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Differential Effects of Technological Change on Midwestern Agriculture

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CONTENTS

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DIFFERENTIAL EFFECTS OF TECHNOLOGICAL CHANGE ON MIDWESTERN AGRICULTURE[1]

Allen C. Wellman[2]

SUMMARY

Technological change is estimated to have had only slight differential effects on the relative income positions of producers in the 14 Midwest states. Technological change has probably induced about 10% and general economic forces (primarily demand and income) about 90% of the farm income changes during the postwar period.

Large consumer gains have been realized. Postwar analyses (generally 1950 to 1965) indicate that the total effect of technological change stemming from field crops, livestock and poultry and the marketing and distribution system has favored Kansas, Nebraska and the Southern Plains (Oklahoma and Texas). Increased feed grain production and usage in beef feeding has enabled these areas to reduce the comparative advantage held by the Corn Belt in these enterprises.

The Corn Belt is able to maintain its overall relative competitive position because of increased soybean productivity. Income improvements in North Dakota, South Dakota and the Lake States have lagged behind the other nine states. Overall indications are that the feed-grain beef areas have made gains relative to the specialized wheat and milk areas.

Although certain isolated areas are not sharing equally in the technological improvement gains, it is concluded that publicly sponsored research is generally not responsible for the income disparities. General economic forces are more responsible for income differences than is technology.

INTRODUCTION

Over the years technological advances have greatly influenced the course of U.S. agriculture. Examples include use of hybrid seeds and fertilizers in crop production, machinery innovations, improvements in animal breeding and nutrition and all types of capital improvements for processing and marketing agricultural products.

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[1] The author acknowledges the suggestions of Dr. James B. Hassler in the preparation and publication of this bulletin.

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Perhaps the very nature of these developments leads to a secular decline in the relative ability of some enterprises and regions to compete. General evidence and more specific data of the recent historical period do not clearly provide information to answer such questions, because this evidence includes the significant effects of changes in population location, demands and incomes and the impacts of major agricultural programs. The effects of technological changes must be separated from the total effects from all changes if valid conclusions are to be reached.

The first objective of this study is to estimate the direct and indirect effects of several specific technological changes related to farm production and subsequent marketing activities on inter-area aspects of income per farm operator, land values, farm size and general adjustments in the competitive strength of states and regions, primarily in the Midwest.

The second objective is to assess the research and policy implications of the results of the first objective.

PROCEDURES

This study concentrates on analyzing the effects of technology in three main areas:

Field crops at the farm level.

Conversion of feed into animal products by livestock and poultry.

Marketing margins in the processing and distribution systems.[3]

Farm Level

At the farm level, the change (if any) in absolute advantage between field crops in 14 states (Fig. 1) from 1950 to 1965 is evaluated based on the net return per acre over variable costs. The cumulative effect of changes in technology and prices from 1950 to 1965 is also evaluated.

Specified yield increments were estimated by Auer[4] for fertilizer and varietal improvement. The remaining yield increments (as a residual) attributable to technological change are lumped together and

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[3] For a more complete discussion of procedure, data and data sources, see Allen C. Wellman, "Differential Effects of Technological Change on Midwestern Agriculture," unpublished Ph.D. dissertation, University of Nebraska, Lincoln, Nebraska, 1969.

[4] Ludwig Auer, "Impact of Crop Yield Technology on U.S. Production," unpublished dissertation, Iowa State University of Science and Technology, Ames, Iowa. 1963. A Cobb-Douglas function analysis was used to develop the basic data.

Figure 1. Study area.

called "other technological factors." These yield estimates are standardized by Auer to exclude weather and locational effects. The yield increments are added together to develop a series of yields per acre attributed to technology for each year from 1950 to 1965.

Incremental and total variable supply costs per acre by crop are also computed on a yearly basis. Actual market prices are used for feed grains. Adjusted prices, using corn (or the total feed grain group) as the comparative base, are estimated for wheat during the 1957–1963 period and soybeans during the 1960–1965 period.

Soybean and wheat prices were adjusted to remove support program price distortions. The net return per acre per year for each crop is calculated by taking the yield per acre times the price minus the total variable supply costs.

