IR-6 Information Report No. 92-1 January, 1992

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This report was approved for publication as an IR-6 Information Report by the Chairman of the Regional Administrative Advisory Committee for IR-6 on January 21, 1992. Copies of the report may be obtained from Publications, Department of Agricultural and Applied Economics, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108.

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Introduction

Considerable analysis has been conducted on the gains from agricultural research. Most has evaluated research gains using yield increases and/or cost reductions at the farm level, and the distribution of these gains (in the form of economic surpluses) among producers and consumers. Recently, analysis has been expanded to include measurement of the economic gains from post-harvest research and the distribution of these gains. Only limited work has been done, however, to allocate the distribution of research benefits that occur at different stages of the production, processing, and distribution chain. Yet the distribution of research-induced technology gains within a multimarket framework can be an important consideration when evaluating some programs of agricultural research.[1/] This is true both in the projective (ex ante) context of research planning and in the ex post evaluation of research already conducted. Public research conducted for malting barley is an example of research with multimarket benefits. Potential beneficiaries of this research include suppliers of farm inputs and farmers; the malting and brewing industries; and, retailers and consumers. Moreover, the research generates benefits both from increasing yields and from improving product quality.

In this publication we report the results of analyses conducted to evaluate the benefits from research conducted at the University of Minnesota Agricultural Experiment Station that resulted in the development of a set of improved malting barley varieties grown extensively in

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the tri-state region of Minnesota, North Dakota, and South Dakota.[2/] Our initial analysis estimates the costs for research conducted at the Minnesota Agricultural Experiment Station and the benefits flowing from this research to Minnesota farmers and input suppliers, the malting and brewing industries and the retail-consumer sectors. Subsequently, costs and benefits are expanded to include the tri-state region.

Overview of the Barley Production Sector

Barley production in the U.S. is concentrated in the northwestern portion of the country, mainly from Minnesota to the West Coast. Table 1 shows total barley production for the U.S. and by selected states for the period 1978 to 1990.

Table 2 shows planted and harvested acres of all barley, per acre yields and value of production for the U.S. for the same period.

A distinction needs to be made between barley varieties grown for malting and for feed. Malting barley varieties are used for brewing (principally beer) and distilling purposes but can also be used for livestock feed. Feed barley varieties, on the other hand, are not used for malting purposes. Virtually all of the excess of malting barley beyond that used by the malting industry is diverted into the lower-value, feed-use market. In recent years, almost 85 percent of the barley produced in the tri-state region of Minnesota, North Dakota and South Dakota was from malting varieties. Of this 85 percent, it is estimated that about 45 percent is for malting purposes and 40 percent for feed uses. On average, the tri-state area produces about 70 percent of the barley grown in the U.S. from malting varieties. In years when the supply of malting barley is large and well beyond the needs of maltsters, the price differential between malting and feed barley is reduced substantially in comparison with years when supplies of malting quality barley are tight relative to demand for malting use. Marketing year price differentials between malting and feed prices for barley are shown in table 3 for the period 1980-81 to 1988-89.

TABLE 1

BARLEY: Production by Selected States and U.S. 1978-1990 (million bushels)

Year	Minnesota	N. Dakota	S. Dakota	Other States	(I) Total USA	(II) Total MN + ND + SD = tri	(II)/(I) Ratio
1978	52	113	21	234	420	186	.44
1979	41	76	21	242	380	138	.36
1980	35	48	16	262	361	99	.27
1981	58	105	20	294	477	183	.38
1982	51	103	23	339	516	177	.34
1983	43	115	23	327	508	181	.36
1984	62	154	30	350	596	246	.41
1985	71	184	32	308	595	287	.48
1986	55	176	36	315	582	267	.46
1987	50	139	34	306	529	223	.42
1988	27	45	8	196	276	80	.29
1989	44	98	19	243	404	161	.40
1990	50	130	25	214	419	205	.49

