Chapter 7

Economic Benefits of Wheat Improvement Research

In this chapter we present several estimates of economic benefits from international wheat improvement research. We begin with simple calculations of gross annual research benefits based on alternate assumptions about yield gains in farmers' fields resulting from wheat improvement research. Following that, we review the most thorough economic study of international wheat improvement research by Byerlee and Traxler (1995), as well as a more recent study by Evenson (2000) that focused on international crop germplasm improvement efforts for wheat and other major crops. We conclude with a discussion of several areas in which the economic evaluation of wheat breeding research could be improved.

Gross Annual Research Benefits from CIMMYT/NARS Wheat Improvement Research[36]

We began this exercise by assuming that annual yield gains attributable to germplasm alone might range from 0.2 to 0.4 t/ha. These yield gains are assumed to result from the use of new varieties developed by wheat breeding programs. A yield gain of 0.2 t/ha is similar to the weighted average yield gain Maredia and Byerlee (1999) estimated for CIMMYT crosses over other ISWYN entries. Another way of looking at a yield gain of 0.2 t/ha is that it implies that over the past 35 years, yields in developing country wheat reached current levels 4 or 5 years earlier than they would have in the absence of CIMMYT/NARS wheat improvement research. This appears to be a fairly conservative assumption. A yield gain of 0.3 t/ha is close to the yield gain implied by Byerlee and Traxler's (1995) more complex analysis for spring bread wheat, considered in further detail below. A yield gain of 0.4 t/ha is similar to Evenson's (2000) "conservative" estimate of yield gains due to CIMMYT alone. It would correspond to the assumption that yields in developing country wheat production would have lagged in their actual values by 8 to 10 years in the absence of the CIMMYT/NARS program.

Additional assumptions in the calculation of gross annual research benefits are that MV wheats cover nearly 84 million hectares in the developing world and that the world wheat price is $120/t. To make the current price US$ 120/t consistent with earlier cost estimates, which were expressed in 1990 dollars, this price was converted to US$ 97/t.

Based on these assumptions, the additional wheat production directly attributable to the CIMMYT/NARS wheat improvement effort each year is estimated to range from 17 to 33 million tons, and the total annual value of extra production is estimated to range from US$ 1.6 to US$ 3.2 billion (1990 dollars) (Table 7.1).

[36] The CIMMYT/NARS international wheat improvement program includes CIMMYT research efforts, the joint CIMMYT/ICARDA program, as well as NARSs wheat improvement programs.

How much of this extra annual production can be attributed to CIMMYT? Table 7.2 applies several of the attribution rules discussed in Chapter 4 to the total value of annual extra production reported in Table 7.1. The CIMMYT cross rule underestimates CIMMYT's contribution, since it assumes that CIMMYT's contribution is confined only to CIMMYT crosses planted in farmers' fields; the any ancestor rule overstates CIMMYT's contribution, since it assumes that all yield gains from any variety with CIMMYT ancestry are credited entirely to CIMMYT. The geometric rule attempts to account for contributions at different stages of the breeding process. It, too, may understate CIMMYT's contribution, if one wants to take into account the catalytic effect CIMMYT research may have had on NARS research (as Evenson does).

This brings up an interesting consideration. There is probably some kind of interaction between the yield gain figure and the proportion of CIMMYT contribution. This interaction is ignored in Table 7.2. If one wants to look at overall benefits over time, then the catalytic role of CIMMYT is particularly important. Furthermore, yield gains (Stage I gains) depend on the counterfactual; they will be smaller if the counterfactual accommodates semidwarf MVs, and they will be larger if the counterfactual includes only tall varieties. Therefore a higher figure (probably even higher than 0.4 t/ha) should be chosen. On the other hand, the very real Stage II gains, which have accounted for two-thirds or more of total benefits achieved since the 1960s (Byerlee and Traxler 1995), should probably be calculated using a smaller yield gain. Smaller yield gains may come closer to estimating the annual marginal benefits that might be expected from future CIMMYT research.

Economic Surplus Studies of Economic Benefits from Wheat MVs

Byerlee and Traxler (1995) provide the most comprehensive attempt to date to evaluate the economic impact of the joint CIMMYT/NARS wheat genetic improvement effort. Focusing on spring bread wheat, they estimate an *ex post* rate of return for wheat breeding research for developing countries. They report the highest returns in South Asia and in irrigated and high rainfall environments. They argue that by 1990 more than two-thirds of the benefits from wheat improvement research were coming from varietal turnover (Stage II) rather than initial MV adoption (Stage I). They project future rates of return would be 35% if all future research were only maintenance research, and greater than 35% if additional gains in yield potential are achieved. In monetary terms, Byerlee and Traxler estimate that total economic surplus in developing countries is about US$ 2.5 billion annually (1990 US$), for a

Table 7.1. Annual benefits from wheat improvement research in the developing world attributable to the CIMMYT/NARS system, simple gross annual research benefits assumption.

Assumed yield gain from MVs (t/ha)	Additional annual production (million/t)	Value of additional production (billion 1990 U.S.$)
0.2	16.7	1.6
0.3	25.1	2.4
0.4	33.4	3.2

Note: Area planted to MV's is 83.6 million hectares; the assumed price of wheat is US$ 97/t (1990 dollars, equivalent to US$ 120/t 2000 dollars).

Table 7.2. Annual benefits attributable to CIMMYT wheat breeding research (billion 1990 US$).

Assumed yield gain from MVs (t/ha)	CIMMYT contribution			
	0.21	0.29	0.46	0.63
	CIMMYT cross rule	Geometric rule	Cross plus parent rule	Any ancestor rule
0.2	0.3	0.5	0.7	1.0
0.3	0.5	0.7	1.1	1.5
0.4	0.7	0.9	1.5	2.0

Note: Total benefits taken from Table 7.1.

total research cost that has never exceeded US$ 70 million annually.[37] They assume a lag of 17 years from initial investment to peak benefits.

