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EVALUATING THE RESEARCH BENEFITS FOR TRADED COMMODITIES

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INTRODUCTION

A great deal of attention has been devoted in the last two decades to assessing the economic consequences of agricultural research. The biotechnology revolution (see, for example, Hueth and Just, 1986; Kalter and Tauer, 1986) may provide a further stimulus to study of the size and distribution of the benefits and costs of research.

The present paper is in two parts. The first part outlines the approach used by Edwards and Freebairn [1981, 1984] to study the benefits from cost-reducing research. The approach is a simple, partial equilibrium one, but it incorporates the tradeability of commodities and the fact that research may reduce costs in the country of primary concern and/or in the rest of the world. Some results obtained with this approach are summarized, and an illustration gives estimates of the benefits to Australia and the rest of the world from research-induced cost reductions in the wheat industry. The second part of the paper contains observations on some additional issues that are relevant in assessing the economics of research for tradeable commodities. The issues are: choice of objective function in cost-benefit analysis of agricultural research; disaggregation into more than two sectors; effect of market distortions on benefits from research; property rights and trade in inputs; equity in distribution of the benefits and costs of research; and demand-shifting research and promotion. Most of these appear to be issues on which further research is appropriate.

MEASURING THE GAINS FROM COST-REDUCING RESEARCH FOR TRADED COMMODITIES

In the relatively small number of studies that allow for international trade, some assume that the country in which research reduces costs can export or import any quantity of the commodity without affecting world price (e.g. Akino and Hayami 1975; Ramalho de Castro and Schuh 1977). Other research allows for impacts on world prices through an excess demand curve (e.g. Martin and Havlicek 1977; Sarris and Schmitz 1981). As far as I know, Edwards and Freebairn [1981, 1984] were the first to allow research to shift the supply curve down in the rest of the world as well as in the country of primary interest. This approach reflected the obvious point that country A's gain from cost-reducing research for an export commodity would be less, ceteris paribus, if the research reduced costs for other countries producing the commodity than if the productivity gain was confined to country A. Use of a disaggregated model with a rest of the world (ROW) sector as well as a country A sector also allowed social benefits from research to be calculated from the perspective of country A, ROW or the world as a whole.

The Model

A diagrammatic version of the Edwards/Freebairn model is shown in Figure 1. The model is a simple free-trade, market-clearing one, with world supply and demand being obtained by horizontal addition of supply and demand, respectively, in the two sectors. Supply and demand are assumed to be linear. The world price determined in the right hand panel applies to producers and consumers throughout the world. Exports by one sector equal imports by the other.

Research causes a downward shift in the supply curve in country A and/or in ROW. Following the argument of Rose [1980] that it is typically most reasonable to assume a