The cumulative effect of changes in technology from 1950 to 1965 is determined as follows:

$$\triangle NR/A = \triangle GR/A - \triangle GC/A \qquad (1)$$

where $\triangle NR/A$ equals change in net returns per acre, $\triangle GR/A$ is the change in gross returns per acre and $\triangle GC/A$ is the change in gross costs per acre. The $\triangle GR/A$ term can be stated from year (t-1) to year (t) as:

$$(\triangle P)\ Y_{t-1} + P_t \sum_{i=1}^{3} \triangle Y_i \qquad (2)$$

where $\triangle P$ equals the change in price, Y_{t-1} equals yield in year (t-1) and $\triangle Y_i$ equals the physical yield increments from other factors, varietal improvement and fertilizer usage. The first term indicates value changes due to price changes on the same yield. The second term equals the sum of terms $P_t\ \triangle Y_i$ which would be the value of the i^{th} increment of the three technological increments being studied. On the cost side, the $\triangle GC/A$ term can be stated from year (t-1) to year (t) as:

$$\sum_{i=1}^{3}(\triangle P_i)\ F_{i(t-1)} + \sum_{i=1}^{3} P_{it}\triangle F_i \qquad (3)$$

where P equals factor prices and F equals factor inputs. The first term indicates changes in costs due to price changes on i^{th} cost factor at the old use rate. The second term indicates the changes due to the change in use rate at new prices. However, since we were not directly interested in separating cost into price and use effects, we use an aggregate increment cost, $\triangle C_i$.

Formula 1 when broken down into term 2 and term 3 produces the change in net returns per acre for one year or between any two time points. From 2 the value increment is obtained ($P_t\ \triangle Y_i$). The cost increments are the values for $\triangle C_i$. When these figures are subtracted, the net value increment attributable to each of the three technologies in a given year is determined.

The effect of market price fluctuations for each crop is calculated as follows:

$$P = \triangle P_{t\text{-}1 \text{ to } t} \cdot Y_{t-1} \qquad (4)$$

where P represents the price effect for a given year which is calculated by multiplying the change in the given crop price from year t-1 to year t (i.e., 1950 to 1951) times the yield per acre (Y) in year t-1 (i.e., X bushels per acre – 1950). Positive and negative price effects for the 16-year period are summed to obtain an aggregate price effect.

A graph is used to present the net returns per acre for specific crops in each state. A table is used to present the estimated net incremental values, for the 16-year period, attributable to the three technological sources (other factors, varietal improvement and fertilizer usage) for the dominant (based on net return calculations) feed grain, wheat and soybeans. The net increments when summed over the 16-year period give a technological value in dollar terms for each state crop. When the aggregate price effects and the net incremental technological effects are totaled, a total net change for the period is derived. The table for each state indicates which technology has contributed the most to net returns per acre for the dominant feed grain, wheat and soybeans in each state.

Based on net return per acre calculations, one crop is selected as the "dominant" crop in each state. Within- and between-state analyses of the crops compare the net returns per acre of the feed grain group (barley, corn, grain sorghum and oats) with food grain (wheat) and soybeans. Between-state shifts in comparative advantage for the field crops (using the dominant crop in each state) are evaluated using Iowa corn as the base for the period.

Feed-Livestock

Evaluation of the effects of changes in feed-livestock conversion rates are made on the basis of their effect on supply costs for animal products and cross-elasticity effects (if any) on the demand side. General changes between the 1922–1941 period and the 1950–1965 period are directionally noted but only the changes during the 1950–1965 period are studied and evaluated.

The livestock-feed conversion analysis points out which livestock class should be gaining relative to all livestock classes studied. Indirectly, this evaluation indicates which state or region has made relative gains because of locational advantages for specific livestock classes.

Marketing Margins

The marketing margins evaluation assumes a competitive costs system. Price analyses using regression techniques between the farm level and the retail level in the market are used to estimate aggregate economic effects of changes in the marketing system. The prewar period (1922–1941) is compared with the post-war periods of 1947–1964 or 1950–1967. The goal of the marketing margins evaluation is to separate the effects of technological change from the general economic demand shifters of income, population and preference or taste changes.

Aggregate

The changes in crop supply costs and derived net incomes per acre are used both within a state and between states to evaluate the change in relative competitive position of states in field crop activities. Livestock and marketing system effects are included to expand the evaluation to full farm-level relative changes in competitive strength as well as suggesting implied changes in enterprise specialization over time.

General policy evaluations are made to appraise whether more rapid adoption or greater specialization should be accelerated by special programs.

INTRASTATE FIELD CROP ANALYSIS

Corn Belt

Oats (and barley in Missouri) have not been economically competitive in the Corn Belt with other crops being evaluated. Net return per acre values for oats are included in figures for each state but no analyses are made of technological effects.

