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# Measuring research benefits in an imperfect market

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## Abstract

In this paper, an imperfect market model is developed for evaluating agricultural research benefits. The main finding is that the increases in societal gain, and the producer's share of this gain, are larger with a monopoly than with a competitive market. The paper argues that if the market for an agricultural input or for a commodity is not competitive, then use of a competitive model for assessing research benefits could lead to understatements of both producer and total benefits.

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## 1. 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. Appraisals of research benefits for input markets have also been undertaken (see Freebairn, Davis and Edwards, 1982; Alston and Scobie, 1983; Holloway, 1989). Past researchers often assumed that the markets for rural inputs and commodities are perfectly competitive.

Commodity markets are usually treated as being perfectly competitive due to the atomistic nature of these markets. However, such an assumption may not always hold given that some of the agricultural markets are fraught with government-induced price policies and interventions, product heterogeneity, domestic and foreign protection policies, among others. In addition, there are grounds for challenging the competitive as-

sumption 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 patent and plant variety rights), economies of size and the effects of uncertainty. The main form of imperfect competition may not be the extreme of a monopoly but rather oligopoly. However, there is no generally accepted price formation model for this (Freebairn, Davis and Edwards, 1982). Many price markup rules exist for imperfect markets. A common procedure is to set output prices at some percentage above marginal costs.

In this paper, a closed-economy monopolistic model is developed for assessing the economic benefits from cost-reducing research. Such a model, as far as the author is aware, has not been used previously for measuring the benefits from agricultural research. In the empirical analysis,

the results with outcomes for a monopoly are compared with those for a competitive industry. The implication of the analysis is that using a competitive model for assessing research benefits in an imperfect industry could cause a distortion in resource allocation. The paper emphasises the role of developing non-competitive models for measuring research benefits in imperfect markets.

## 2. Analytical framework

In this section, welfare effects of research which shifts down the marginal cost curve for a monopolistic firm are examined (see Fig. 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 func-

tions 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  $\alpha$  is the demand price slope:  $\alpha = P_m/(\eta Q_m)$ , in which  $\eta$  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  $\beta$  is the price slope:  $\beta = k/(eQ_m)$ , in which  $e$  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  $P_m = (a + k)/2$ .

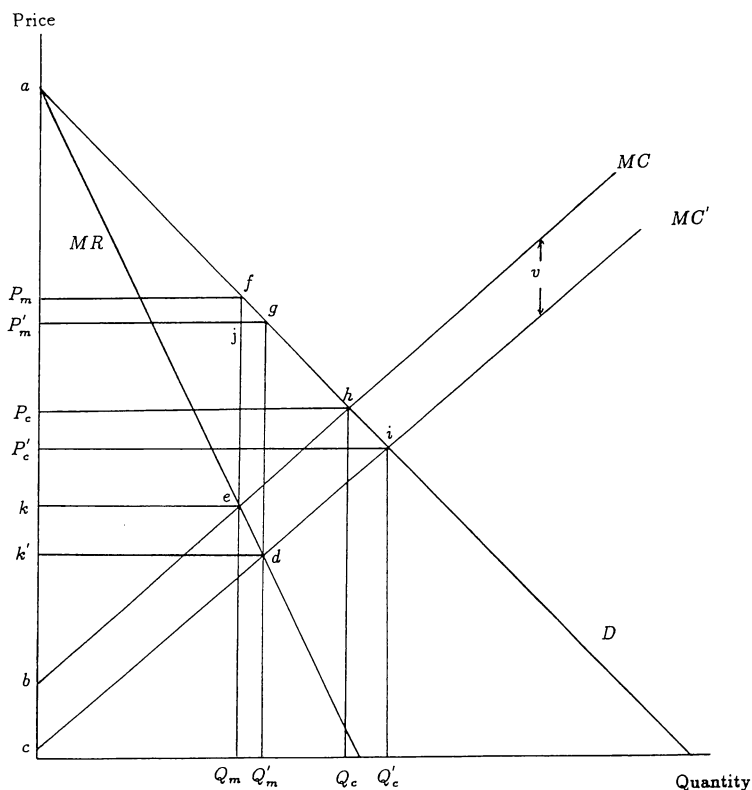


Fig. 1. Welfare effects of a downward shift in the marginal cost curve for a monopoly.