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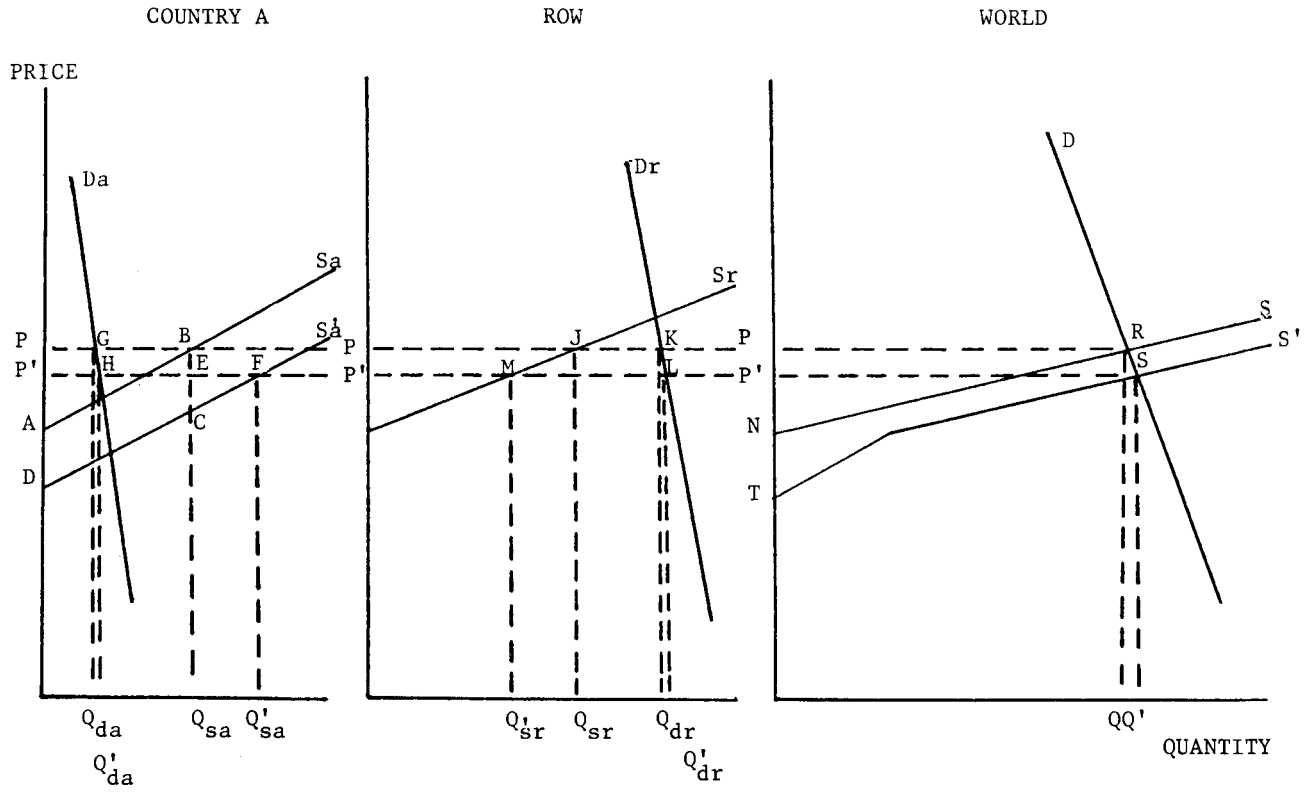
Figure 1. Economic Benefits from Research for a Traded Commodity



parallel shift, a parallel shift is used. The research that causes supply to shift could be carried out in country A or in ROW. Research benefits may be defined net or gross of research costs, depending on whether those costs are included in the price of new technology to producers and hence in the 'with research' supply curve.

Figure 1 is drawn for the case where country A is an exporter of the commodity, and research shifts supply only in country A. Country A producers gain economic surplus equal to area (ABCD+CEF-PBEP') from the research, and gains to country A consumers are equal to area PGHP'. Aggregate gain to country A equals area (ABCD+CEF-GBEH). The fall in world price resulting from the research - induced shift in supply causes gains to ROW consumers equal to area PKLP', losses to ROW producers of area PJMP' and a net gain to ROW equal to area JKLM. The increase in world welfare can be obtained by adding the welfare gains for country A from the left panel and for ROW in the center panel, or by calculating the area NRST in the right hand panel. Expressions for calculating gains to producers and to consumers in country A, ROW and the world as a whole are given if Edwards and Freebairn [1984].

A more general summary of the gainers and losers from shifts in supply in a two-sector market is given in the left-hand side of Table 1. Producers in a sector gain from cost reductions in that sector and lose from cost falls in the other sector. Consumers in a sector benefit from price falls resulting from downward shifts in supply in either sector. The aggregate welfare gain to producers plus consumers in a sector is necessarily positive for a research-induced reduction in domestic costs. The aggregate welfare gain to sector A from a cost reduction in ROW is negative if country A is an exporter of the commodity and positive if country A imports the commodity.

Table 1

Gainers and Losers from Falls in Supply and Rises in Demand in a Two-Sector Market

Group	Fall in Supply Occurring in		Rise in Demand Occurring in	
	The Group's Sector	The Other Sector	The Group's Sector	The Other Sector
Producers in a sector	+	-	+	+
Consumers in a sector	+	+	+	-
Producers plus consumers in a sector[a]	+	-(x) or +(m)	+	+(x) or -(m)

(a) x and m indicate that the sector is respectively an exporter or an importer of the commodity.