Illinois

Four crops are evaluated for Illinois: corn, oats, wheat and soybeans. Corn is the dominant crop in Illinois (Fig. 2) . Soybeans rank second, wheat third. The adjusted net return for soybeans and wheat indicates that neither crop has seriously challenged the absolute advantage of corn. When soybeans were evaluated at actual market

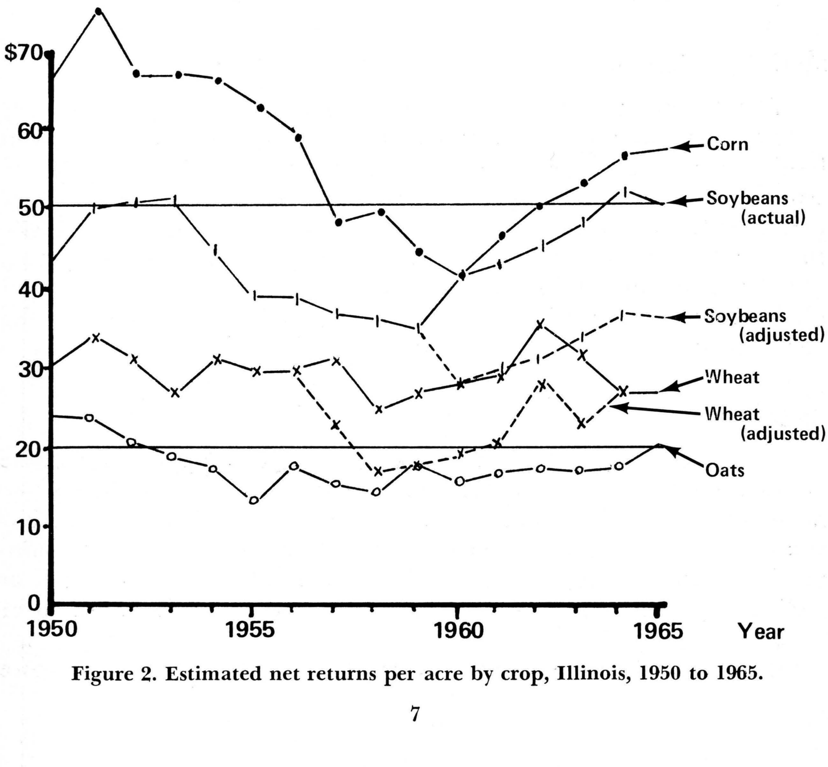

Figure 2. Estimated net returns per acre by crop, Illinois, 1950 to 1965.

prices, however, there was a definite reduction in the magnitude of the absolute advantage held by corn.

Corn received the greatest technological push in Illinois ($17.68) (Table 1). Fertilizer contributed slightly more to corn net returns than did the other two increments. Varietal improvement was the major technological contributor to wheat net returns. The aggregate price effect was negative for all crops, except when soybeans were evaluated at market prices. Technology has contributed to the incomes of producers in Illinois but product price movements during the periods have more than offset technology gains.

Table 1. Changes in net returns per acre due to technological factors and price effects for selected crops in Illinois from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	5.48	5.87	6.33	17.68	18.85	44.88	–26.03	–8.35
Wheat[a]	1.15	4.58	1.06	6.79	20.93	31.79	–10.86	–4.07
Wheat[b]	1.47	4.74	1.22	7.43	17.63	29.12	–11.49	–4.06
Soybeans[c]	–7.11[d]	4.07	7.17	4.13	15.31	26.31	–11.00	–5.87
Soybeans[b]	–7.51[d]	4.47	7.51	4.47	23.23	20.44	+ 2.79	+7.26

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] Price adjusted 1960–1965.

[d] The negative value for soybeans from other factors was due to problems of analytic separation. The total technological value for Illinois soybeans was acceptable for between crop and between state comparisons.

Table 2. Changes in net returns per acre due to technological factors and price effects for selected crops in Indiana from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	–5.03[d]	4.81	3.22	3.00	14.07	42.05	–27.98	–24.98
Wheat[a]	.59	5.96	1.15	7.70	23.67	36.52	–12.85	– 5.15
Wheat[b]	.84	6.72	1.52	9.08	21.77	31.39	– 9.62	– .54
Soybeans[c]	2.23	6.16	1.07	9.46	17.26	29.39	–12.13	– 2.67
Soybeans[b]	2.75	6.74	1.19	10.68	24.52	22.26	+ 2.26	+12.94

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] Price adjusted 1960–1965.

[d] The negative value for corn (other factors) was due to problems of analytic separation. The total technological value for Indiana corn was acceptable for between crop and between state comparisons.