Source: USA National Agricultural Statistical Service

TABLE 2

Area, Yield, Production and Value of Barley: U.S. 1978-1990

Year	Planted (000 acres)[1/]	Harvest (000 acres)	Yield/ acre/bu.	Product (000 bu.)	Price $/bu.[2/]	Value of Product (000 $)[2/]
1978	9,989	9,248	49.2	454,759	1.92	871,070
1979	8,116	7,527	50.9	383,201	2.29	872,308
1980	8,320	7,260	49.7	361,135	2.84	1,016,842
1981	9,618	9,038	52.4	473,512	2.44	1,154,497
1982	9,549	9,013	57.2	515,935	2.22	1,143,209
1983	10,422	9,731	52.3	508,925	2.50	1,268,906
1984	11,957	11,231	53.4	599,204	2.26	1,356,316
1985	13,156	11,603	51.0	591,383	1.98	1,132,537
1986	13,059	12,007	50.8	610,522	1.61	993,905
1987	11,046	10,027	52.6	527,010	1.86	935,163
1988	9,831	7,636	38.0	289,994	2.80	775,228
1989	9,125	8,313	48.6	404,203	2.42	968,180
1990	8,201	7,499	55.9	418,856	2.14	905,923

1/ Barley sown for all purposes, including barley sown in the preceding fall.

2/ Includes allowance for loans outstanding and purchases by the government valued at the state average loan and purchase rate where applicable.

Source: USA National Agricultural Statistical Service

TABLE 3

Malting and Feed Barley Prices and Price Differentials 1980-81 to 1988-89 (dollars per bushel)

Marketing Year	Feed Barley	Malting Barley	Net Difference
1980-81	2.60	3.64	1.04
1981-82	2.21	3.06	0.85
1982-83	1.76	2.53	0.77
1983-84	2.48	2.84	0.36
1984-85	2.09	2.55	0.46
1985-86	1.53	2.24	0.71
1986-87	1.44	1.89	0.45
1987-88	1.78	2.04	0.26
1988-89	2.31	4.11	1.80

Note: Prices are seasonal prices for Minneapolis (Duluth beginning March, 1987).

Source: CRB Commodity Year Book, 1990

Overview of the Malting Industry

By the late 1980s the U.S. malting capacity was around 2.7 million metric tons per annum. Of this total, about 2.1 million metric tons was non-brewer owned malting capacity and .6 million metric tons was malting capacity of brewers.

Malting is a highly capital intensive process and large size plants are required for efficiency. New plants are built with 200 thousand tons per year capacity or greater. Malt production is, in turn, purchased by about 215 licensed breweries. More than 41 percent of the malting capacity is located in Wisconsin and about 38 percent in the tri-state region of Minnesota, North Dakota, and South Dakota. Thus a high proportion of the malting capacity is located near the major supply sources of malting barley and numerous nearby breweries in Wisconsin, Minnesota, and Iowa. Although some aspects of malting barley quality are important to brewers in processing products other than malt, our analysis of malting barley quality characteristics is limited to that pertaining to the malting industry.

Expenditures on Barley Research at the Minnesota Agricultural Experiment Station

Table 4 shows expenditures for malting barley research at the Minnesota Agricultural Experiment Station from 1958 to 1988 in both nominal and 1989 dollars. Although a high proportion of the research investment was associated with a major varietal breeding and testing program, related costs of research on plant pathology, soils, cultural practices, and the like are also included. Table 4 also depicts the break down of public expenditures and industry funds allocated to the barley research program. These data indicate that the share of program funding by industry declined from about 73 percent in 1959-61 to 31 percent in 1987-88.

TABLE 4

Total Research Expenditures for Malting Barley by Year and Fund Source, Minnesota Agricultural Experiment Station, 1958-1988

Year	Federal and State funds (000/$)	%	Industry funds (000/$)	%	Total in Nominal (000/$)	Total in (000/$/1989)
1958	24.4	38	39.2	62	63.6	343.0
1959	24.4	27	66.2	73	90.6	473.4
1960	24.0	28	61.4	72	85.4	416.9
1961	22.0	27	60.0	73	82.0	386.6
1962	27.9	36	49.6	64	77.5	351.4
1963	27.9	44	36.1	56	64.0	277.5
1964	24.5	40	36.1	60	60.5	252.3
1965	23.5	38	38.0	62	61.5	245.4
1966	27.6	48	30.0	52	57.7	220.2
1967	29.7	49	31.2	51	60.9	227.4
1968	32.2	48	35.2	52	67.4	232.6
1969	43.6	71	18.2	29	61.7	197.0
1970	53.7	63	31.6	37	85.2	253.2
1971	53.7	62	33.5	38	87.1	244.2
1972	76.1	68	35.1	32	111.2	299.0
1973	79.3	68	36.9	32	116.2	294.5
1974	89.9	70	38.7	30	128.6	303.2
1975	98.9	71	41.0	29	139.9	308.0
1976	104.9	71	43.0	29	147.9	306.3
1977	126.2	73	47.3	27	173.5	345.1
1978	144.2	74	50.1	26	194.4	364.4
1979	134.7	71	55.0	29	189.8	331.6
1980	151.0	72	58.3	28	209.3	337.6
1981	151.3	70	65.6	30	216.9	320.7
1982	147.9	69	67.0	31	214.9	294.0
1983	201.3	73	75.4	27	276.6	345.7
1984	183.6	65	100.0	35	283.6	343.4
1985	215.7	67	107.4	33	323.1	360.6
1986	226.5	62	140.9	38	367.4	400.9
1987	236.6	69	108.6	31	345.3	358.8
1988	248.5	69	112.0	31	360.5	376.7