Some Implications

Seven implications of the analysis are mentioned here.

First, the gain to country A (producers plus consumers) from research will be positive so long as

$$(1) \quad \frac{k}{h} > \frac{e_{sr}\, Q_{sr}(Q_{sa} - Q_{da})}{(e_{da}\, Q_{da} + e_{dr}\, Q_{dr} + e_{sr}\, Q_{sr})Q_{sa} + e_{sa}\, Q_{sa}\, Q_{da}}$$

where k and h are research-induced cost reductions per unit of output in country A and ROW, respectively; e_{sr}, e_{dr}, e_{sa}, and e_{da} are elasticities of supply in ROW, demand in ROW, supply in country A and demand in country A, respectively, all defined at the initial equilibrium; and Q_{sr}, Q_{dr}, Q_{sa} and Q_{da} are initial equilibrium quantities supplied in ROW, demanded in ROW, supplied in country A and demanded in country A, respectively. Expression (1) can be used to calculate minimum ratios of domestic to ROW cost reductions for a country to gain from research. Table 2 presents a selection of such break-even price ratios for the case where the four elasticities e_{sr}, e_{dr}, e_{sa} and e_{da} are of any identical (absolute) size.

Table 2

Minimum Ratios of Domestic to Rest-of-World Cost Reductions (k/h) for a Country to Gain from Research

Ratio of Domestic Production to World Production	Ratio of Domestic Consumption to Domestic Production				
	0.00	0.25	0.50	0.75	1.00
0.01	0.497	0.373	0.248	0.124	0.000
0.10	0.474	0.351	0.231	0.114	0.000
0.20	0.444	0.324	0.211	0.103	0.000
0.30	0.412	0.296	0.189	0.091	0.000
0.40	0.375	0.265	0.167	0.079	0.000

Source: Edwards and Freebairn (1984).

When country A's share in world production does not exceed 20 percent, the break-even ratio is close to one-half with no domestic consumption, approximately one-quarter with half of production consumed domestically, and zero when all production is consumed domestically. The value of k/h required for country A to benefit from research for an export commodity decreases as A's share in world production rises. This is because the price effect of a given cost reduction in ROW diminishes as ROW's share in world production decreases. Inspection of expression (1) reveals that any combination of cost reductions in country A and ROW results in welfare gains to A if it is an importer of the commodity. Although the break-even values of k/h are unaffected by the values of the elasticities of supply and demand when these are identical in size, changes in individual elasticities influence the break-even cost reduction ratios. For export commodities, the break-even k/h increases with increases in the elasticity of supply in ROW and falls with increases in the elasticity of supply in country A and with the elasticity of demand in A and ROW.

Second, country A's producers will always gain from a research-induced parallel downward shift in supply of a traded commodity if supply is unaffected in ROW. This is contrary to the suggestions of some researchers. However, a fall in costs confined to a country that represents part of the total market will reduce price less than the reduction in costs unless demand in the market as a whole is perfectly inelastic and supply in the whole market is perfectly elastic.

Third, while producers in country A have their gains reduced if research lowers costs in ROW as well as in A, they will lose from the research only if the cost reductions in ROW exceed their own by a sufficiently large margin. For producers in country A the gain from their fall in costs, net of their losses from the fall in world price, will be positive so long as

$$(2)\quad \frac{k}{h} > \frac{e_{sr}\, Q_{sr}}{e_{da}\, Q_{da} + e_{dr}\, Q_{dr} + e_{sr}\, Q_{sr}}$$

Application of expression (2) can be illustrated by reference to the first column of Table 2. With no consumption of the commodity in country A (research gains to the country accrue entirely to producers), and A's production one percent of world production, country A producers will gain from the research if they experience a unit cost reduction at least half the cost reduction in ROW. With country A's production equal to 40 percent of world production the break-even cost reduction ratio falls to 37.5 percent. (The reason for the fall as the ratio of domestic to world production increases is the same reason that caused the break-even ratio of k/h to decrease with Q_{sa}/Q in the case of gains to producers plus consumers in country A). Changes in the proportion of production exported have no influence on producers' gains or, therefore, on the break-even k/h. As in the case of aggregate gains to country A for an export commodity, the break-even cost ratio, below which country A producers lose from research, decreases with increases in the domestic and foreign elasticities of demand and increases with increases in the foreign elasticity of supply.