Indiana

The four crops evaluated in Indiana are corn, oats, wheat and soybeans. Corn is the dominant crop in Indiana (Fig. 3). Soybeans are ranked second but they have been competitive with corn since 1957. Wheat is ranked third. Using market prices, net returns per acre for soybeans have exceeded corn since 1959. Wheat returns per acre have gained considerably on corn during the period.

Soybeans realized the largest technological gains in Indiana ($9.46) (Table 2). Varietal improvement was the largest contributor to the change in net returns per acre for all crops. Negative price effects dominated the period for each crop, except when soybeans were evaluated at market prices.

Iowa

The four crops evaluated in Iowa are corn, oats, wheat and soybeans. Corn is the dominant crop in Iowa (Fig. 4). Soybeans are the second ranked crop. Wheat is third. Adjusted net returns for soybeans and wheat indicate that neither crop has seriously challenged the

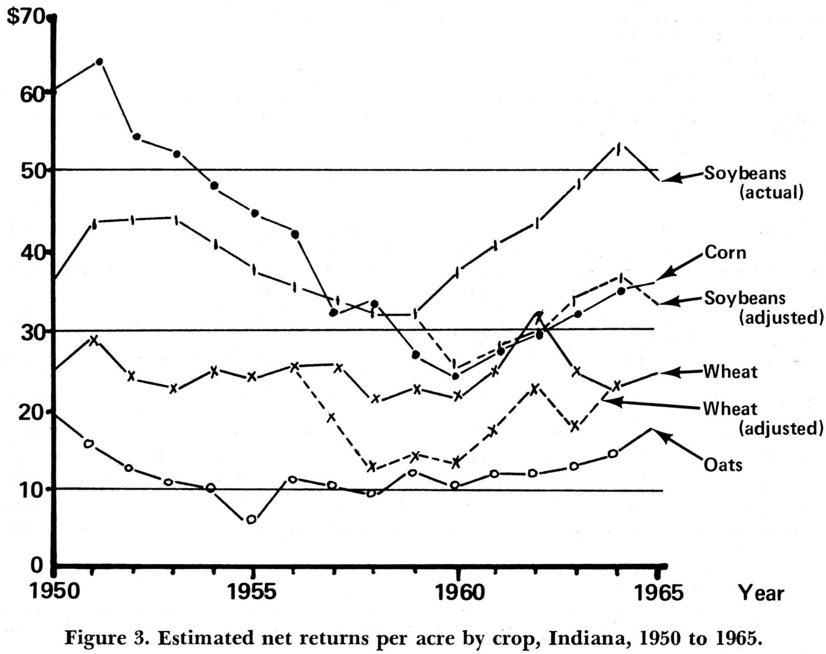

Figure 3. Estimated net returns per acre by crop, Indiana, 1950 to 1965.

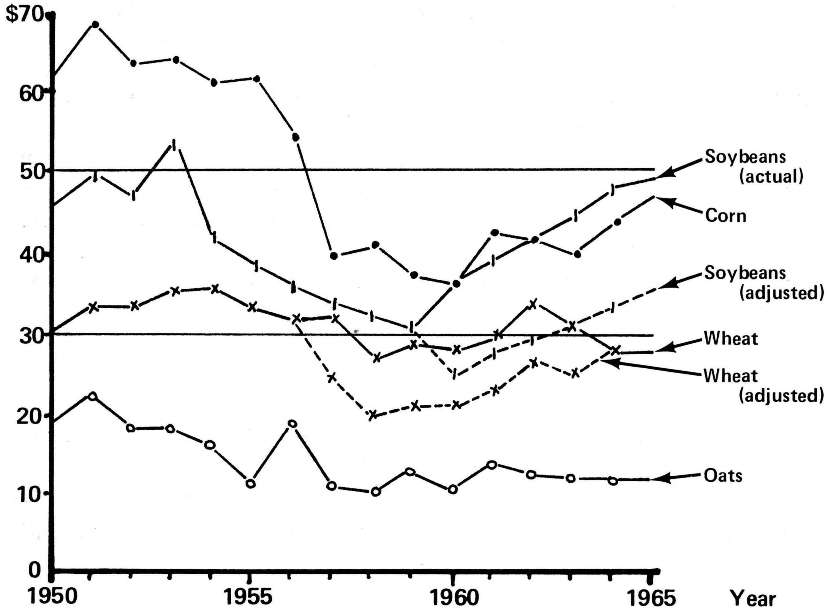

Figure 4. Estimated net returns per acre by crop, Iowa, 1950 to 1955.

absolute advantage enjoyed by corn. When soybeans and wheat are evaluated at actual market prices, there is a definite reduction in the magnitude of the absolute advantage held by corn. From 1963 to 1965 soybeans had higher net returns per acre than corn when actual market prices were used in calculating net returns per acre.