Note: Expenditures include a share of all research programs related to barley as well as administrative expenditures, overhead, etc.

Source: Compiled from unpublished data provided by the Minnesota Agricultural Experiment Station

Potential Gains from Improved Malting Barley Varieties

As already suggested, potential gains from improvement of malting barley varieties are both those of increased yield per acre and improved malting quality characteristics. Quality characteristics of special importance for malting are the amount of malt extract produced per bushel, and the level of selected enzymes, particularly alpha amylase, which accelerates germination during processing. Reduced germination time, in turn, extends the capacity of malting plants by increasing the number of batches of malt that can be processed per unit of time. Table 5 shows a comparison of per acre yields and the quantities of malt extract and alpha amylase for three important malting barley varieties. The Larker variety was developed at North Dakota State University and Morex and Robust at the University of Minnesota.

Larker was the highest acreage malting variety planted in the tri-state region from 1970 to 1979, Morex from 1980 to 1984 and Robust from 1985 to date. Because of its quality advantages and sometimes pricing advantage compared with Robust, Morex continued to retain a significant percentage of acreage planted despite the higher yielding capacity of Robust. Total acres planted by variety in the tri-state region are shown in table 6 for the period 1970-1990.

The Conceptual Framework

Traditionally, productivity enhancing technical change has been modeled at the farm level as a downward shift in the product supply curve from S_0 to S_1 as the cost structure for production is lowered (Figure 1). This in turn lowers the market price for the product from P_0 to P_1, a decline that is somewhat less than the corresponding decline in unit production costs from P_0 to d. The total benefit arising from research is represented by the area I_0 a b I_1. It comprises benefits to "consumers" of area P_0 a b P_1 arising from a lowered commodity prices and benefits to producers from lowered costs of production of area I_0 a b I_1 minus P_0 a b P_1,

TABLE 5

BARLEY: Variety Comparison

	Larker	Morex	Robust
Malt extract (%)	75.9	78.1	78.1
Alpha amylase (20° units)	37.2	45.4	38.0
Yield/hectare (kilograms)	3,665	3,914	4,249

Source: Quality data (malt extract and alpha amylase) are from Mississippi Valley Nursery Quality Report 1986, 1987, 1988. Cereal Crops Research Unit, ARS, USDA, Madison, Wisconsin.

Yield information was obtained from 11 trials at different locations. See Mississippi Valley Uniform Regional Nursery Reports (1980 to 1991) for confirmation of long-term yield performance of Larker, Morex and Robust.

TABLE 6

Planted Barley Acreage by Variety (1970-1990)
Tri-State Region: Minnesota, North Dakota, and South Dakota

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total Acres (000)	2992	3636	4109	4434	3564	3730	3660	4280	4170	3020	3340	3950	3540	4330	4430	5560	5730	5070	4550	4425	4130
Variety	Percent of Planted Acreage																				
Larker	51	55	51	49	49	47	46	50	46	43	22	16	11	5							
Dikson	34	28	26	15																	
Beacon					13	22	26	26	23	16	6	3									
Morex										14	43	42	46	37	37	21	16	20	20	15	13
Glenn											13	27	23	37	18						
Azure															14	11	13	12	12	10	6
Robust														7	13	47	45	46	50	54	58
Bowman																	6	8	8	10	10
Busch 1602																				5	8
Others	15	16	23	31	36	31	28	24	31	27	16	15	20	14	18	21	20	14	8	6	5

Source: American Malting Barley Association

Note: Varieties with less than 5 percent of planted acreage are included in "Others."

