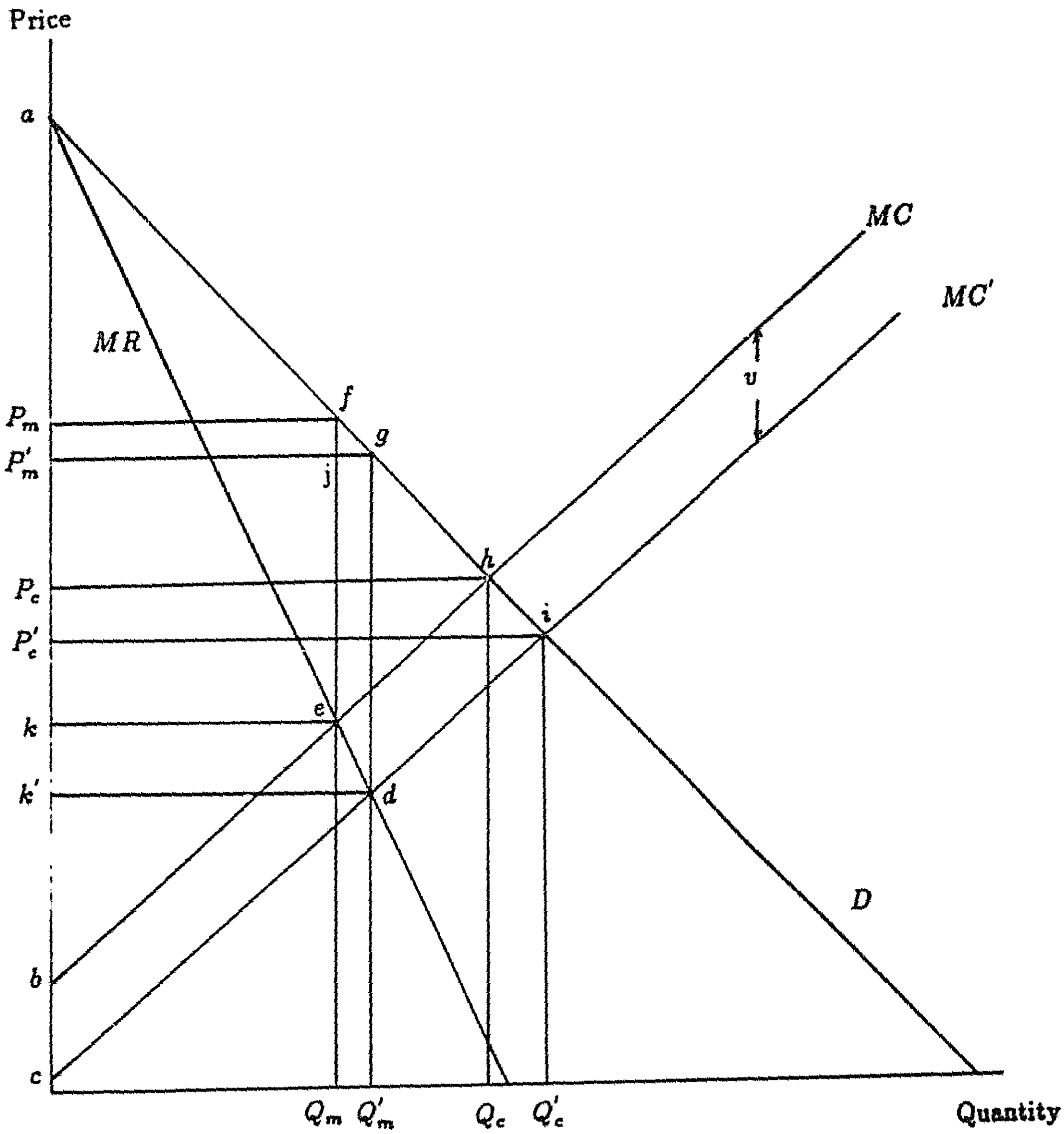

Figure 1. Welfare effects of a downward shift in the marginal cost curve for a monopoly.