Table 3. Changes in net returns per acre due to technological factors and price effects for selected crops in Iowa from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	.69	7.95	−2.97	5.67	19.51	41.75	−22.24	−16.57
Wheat[a]	−1.44	2.12	5.48	6.16	12.56	22.90	−10.34	− 4.18
Wheat[b]	−1.36	2.40	5.56	6.60	9.28	19.04	− 9.76	− 3.16
Soybeans[c]	1.05	1.11	− .05	2.11	16.83	30.99	−14.16	−12.05
Soybeans[b]	1.45	1.37	− .04	2.78	24.60	24.95	− .35	+ 2.43

[a] Price adjusted 1957–1963.
[b] Actual output prices.
[c] Price adjusted 1960–1965.

Wheat (adjusted price) registered the largest technological gains in Iowa ($6.16) (Table 3). Fertilizer was the most important technological contributor to wheat net returns per acre, while varietal improvement was the most important for corn and soybeans. Negative aggregate price effects occur for all crops, with the largest being for corn at $22.24 per acre.

Overall, the dominant position of corn in Iowa is being moderately challenged by soybeans. Wheat has gained on corn in a relative sense but the absolute net return per acre differences are still large. Technology gains by the three crops have been small in Iowa. The gains made by all three crops have been offset by negative market price effects during the 1950 to 1965 period.

Missouri

The five crops evaluated in Missouri are barley, corn, oats, wheat and soybeans.

Corn is the dominant crop in Missouri (Fig. 5). Wheat and soybeans are about tied for second. Adjusted net returns per acre indi-

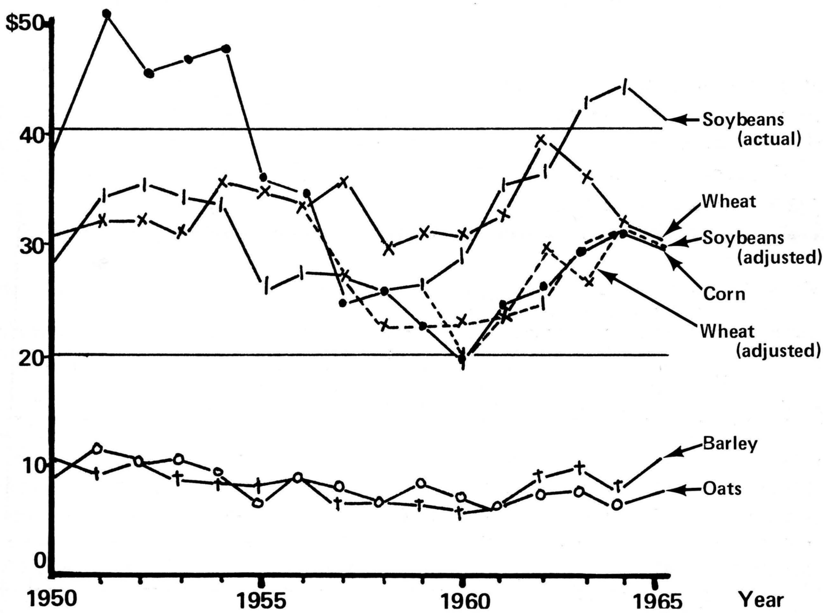

Figure 5. Estimated net returns per acre by crop, Missouri, 1950 to 1965.

Table 4. **Changes in net returns per acre due to technological factors and price effects for selected crops in Missouri from 1950 to 1965.**

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	–4.10[d]	4.13	3.65	3.68	20.63	33.72	–13.09	– 9.41
Wheat[a]	.61	3.96	4.70	9.27	18.05	28.28	–10.23	– .96
Wheat[b]	.86	4.29	4.91	10.06	13.58	24.61	–11.03	– .97
Soybeans[c]	3.34	5.29	– .69	7.94	16.08	27.24	–11.16	– 3.22
Soybeans[b]	3.98	5.99	– .67	9.30	21.01	18.34	+ 2.67	+11.97

[a] Price adjusted 1957–1963.
[b] Actual output prices.
[c] Price adjusted 1960–1965.
[d] The negative incremental value for corn (other factors) was due to problems of analytic separation. The total technological value for Missouri corn was accepted for between crop and between state comparisons.

cate that both soybeans and wheat have challenged the absolute advantage held by corn. During the periods where soybeans and wheat were evaluated at actual market prices, both crops had higher net returns per acre than corn.