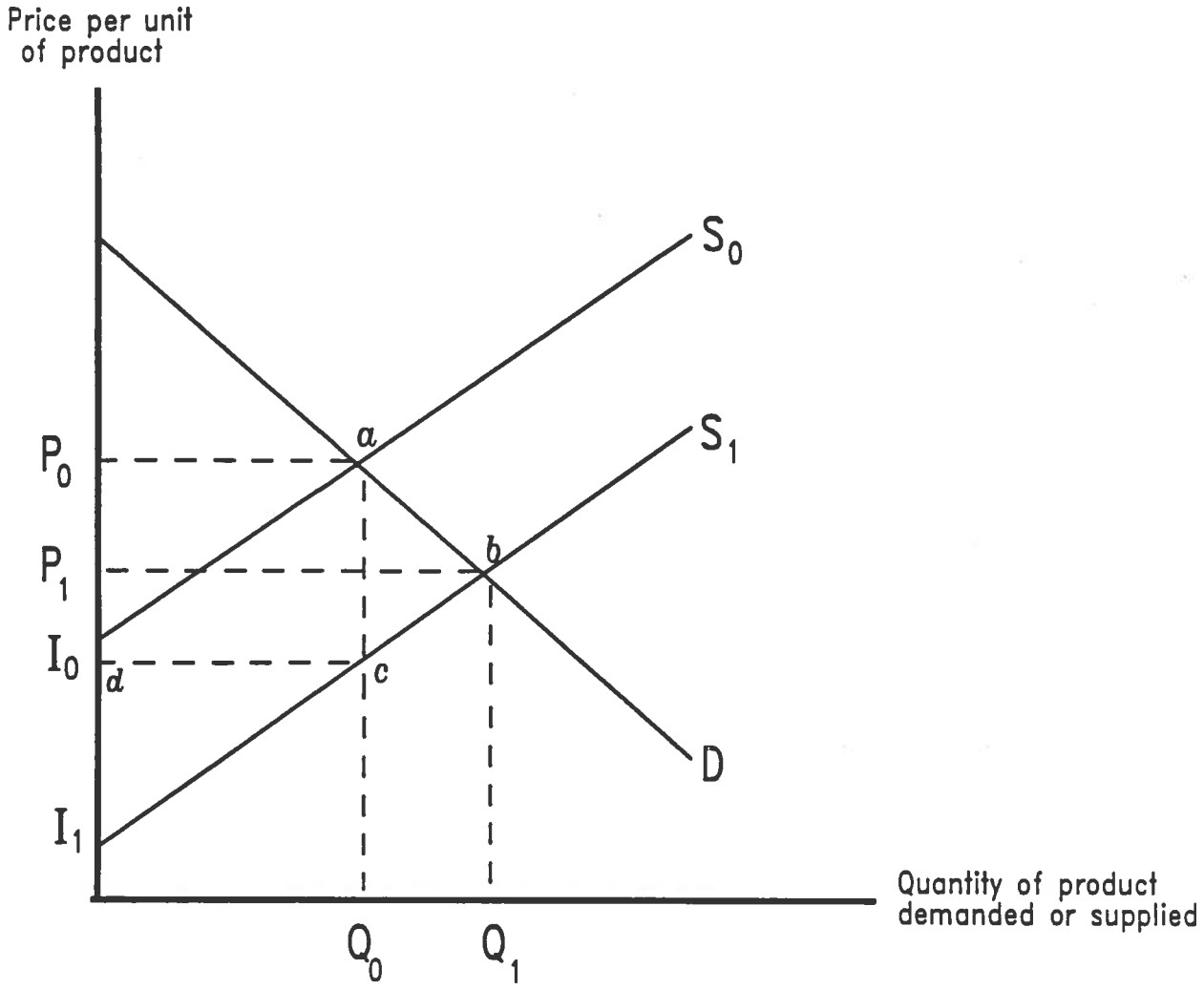

Figure 1: The Effect of Agricultural Research Investment on "Consumer" and "Producer" Surpluses

which in this case is equivalent to P_1 b c d. When viewed from a farm-level perspective, "consumer" benefits in fact measure the sum total of benefits accruing to those beyond the farm gate including those involved in processing, marketing and distribution, as well as final consumers. Similarly, "producer" benefits include benefits accruing to those who provide resources through the farm production stage (farm input suppliers and farmers).