Fourth, the analysis implies that for export industries research that overcomes problems unique to a country will give a higher national economic return, other things being equal, than research into problems that are also significant in ROW. Research directed to adapting foreign research findings to the domestic environment may also be attractive on this basis. For research that does reduce costs in country A and in ROW, A's gain will be greater the more quickly the research findings can be put into effect in country A relative to country B. In the case of research that reduces costs for an import industry, country A's gain will be greater if its research (or ROW's) reduces costs in other countries as well as in A, and if cost reductions in both sectors occur quickly rather than slowly.

Fifth, with identical values for initial production and consumption in country A, and identical values for elasticities of supply and demand, country A gains more from research that causes given cost reductions in A and in ROW for an imported commodity than it does for an export commodity. While producer gains are equal in the two cases, consumer gains are greater for the imported item because consumption is greater.

Sixth, for a given cost reduction per unit applying in an export industry, in an import industry and in a non-traded industry all having equal initial production in country A, the ranking of industries from largest to smallest welfare gains to country A is: import, non-traded, export. For a non-traded industry, country A's gain depends almost entirely on the size of the cost reduction parallelogram applying to initial production; the triangle between the 'with research' supply curve and the demand curve is normally small relative to the cost savings on initial output (e.g. Hertford and Schmitz, [1977]). The price reduction due to research represents a welfare transfer from producers to consumers in the case of non-traded commodities, whereas it influences country A's research benefits in the case of traded commodities. The margin by which A's benefits from research for a non-traded commodity exceed its benefits for an export commodity is increased if costs for the export commodity are reduced in ROW as well as in A. The reason A benefits more from a given cost reduction for an import commodity than a non-traded one when its production is set at identical levels for the two is that it consumes more of the imported commodity. The margin in favor of the import is increased if research lowers costs in ROW.

Of course, the distribution of research benefits is likely to be very different for non-traded commodities on the one hand and traded ones on the other. Because falls in world price for traded commodities due to a given cost reduction in country A will normally be much smaller than the fall in domestic price of a non-traded commodity experiencing the same cost reduction, producers would usually obtain a higher proportion of the research benefits for an import or export commodity than for a non-traded commodity.

Seventh, and finally, the analysis suggests that conflicts can exist between the research investments that are optimal for a country if it considers the economic return to its own citizens and those that are optimal from the view of the world as a whole. Scitovsky [1954] pointed out that effects on foreigners through changes in world prices make investment in

export industries less desirable from a national view than from a world view, and investment in import industries more attractive from a national view than from a world view. Another concern for those taking a world view is the possibility that individual countries may find it economically beneficial to emphasize research for export commodities expected to have little applicability in other countries and research for import commodities expected to be useful to other countries.

An Application

An application of the model to the wheat industry is shown in Table 3. Benefits are presented for Australia, the rest of the world, and the world from research-induced cost reductions equal to 10 percent of the initial equilibrium price. The cost reductions are assumed to occur in Australia or in ROW or in both. The initial equilibrium price and quantity data is for the period 1979-80/1980-81. Further information is in Edwards and Freebairn [1984].

The results in Table 3 illustrate the dramatic increases that can occur in welfare of consumers in a 'small country' from a downward shift in supply in ROW, and the large losses that can accrue to producers and (for an export commodity) to the country as a whole from such a shift.