Wheat ($9.27) registered the largest technological gains in Missouri (Table 4). Varietal improvement was a significant contributor to net returns per acre for all crops. Fertilizer was also important for corn and wheat.

Using adjusted prices, negative price effects dominated the period for each crop ranging from -$10.23 per acre for wheat to -$13.09 for corn. Net returns per acre for corn, after technological effects and price effects are totaled, were reduced by $9.41 from their 1950 net returns per acre level. Wheat and soybean net returns for the same period were reduced 96¢ and $3.22, respectively, with adjusted prices. Soybeans gained $11.97 in net returns for the 16-year period when actual soybean prices were used.

Ohio

The four crops evaluated in Ohio are corn, oats, wheat and soybeans. Corn is the dominant crop in Ohio (Fig. 6). Soybeans are ranked second; wheat, third. The adjusted net return lines for soybeans and wheat indicate that neither crop has seriously challenged the absolute advantage enjoyed by corn. If actual market prices are used, soybeans had an absolute advantage over corn since 1960. During the 16-year period, the largest relative gains in absolute advantage have been made by wheat (at actual prices).

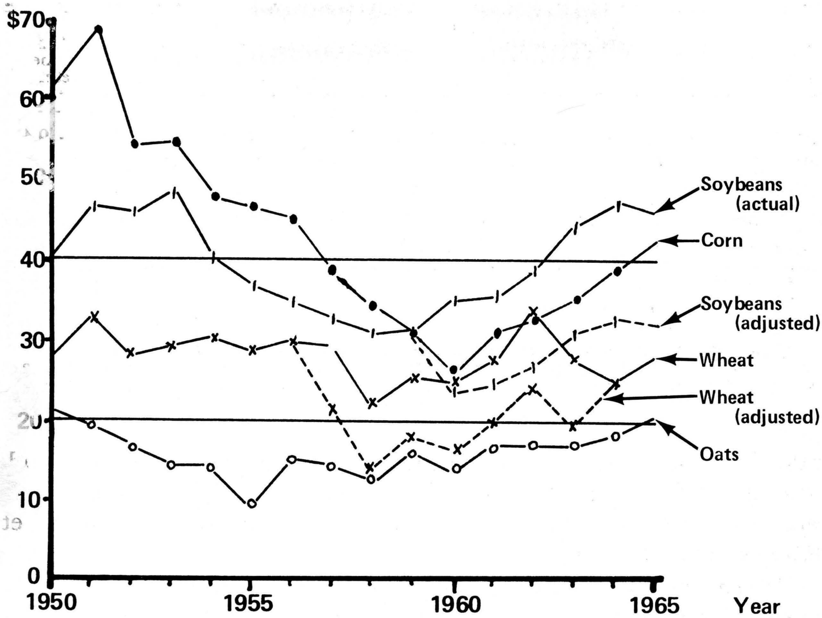

Figure 6. Estimated net returns per acre by crop, Ohio, 1950 to 1965.

Wheat ($6.68) received the largest technological push in Ohio (Table 5). Fertilizer was the most important technology for corn and wheat, varietal improvement the most important for soybeans.

Table 5. Changes in net returns per acre due to technological factors and price effects for selected crops in Ohio from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	−1.38	.85	5.81	5.28	19.52	44.98	−25.46	−20.18
Wheat[a]	.65	2.09	3.94	6.68	27.73	36.78	− 9.05	− 2.37
Wheat[b]	.89	2.25	4.06	7.20	22.18	31.77	− 9.59	− 2.39
Soybeans[c]	−3.50[d]	4.99	.93	2.42	15.87	27.97	−12.10	− 9.68
Soybeans[b]	−3.55[d]	5.30	1.02	2.77	23.71	22.34	+ 1.37	+ 4.14

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] Price adjusted 1960–1965.

[d] The negative net incremental value for soybeans from other factors was due to problems of analytic separation. The total technological value for Ohio soybeans was acceptable for between crop and between state comparisons.

Using adjusted prices, negative price effects dominated the period for each crop. Corn was the hardest hit with aggregate price effects being a negative $25.46. Soybeans had a positive aggregate price effect of $1.37 when actual market prices were used. Net returns per acre for corn, after technological and price effects are totaled, were reduced by $20.18 from their 1950 net returns per acre level. Wheat and soybean net returns per acre for the same period were reduced $2.37 and $9.68, respectively, with adjusted prices. Soybeans gained $4.14 per acre in net returns for the 16-year period using actual market prices.