Recasting the analysis in a multimarket framework offers the possibility of vertically disaggregating the distribution of research benefits and its associated costs across various levels in the production-processing chain. In this case it also facilitates partitioning the impacts of research between those arising from yield improvements (cost reductions at the farm level) and those arising from quality improvements of relevance to the malting industry. In figure 2 yield improvements are modeled as a downward shift in the industry's supply curve from S_m^0 to S_m^1 and quality improvements as a shift from S_m^1 to S_m^2. To the extent these benefits are passed down to the farm level they also induce an upward shift in the farm-level derived demand curve from D_f^0 to D_f^1 and generate a higher farm-level product price, P_f^2.

In the case of malting barley, some maltsters have been willing to pay a price premium to producers of the Morex variety, as compared with Robust, because of the superior malting qualities of Morex such as shorter malting time and higher alpha amylase content (see table 5). These quality enhancements reduce the cost structure for maltsters using the Morex variety. Our accounting procedure incorporates these quality related price adjustments into the analysis.

Because research and extension expenditures must be made well in advance of the realization of resulting economic benefits, a lag of six years is applied between the incurring of research expenditures and the generation of benefits. The time lag assumed between expenditures for technology transfer to farmers via extension and the realization of farm-level benefits is three years.

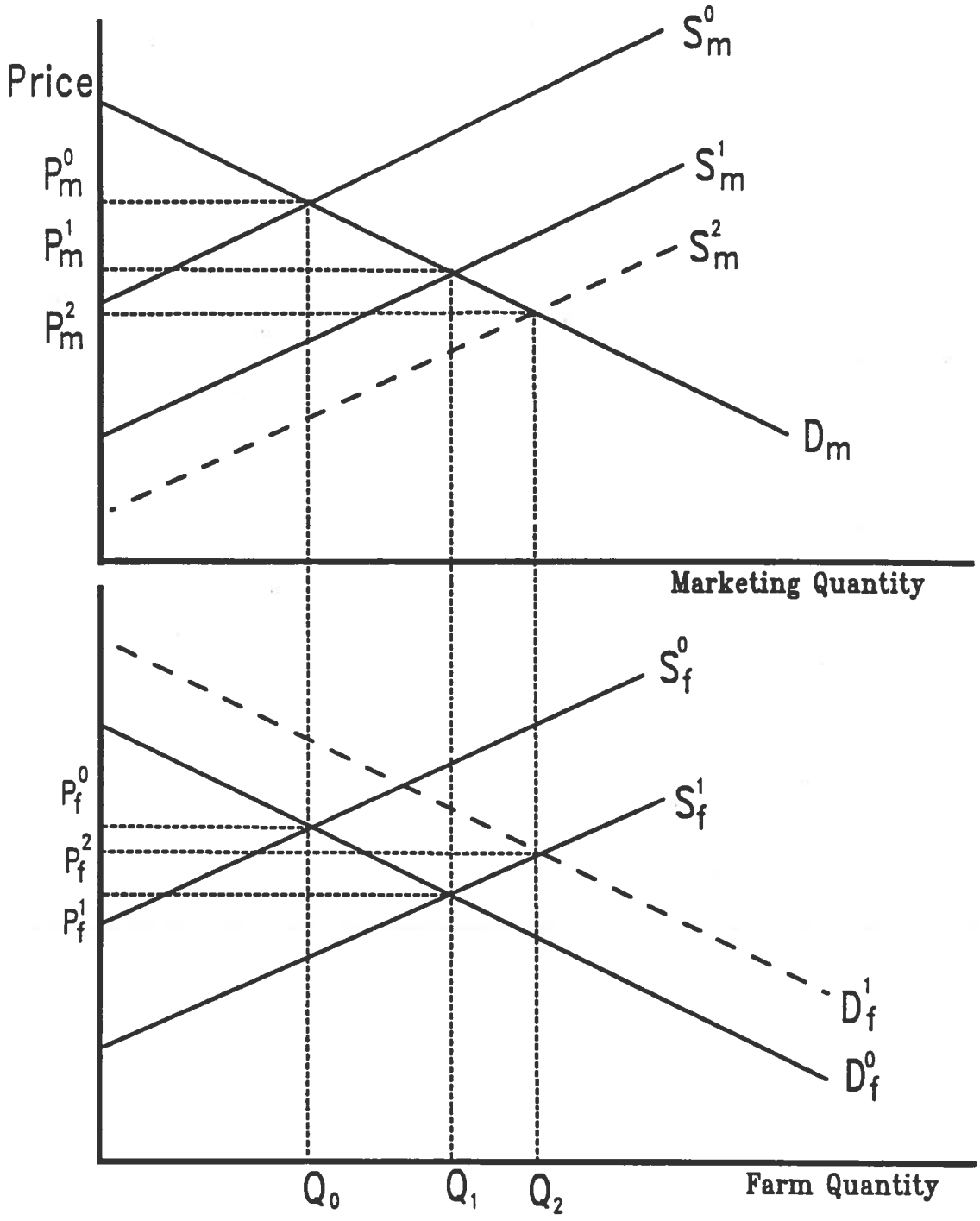

Figure 2: Cost Reducing Technologies at the Farm and Marketing Levels

The measures used to assess the relationship between expenditures and benefits in this study are the benefit/cost ratio (B/C) and the internal-rate-of-return on investment (IRR). The latter is a measure of the discount rate which makes the 1989 dollar value of all benefits arising from malting barley research and extension just equal to the 1989 dollar value of all costs. It can be interpreted as an annual rate of return (or interest) being earned on these research and extension expenditures. The deflation of costs and benefits to a common base year (in this case 1989) is required in order to avoid biases in calculations resulting from changes in price levels over time.

The Empirical Results: Minnesota