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  $MC' = c + \beta Q'$ , in which  $c = b - v$  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.<sup>1</sup>

The conventional producer and consumer surplus measures are used in this paper to quantify the size and distribution of research benefits.<sup>2</sup> In Fig. 1, consumer surplus increases by area  $P_m fgP'_m$ . 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 Fig. 1, producers' quasi-rent increases by area  $P'_m gdc$  less area  $P_m feb$ , which is area  $(bedc + fgde - P_m fjP'_m)$ . Algebraically, the gain in consumer surplus,  $CS_m$ , the gain in producer surplus,  $PS_m$  and the aggregate (societal) gain,  $TS_m$ , can be speci-

fied as follows:

$$CS_m = 0.5(P_m - P'_m)(Q_m + Q'_m) \quad (1)$$

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

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

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 Eqs. (1) through (3):<sup>3</sup>

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

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

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

### 3. Results and Implications

For illustrative purposes, the initial-equilibrium price and quantity were set at unity for the two market structures, the absolute shift was set at  $0.1P$ , and a range of demand and supply elasticities was used for comparison, following Voon and Edwards (1991).

Table 1 indicates that the increase in social benefits, holding other parameters constant, is larger with monopoly than with perfect competition. Hence, if the monopolistic market structure is a better description of the industry, then use of a competitive model for assessing research benefits could lead to an underestimation of research benefits.

Table 1 also shows the distribution of research benefits among producers and consumers. In the competitive case, the bulk of the benefits accrues to consumers (67–91%), reflecting the larger values for supply price elasticity relative to that for demand. The aggregate benefits are little affected by demand and supply elasticities. In contrast, if a monopoly is assumed for the market, about 68–73% of the net gains from research accrues to producers rather than to consumers. It is of interest that both the size and the distribu-

<sup>1</sup> Equations for calculating the size and the distribution of research benefits in a competitive industry are given in Appendix 1.

<sup>2</sup> 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).

<sup>3</sup> Derivations are available from the author.

Table 1

Gains to producers, consumers and aggregate gains from cost-reducing agricultural research (values in dollar unit per year)

Price elasticities <sup>a</sup>	(1) Gains when MC curve shifts down for a competitive industry			
	Producer (%)	Consumer (%)	Total (%)	Producer share (%)
$\epsilon = -0.5, e = 2.0$	0.0204	0.0816	0.1020	20.00
$\epsilon = -0.5, e = 5$	0.0093	0.0930	0.1023	9.09
$\epsilon = -1.0, e = 2$	0.0344	0.0689	0.1033	33.33
$\epsilon = -1.0, e = 5$	0.0174	0.0868	0.1042	16.67
Price elasticities	(2) Gains when MC curve shifts down for a monopolistic industry			
	Producer (%)	Consumer (%)	Total (%)	Producer share (%)
$\epsilon = -0.5, e = 2.0$	0.1040	0.0416	0.1456	71.43
$\epsilon = -0.5, e = 5$	0.1045	0.0475	0.1520	68.75
$\epsilon = -1.0, e = 2.0$	0.1045	0.0471	0.1516	68.94
$\epsilon = -1.0, e = 5$	0.1054	0.0567	0.01621	65.02

<sup>a</sup> Note that a monopolist always produces at the elastic region of the demand curve. For  $\epsilon_c = -0.5$  (point *h*),  $\epsilon_m = -2.0$  (point *f*, see Fig. 1).

tion of net benefits from research are not very responsive to price elasticities of demand and supply in the case of a monopoly.

An implication of the above analysis is that treating a market as competitive when in fact it is non-competitive and using a competitive rather than a non-competitive model for measuring research benefits could cause an underinvestment in agricultural research. The underinvestment hypothesis for agricultural research which has been so strongly argued for in the literature (see, for example, Ruttan, 1982; Lloyd and Harris, 1990), could, perhaps, be attributed, among other things, to inappropriate modelling. It is suggested in this paper that more research be devoted to developing economic frameworks for evaluating agricultural research benefits in imperfect markets.

#### 4. Acknowledgement

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#### 6. Appendix 1

In a competitive market, consumer surplus increases by area  $P_c hiP'_c$  and producers' quasi-rent increases by area  $(bcih - P_c hiP'_c)$  (refer Fig. 1).

These gains can be expressed as:

$$cs_c = 0.5(P_c - P'_c)(Q_c + Q'_c) \quad (7)$$

$$ps_c = 0.5[v - (P_c - P'_c)](Q_c + Q'_c) \quad (8)$$

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

$$P'_c = P_c(1 - Z) \quad (9)$$

$$Q'_c = Q_c(1 + \eta Z) \quad (10)$$

where  $Z = ke/(e + \eta)$  and the subscript c denotes a competitive market. By substituting Eqs. (9) and (10) into Eqs. (7) and (8):

$$cs_c = P_c Q_c Z(1 + 0.5\eta Z) \quad (11)$$

$$ps_c = 0.5P_c Q_c(k - Z)(2 + \eta Z) \quad (12)$$

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