In an alternative approach, Evenson (2000) estimates the direct contribution of IARC crop improvement research to NARS varietal releases (Evenson considers a number of crops, including wheat). He analyzes econometrically the indirect impacts of IARC germplasm improvement efforts on NARSs' varietal releases and then presents the results of another model estimating the net impacts of IARC breeding programs on NARSs' crop genetic improvement investments. The results are combined to determine a counterfactual scenario of NARS varietal releases in the absence of the IARC system and fed into the IMPACT general equilibrium model developed by IFPRI.

Evenson estimates that the number of wheat varieties released would have been between 32% and 45% lower in the absence of the IARC system. Evenson's estimates from the IMPACT model suggest that wheat imports by developing countries would have been 15-20% higher had there been no IARC wheat genetic improvement research. The IMPACT model also suggests that real wheat prices would have been 26-34% higher, and the area planted to wheat 3-4% greater, had there been no international wheat research.

It is difficult to compare the estimates made by Byerlee and Traxler of the economic benefits of IARC wheat research with those made by Evenson, because the summary statements focus on different indicators. It is possible, however, to make some rough comparisons by coupling straightforward projections of major indicators used by Byerlee and Traxler on the one hand and by Evenson on the other with simple assumptions about supply and demand elasticities. The Byerlee-Traxler assumptions suggest that by the late 1990s, without the CIMMYT-NARS wheat improvement research, developing country wheat yields would have been 8% or 9% lower, developing country wheat production would have been around 24 million tons less, and international wheat prices would have been around 7% higher. The Evenson assumptions suggest that without IARC wheat improvement research, developing country yields would have been 13-20% lower, developing country production 35-65 million tons less, and international wheat prices 26-34% higher.

In terms of methodology, Byerlee and Traxler use relatively simple price assumptions to capture the effects of large regions' positions as net wheat importers or self-sufficient producers. They do not consider the price effects of changing levels of wheat supply. They estimate benefits from all international wheat crop improvement research, not benefits attributable to CIMMYT alone. Furthermore, as indicated in Chapter 6, it is possible that the yield assumptions they use no longer track wheat yield changes in farmers' fields, especially since aggregate statistics show that country wheat yields are no longer growing at the phenomenal rates seen from the Green Revolution through the mid-1980s. On the other hand, Byerlee and Traxler focus exclusively on research in spring bread wheat for four major environments in which this type of wheat is grown. Adding all spring bread wheat area, spring durum wheat area, and winter wheat area to the analysis would have resulted in larger yield, output, and price effects than they reported.[38, 39]

Evenson, too, may have overestimated the economic benefits of international wheat genetic improvement research. While the IMPACT model disaggregates wheat production and consumption

[37] As noted, Byerlee and Traxler were estimating the costs of spring bread wheat genetic research only.
[38] It should be remembered, however, that the four spring bread wheat environments chosen were those in which CIMMYT wheat improvement research had had the largest impacts.
[39] Spillover benefits to industrialized countries are also ignored.

into a number of different regions, Evenson's model does not allow for the possibility that supply effects resulting from IARC research (including numbers of varieties released and production advantages from IARC-related varieties) might differ significantly from region to region. Furthermore, one key component of Evenson's counterfactual scenario for wheat, ln(*SC*), or the natural logarithm of the number of wheat improvement scientists in NARSs, is a publications-based estimate and seems considerably larger (almost by a factor of 10) than the count-based estimates used as the basis of our calculations of numbers of wheat scientists reported in Chapter 2.

Using different attribution rules comparable to those used in Table 7.2, estimates of annual benefits attributable to wheat improvement research by Byerlee and Traxler (1995) and Evenson (2000) are shown in Table 7.3. Evenson implies that all estimated benefits (first column of Table 7.3) are attributable to IARC wheat research, which in turn suggest that the IARC/NARS total would be even larger. Tables 7.2 and 7.3 indicate that annual benefits currently attributable to CIMMYT research could range anywhere from US$ 300 million up to nearly US$ 6 billion (1990 dollars). The larger estimates derive from what amounts to the assumption that had CIMMYT never existed, wheat yields in developing countries would have remained near their pre-Green Revolution levels. The figures based on Byerlee and Traxler (1995), adjusted upward to account for CIMMYT's impact outside of the main spring bread wheat environments, are probably the most reliable. Using these figures or, alternatively, the middle two columns of Table 7.2, a plausible estimate of the expected marginal benefits from CIMMYT research might range between US$ 500 million and US$ 1.6 billion annually (1990 dollars).

Despite differences in assumptions and estimation procedures, it is quite clear that without IARC wheat genetic improvement research:

- annual wheat production in developing countries would today be significantly lower;
- total wheat production in developing countries over the past 30 or more years would have been much lower;
- wheat imports by developing countries would today be notably larger;
- real world wheat prices would today be significantly higher; and
- the area planted to wheat in developing countries would today be slightly higher.

Table 7.3. Estimates of annual benefits from IARC/NARS wheat improvement research based on previous economic surplus studies.

	Total annual benefits	CIMMYT contribution			
		0.21	0.29	0.46	0.63
Basis of calculation	(billion 1990 US$)	CIMMYT cross rule	Geometric rule	Cross plus parent rule	Any ancestor rule
Byerlee and Traxler (1995)	2.5	0.5	0.7	1.2	1.6
Evenson (2000) I	3.4	0.7	1.0	1.6	2.1
Evenson (2000) II	6.3	1.3	1.8	2.9	3.9

Note: Assumed price of wheat: $97/t (1990 dollars, equivalent to $120/t 2000 dollars).