In the sections that follow, we document the costs and benefits for malting barley research conducted at the Minnesota Agricultural Experiment Station that resulted in the development of two major malting barley varieties, Morex and Robust. These costs and benefits are evaluated over the period 1973 to 1989, although major benefits have continued beyond 1989. The Morex variety was first made available to farmers on a commercial basis in 1979. Given a six-year lag between the initiation of variety development and commercial adoption, research development costs are tabulated from 1973. Since the Robust variety was released to farmers in 1983, research expenditures are tabulated through that year and extension expenses through 1986. Research benefits for Morex are calculated as the value of improvements of Morex over the highest use predecessor variety, Larker. Benefits include those of higher yield, greater malt extract and faster germination and modification in the malting process. Faster germination and modification time in Morex leads to a reduction in malting costs. Yield and malt extract computations are based on data in table 5. Reduction in malting costs associated with Morex are estimates based on consultation with industry specialists.

Table 7 summarizes the research and extension costs (totaling $5.703 million in 1989 dollars over the 1973 to 1986 period) for development of the Morex and Robust varieties and the transfer of this technology to Minnesota farmers. In return, benefits were generated in the amount of $154.3 million for a benefit/cost ratio of more than $27 of returns for each dollar invested. This resulted in an internal rate-of-return of almost 85 percent.

Of the total benefits generated by the research and extension investments, about 32 percent went to farmers and input suppliers, 8 percent to the malting industry, and about 60 percent to the brewing industry and post brewing sectors. Available data do not permit determination of the distribution of gains among those groups beyond the malting industry.

With respect to the origin of the research benefits from the two malting barley varieties, about 72 percent of the gains are attributable to increasing per acre yields and malt extract quantities. The remaining 28 percent are attributable to the gains resulting from faster germination and modification and the resulting reduction in costs for malting.

The Empirical Results: The Tri-State Region

As indicated earlier, the research program which resulted in development of the Morex and Robust malting barley varieties was conducted by the Minnesota Agricultural Experiment Station. In addition, modest expenditures were made by the North Dakota and South Dakota Agricultural Experiment Stations for varietal trials and testing and by the Agricultural Extension Services of each of the three states for assistance in transferring the new varieties to farmer users. Estimates of these investment costs are shown in table 8. Total research and extension expenditures for the two varieties are estimated at $9.21 million with about 86 percent of the investment coming from public and 14 percent from private sources.