Northern Plains

The yield and value increments attributable to technology indicate that oats have not been economically competitive in the Northern Plains with the other crops being evaluated. The same seems to be true for corn in North Dakota and barley in Kansas and Nebraska. Net return per acre values for these crops are included in the figure for each state but no analyses are made of the technological effects.

Kansas

The five crops evaluated in Kansas are barley, corn, grain sorghum, oats and wheat. Wheat is the dominant crop in Kansas (Fig. 7). Corn is ranked second; grain sorghum, third. The net return line for corn indicates that corn has earned net returns per acre almost equal to those of wheat (at adjusted prices) during the entire 16 years. When actual market prices were used, wheat had a larger absolute advantage for a 7-year period from 1957 to 1964. Grain sorghum net returns per acre increased considerably relative to wheat returns from 1958 to 1965.

Corn ($12.01) received the largest technological gain in Kansas (Table 6). The largest single technological contributor to corn was fertilizer. Varietal improvement was the major technological contributor to grain sorghum. Wheat had positive technological gains from all three technologies but ranked third in total technological gains for the 1950 to 1965 period.

Both corn and grain sorghum had fairly large technological gains which offset negative price effects during the 16 years. Grain sorghum was the biggest gainer in net returns per acre ($5.63) with corn second at $4.09. Wheat lost $2.93 when adjusted wheat prices were used. Negative price effects (—$7.39) were larger than the technological effects ($4.46).

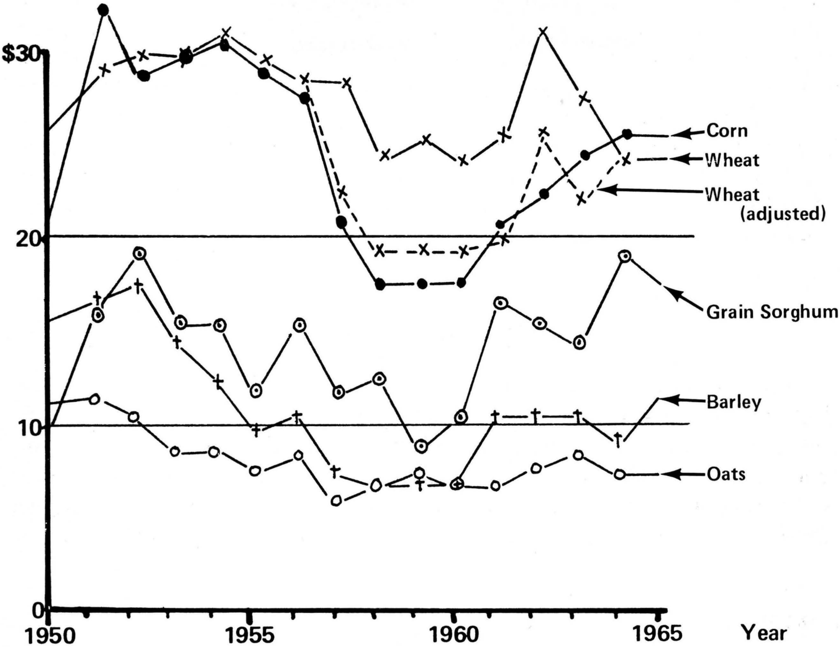

Figure 7. Estimated net returns per acre by crop, Kansas, 1950 to 1965.

Nebraska

The six crops evaluated in Nebraska are barley, corn, grain sorghum, oats, wheat and soybeans. Corn is the dominant crop in Ne-

Table 6. Changes in net returns per acre due to technological factors and price effects for selected crops in Kansas from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	−0.66	3.42	9.25	12.01	15.05	22.97	−7.92	+4.09
Grain Sorghum	−1.51	7.59	1.21	7.29	21.77	23.43	−1.66	+5.63
Wheat[a]	2.56	.42	1.48	4.46	13.02	20.41	−7.39	−2.93
Wheat[b]	2.92	.47	1.85	5.24	10.54	19.19	−8.65	−3.41

[a] Price adjusted 1957–1963.
[b] Actual output prices.