FURTHER ISSUES IN EVALUATING RESEARCH BENEFITS FOR TRADED COMMODITIES

Choice of Objective Function

Some national and regional productivity increases for export commodities have been evaluated by researchers within the countries concerned from a world view rather than a national view. Specifically, net gains to ROW from the fall in world price have been counted as benefits from the downward shift in supply in country A (e.g. Vere, Sinden and Campbell 1980; Zentner 1985; Ulrich, Furtan and Schmitz 1986). It is not always clear whether use of this catholic welfare function is intentional. In my view, it would nearly always accord more closely with the motivation of national governments to carry out benefit-cost analysis of research, and other government-funded projects, from a national view than from a global view. At the very least, it would seem desirable to justify departures from the principle that only benefits and costs accruing to a country's own citizens be counted when the objective is to assess the efficiency of resource allocation decisions within that country. It remains true, as discussed earlier, that the ranking of some investments in agricultural research - and of other investments - may differ when the unit of concern is a particular country and when it is the world.

Further Disaggregation

With another level of disaggregation, the model outlined in the first part of the paper can be applied to situations where productivity increases in only a part of country A's industry. Edwards and Freebairn [1982] used such a model to estimate the economic benefits from the control of serrated tussock weed in the wool industry in the tablelands area of New South Wales. The region gained from weed control, the rest of Australia lost (though less than the region's gain) and the rest of the world (an importer of wool) gained.

Market Distortions and Research Benefits

A substantial proportion of world trade in agricultural commodities is affected by tariffs and other trade restrictions. These policies, when applied in ROW, reduce world prices and hence country A's cost savings from research. A further loss to country A arises in the case of its export industries because ROW's protection policies reduce the elasticity

Table 3

Gains to Australia, Rest of World, and World from Research that Reduces Costs of Producing Wheat (Present Values in Millions of Dollars Summed Over 30 Years)

	Cost Reduction 10% in Australia 0% in ROW				Cost Reduction 10% in Australia 10% in ROW				Cost Reduction 0% in Australia 10% in ROW			
	Elasticities of Supply and Demand											
	0.3 -0.1	1.0 -0.1	0.3 -0.2	1.0 -0.2	0.3 -0.1	1.0 -0.1	0.3 -0.2	1.0 -0.2	0.3 -0.1	1.0 -0.1	0.3 -0.2	1.0 -0.2
Gain to Australia												
Consumers	8	9	6	9	256	310	205	285	248	300	199	276
Producers	1,789	1,835	1,798	1,840	453	165	727	303	-1,301	-1,578	-1,043	-1,406
Total	1,797	1,844	1,804	1,849	709	475	932	589	-1,053	-1,228	-844	-1,130
Gain to ROW												
Consumers	1,347	1,633	1,078	1,498	44,419	53,880	35,608	49,561	43,063	52,234	34,519	48,042
Producers	-1,313	-1,590	-1,051	-1,458	14,438	5,254	23,149	9,666	15,761	6,862	24,212	11,150
Total	34	43	27	40	58,757	59,134	58,757	59,227	58,824	59,096	58,730	59,192
Gain to World												
Consumers	1,355	1,642	1,084	1,508	44,675	54,190	35,813	49,846	43,311	52,534	34,718	48,318
Producers	476	245	747	382	14,891	5,419	23,876	9,969	14,460	5,334	23,169	9,744
Total	1,831	1,887	1,831	1,890	59,566	59,609	59,689	59,815	57,771	57,868	57,887	58,062

Source: Edwards and Freebairn (1984).

of excess demand in ROW, increasing the price fall caused by research-induced supply shifts in A. The effect of market distortions in ROW on gains to country A from supply shifts for its import industries is ambiguous because the cost savings effect and the price effect are in opposite directions.

A closer examination of the effects of several types of market distortions on the size and the distribution of research benefits is given in Alston, Edwards and Freebairn [1986]. That study found that a country's benefits from research that lowered its supply curve for a commodity could be reduced, left unchanged, or increased by its own market distortions, depending on the nature of the intervention and the country's trading status. It was found, for example, that a country's gains from research would be: reduced by a target price with deficiency payments and, for a large exporter or importer, by a subsidy on output or exports, or a tax on imports; left unchanged by a subsidy on output or exports or a tax on imports for a small country trader; and increased by a home consumption price scheme with equalization of prices to producers in the case of a small country exporter. These results rest on the assumptions that the research-induced cost reduction is independent of commodity price and hence of the market distortions. For the tax and subsidy policies, linear demand and supply with parallel supply shifts due to research is also assumed. Consideration of the sensitivity of results to relaxing the assumption of exogenously determined research and supply shift, in particular, is a challenge.