TABLE 7

Cost and Benefits from Barley Research

Region: Minnesota
Varieties: Morex and Robust

Year	Benefits for Farmers[a/] (in 000 $/1989)[b/]	%	Benefits for the Malting Industry (in 000 $/1989)[c/]	%	Benefit for Brewers and Final Consumers (in 000 $/1989)[d/]	%	Total Benefit (in 000 $/1989)	Research and Extension Costs (in 000 $/1989)	Benefits Minus Costs (in 000 $/1989)
1973								294.5	-294.50
1974								303.2	-303.20
1975								308.0	-308.00
1976								587.2	-587.20
1977								526.1	-526.10
1978								555.4	-555.40
1979	2,405.1	26	719.5	8	6,102.3	66	9,226.90	508.6	8,718.30
1980	4,677.6	25	1,122.1	6	12,887.8	69	18,687.50	517.6	18,169.90
1981	4,590.4	30	1,142.4	7	9,812.6	63	15,545.40	493.7	15,051.70
1982	4,677.6	26	2,814.4	16	10,165.0	58	17,657.00	485.0	17,172.00
1983	4,256.9	26	2,686.8	16	9,538.9	58	16,482.60	541.7	15,940.90
1984	3,586.8	25	2,375.9	17	8,172.0	58	14,134.70	194.0	13,940.70
1985	5,235.7	40	304.2	2	7,703.3	58	13,243.20	194.0	13,049.20
1986	5,034.5	40	198.1	2	7,480.5	59	12,713.10	194.0	12,519.10
1987	5,288.5	39	272.6	2	8,151.2	59	13,712.30		13,712.30
1988	5,116.5	39	237.6	2	7,794.7	59	13,148.80		13,148.80
1989	3,723.7	38	215.3	2	5,823.0	60	9,762.00		9,762.00
TOTAL	48,593.3	31.5	12,088.9	7.8	93,631.3	60.7	154,313.50	5,703.0	148,610.50

Benefit Cost Ratio: 27.1:1

IRR estimation: 0.848 (85%)

a/ A minor portion of these benefits are captured by suppliers of farm inputs, mainly seed.

b/ Includes yield and malt extract effect plus $.18/bu. from 1985 on for quantities sold of Morex up to 10 mill. bu. max.

c/ Includes yield and malt extract effects for change in producer surplus at the industry level, minus change in producer surplus at the farm level. It also includes the difference between change in producer surplus from germination effect and total premium paid.

d/ Includes change in consumer surplus calculated at the industry level for yield and malt extract effect, and change in consumer surplus for reduction in malting costs.

TABLE 8

Research and Extension Expenditures Related to Development and Adoption of Morex and Robust Varieties (in constant 1989 dollars)

Region: Tri-state (MN, ND, SD) Period: 1973-1989

Year	I Research Expenditures (000 $/1989)			II Extension Expenditures (000 $/1989)			Total (I) + (II) (tri-state) (000 $/1989)
	MN	ND	SD	MN	ND	SD	
1973	294.5	12.1	12				318.60
1974	303.2	14.6	12				329.80
1975	308.0	23.2	12				343.20
1976	306.2	26.3	12	181.0	223.0	43.0	791.50
1977	345.1	32.8	12	181.0	226.0	45.0	841.90
1978	364.4	31.2	12	191.0	222.0	47.0	867.60
1979	331.6	32.5	12	177.0	222.0	48.0	823.10
1980	337.6	32.1	12	180.0	223.0	45.0	829.70
1981	320.7	41.2	12	173.0	222.0	41.0	809.90
1982	294.0	39.5	12	191.0	261.0	42.0	839.50
1983	345.7	40.6	12	196.0	260.0	43.0	897.30
1984				194.0	268.0	44.0	506.00
1985				194.0	268.0	44.0	506.00
1986				194.0	268.0	44.0	506.00
TOTAL	3,551.0	326.1	132.0	2,052.0	2,663.0	486.0	9,210.10

Source: Minnesota, North Dakota, and South Dakota Experiment Stations and Extension Services.

The economic benefits accruing to investments made in research and extension in the tri-state region for the Morex and Robust varieties are shown in table 9. Benefits total to $296.7 million for an estimated benefit/cost ratio of about 32.2:1 and an internal rate-of-return of about 91 percent. Thus, the total investments to develop the two varieties and to transfer this technology to farmers in the tri-state region are outstandingly high. Moreover, with the continuation of the malting barley research program and the release by the Minnesota Agricultural Experiment Station of a new, highly promising variety, Excel, in 1991, very high rates of research returns are expected to continue into the 1990s.

Summary and Conclusions

Research conducted by the Minnesota Agricultural Experiment Station from 1973 to 1983 resulted in the development of two outstanding malting barley varieties, Morex and Robust. This research and related Minnesota extension programs cost about $5.7 million in 1989 dollars and generated economic benefits of about $154 million between 1979 and 1989. This resulted in a benefit/cost ratio of about 27:1 and generated an annual internal rate of return on investment of about 85 percent. Of the total benefits generated by the malting barley improvement program, about one-third went to Minnesota farmers and input suppliers (mainly the former) and two-thirds to the malting and brewing industries and to consumers.

When expanded to the tri-state area of Minnesota, North Dakota and South Dakota, aggregate benefits are almost doubled at $297 million. Additional expenditures mainly for varietal trials and extension expand total program costs to about $9.2 million. This results in a benefit/cost ratio of more than 32:1, and the annual internal rate-of-return on investment increases to about 91 percent.

TABLE 9

Cost and Benefits from Barley Research

Region: Tri-state (MN, ND, SD)
Varieties: Morex and Robust

Year	Benefits for Farmers[a/] (in 000 $/1989)[b/]	%	Benefits for the Malting Industry (in 000 $/1989)[c/]	%	Benefit for Brewers and Final Consumers (in 000 $/1989)[d/]	%	Total Benefit (in 000 $/1989)	Research and Extension Costs (in 000 $/1989)	Benefits Minus Costs (in 000 $/1989)
1973								318.6	-319
1974								329.8	-330
1975								343.2	-343
1976								791.5	-792
1977								841.9	-842
1978								867.6	-868
1979	2,883	28	2,331	24	4,794	48	10,008	823.1	9,185
1980	8,672	29	6,443	22	14,490	49	29,605	829.7	28,775
1981	8,188	29	6,252	22	13,523	49	27,963	809.9	27,153
1982	8,674	28	6,762	22	14,496	49	29,932	839.5	29,093
1983	8,032	31	5,359	21	12,046	48	25,437	897.3	24,540
1984	8,773	31	5,746	21	13,634	48	28,153	506.0	27,647
1985	14,795	59	54	2	9,695	39	24,544	506.0	24,038
1986	14,699	49	2,057	6	13,818	45	30,574	506.0	30,068
1987	13,277	40	3,429	11	16,673	49	33,379		33,379
1988	14,172	40	796	6	15,263	54	30,231		30,231
1989	10,910	40	1,321	5	14,595	55	26,826		26,826
TOTAL	113,075	38.1	40,550	13.7	143,027	48.2	296,652	9,210.1	287,442

Benefit Cost Ratio: 32.2:1

IRR estimation: 0.909 (91%)

a/ A minor portion of these benefits are captured by suppliers of farm inputs, mainly seed.
b/ Includes yield and malt extract effect plus $.18/bu. from 1985 on for quantities sold of Morex up to 30 mill. bu. max.
c/ Includes yield and malt extract effects for change in producer surplus at the industry level, minus change in producer surplus at the farm level. It also includes the difference between change in producer surplus from germination effect and total premium paid.
d/ Includes change in consumer surplus calculated at the industry level for yield and malt extract effect, and change in consumer surplus for reduction in malting costs.

Of the research and extension benefits accruing between 1979 and 1989, about 72 percent are attributable to increases in per acre and malt extract yields. The remaining 28 percent is due to faster germination and modification for Morex in the malting process.

Finally, with the development of still another new improved malting barley variety, Excel, released by the Minnesota Agricultural Experiment Station in 1990, the historically high returns from malting barley research at the Minnesota Agricultural Experiment Station are expected to continue through the decade of the 1990s. As a result, Minnesota farmers, the malting and brewing industries, product marketers and consumers will continue to reap major economic gains from Minnesota's malting barley research program.

FOOTNOTES

1/ For a technical discussion of the distribution of economic effects of research in a multimarket framework, see particularly: 1) Freebairn, J.W., J.S. Davis and G.W. Edwards, "Distributions of Research Gains in Multistage Production Systems," Amer. J. Agr. Econ., Vol. 64, No. 1, February, 1982, 2) Alston, J.M. and G.M. Scobie, "Distribution of Research Gains in Multistage Production Systems: Comment," Amer. J. Agr. Econ., Vol 64, No. 2, May 1983 and 3) Alston, J.M. "Research Benefits in a Multimarket Setting." ACIAR-ISNAR Project Paper No. 18, 1990.

2/ For a more detailed technical discussion of the economic analysis summarized in this report see Luis F. Macagno, "The Nature and Distribution of Gains from Quality Improving Research in a Multimarket Framework: The Case of Barley," Unpublished Ph.D. Dissertation, University of Minnesota, September, 1990.