Property Rights and Trade in Inputs

A firm or industry in country A that supplies inputs to producers of a commodity in ROW will cause a loss to producers of the commodity in country A (and to producers plus consumers of the commodity in A if it is an export) if it make a technological advance that is applicable in ROW but not in A. There may be a loss for country A producers and a social loss in the commodity market even if the advance reduces costs in A and in ROW, if the reduction in ROW is sufficiently large relative to that in A. With zero government intervention in markets, input suppliers would have no incentive to allow for any adverse effect that sale of its technological progress to foreigners exerted on other domestic industries. Would the situation be different if the optimal set of trade taxes was in place? (The optimal set of trade taxes may be changed by the technical advance in the input supply industry). Exports of inputs would then be restricted to the optimal extent, from a national view, before and after the new technology was developed. However, optimal trade taxes are defined for given production functions, and they do not ensure that a country will always gain from shifts in that function in an input supply industry.

The benefits to the input supplying industry from a technological development for which it is responsible, and also the benefits to country A, will be influenced by the effectiveness of the supplier's property rights in the development. The more complete these property rights are, the greater the proportion of the value of the technological development that the input supplier will be able to capture, ceteris paribus. More complete property rights need not always be to the advantage of country A, however. If fuller rights cause the input supply industry to invest more in developing technologies that are useful only or mainly in ROW, the greater returns to country A from sale of technology could be more than offset by the additional losses to country A's commodity exporters.

Shifts in Demand

The framework outlined in the first part of the paper can readily be modified to analyze the effects of shifts in demand. The effects of upward shifts in demand on welfare of producers, consumers and producers plus consumers in a two-sector market are shown in the right-hand side of Table 1. The effects are symmetric with those caused by downward shifts in supply.

The demand for a commodity may rise as a result of certain research activities or of promotion. The derived demand for wool, for example, may rise as a result of new knowledge that allows a cost reduction in any of the industries between the wool-growers and the

consumers of wool products, or that allows a new characteristic to be imparted to the wool product. Research which allows a more highly valued bundle of characteristics to be embodied in each pound of wool produced by wool-growers may cause a rise in demand for their output. (The fact that the nature of wool-growers' output is changed by this research raises problems for evaluating research benefits that do not arise with cost-reducing research in the marketing chain or with research that changes the characteristics of the final wool product). Another possible cause of a rise in the demand for wool at farm level is promotion of wool-growers' commodity or of wool products.

It will sometimes be important to look beyond the market of direct concern to obtain a comprehensive picture of the welfare effects of rises in demand due to research or promotion. However, even if a rise in the demand for one commodity due to research or promotion causes significant welfare effects in other markets, those effects will sometimes be regarded as irrelevant because of the perspective of the analyst. In an investigation of the economic benefits to Australia from investment in extra research or promotion to raise the demand curve for wool, losses to overseas producers of natural or synthetic fibers would be disregarded.

Equity in the Distribution of the Benefits and Costs of Research and Promotion

Australia's Industries Assistance Commission [1976] supported on equity grounds the principle of sharing the costs of research and promotion between producers and consumers in the same proportions as the benefits. While research shifts the curve down, a levy (tax) for research or promotion shifts the supply curve upwards. A levy paid by consumers shifts the market-place demand curve downwards. For a non-traded good, the equity principle favored by the IAC can be achieved by means of a tax on either production or consumption if supply and demand in the relevant ranges are approximately linear. The analysis is similar to the analysis of the incidence of an excise tax. When the market comprises two sectors, it is necessary for research or promotion that shift supply in a sector to be paid for initially by that sector's producers and for activities that shift sector demand to be funded initially by the sector's consumers to meet the equity criterion [Edwards, 1984]. When research funded by one sector shifts supply down or demand up in the other sector it is not in general possible to achieve symmetry in the distribution of the costs and benefits of research.

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