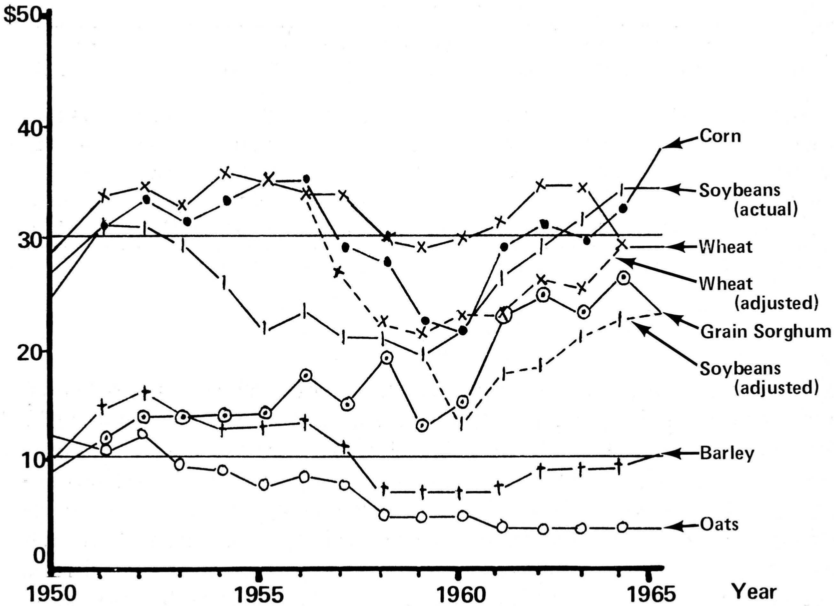

Figure 8. Estimated net returns per acre by crop, Nebraska, 1950 to 1965.

braska (Fig. 8). Wheat is second, soybeans third and grain sorghum fourth. Using adjusted prices, soybeans have not improved their position relative to corn. The largest gains in net returns per acre were made by grain sorghum. During the period when wheat was evaluated at actual market prices, it had higher net returns per acre than corn. Soybean net returns per acre were about equal to those for corn from 1960 to 1965 when actual prices were used.

Corn and grain sorghum both registered large technological gains in Nebraska (Table 7). Corn had a net technological gain of $19.08 per acre and grain sorghum $16.86 per acre. Other factors (mainly irrigation water) were the largest contributors to net returns per acre for corn and grain sorghum.

Varietal improvement and fertilizer gains were expanded through the use of irrigation water. Varietal improvement was an important contributor to soybean net returns.

Using adjusted prices, negative price effects dominated the 1950

Table 7. **Changes in net returns per acre due to technological factors and price effects for selected crops in Nebraska from 1950 to 1965.**

Crop	Technological values: Other factors	Var. imp.	Ferti-lizer	Total	Price effects: Posi-tive	Nega-tive	Aggre-gate	Change in net returns
	(dollars per acre)							
Corn	9.67	5.13	4.28	19.08	16.15	25.16	−9.01	+10.07
Grain Sorghum	9.28	4.75	2.83	16.86	25.49	29.32	−3.83	+13.03
Wheat[a]	3.21	.27	3.57	7.05	11.24	20.01	−8.77	− 1.72
Wheat[b]	3.65	.32	3.98	7.95	8.57	17.23	−8.66	− .71
Soybeans[c]	1.81	3.67	− .44	5.04	14.52	23.90	−9.38	− 4.34
Soybeans[b]	2.29	4.10	− .45	5.94	20.47	17.42	+3.05	+ 8.99

[a] Price adjusted 1957–1963.
[b] Actual output prices.
[c] Price adjusted 1960–1965.

to 1965 period for each crop. Three crops (corn, wheat and soybeans) had negative price effects (adjusted prices) that ranged from $8.77 for wheat to a high of $9.38 for soybeans. Soybeans had a positive price effect of $3.05 when actual market prices were used. Net returns per acre for grain sorghum, after the technological effects and price effects are totaled, were increased by $13.03 from their 1950 net returns per acre level. Corn net returns per acre also had a positive net change of $10.07. Wheat and soybean net returns for the same period were reduced $1.72 and $4.34, respectively, with adjusted prices. Soybeans gained $8.99 in net returns for the 16 years when actual soybeans prices were used.

Corn is maintaining an absolute advantage in Nebraska. Wheat is a strong challenger in marginal corn areas. Both grain sorghum and soybeans gained on corn during the period. Technological gains have favored corn and grain sorghum in Nebraska to a larger degree than the technology gains enjoyed by either wheat or soybeans. Negative price effects dominated the period but technology gains were larger than the negative price effects so net return per acre gains from 1950 to 1965 were made by corn and grain sorghum. Negative price effects washed out all technological gains made by wheat and soybeans when adjusted prices were used.

North Dakota

The four crops evaluated in North Dakota are barley, corn, oats and wheat. Wheat is the dominant crop in North Dakota (Fig. 9). Barley is second. When the adjusted net return line for wheat is used, there is no indication that barley is challenging the absolute advantage

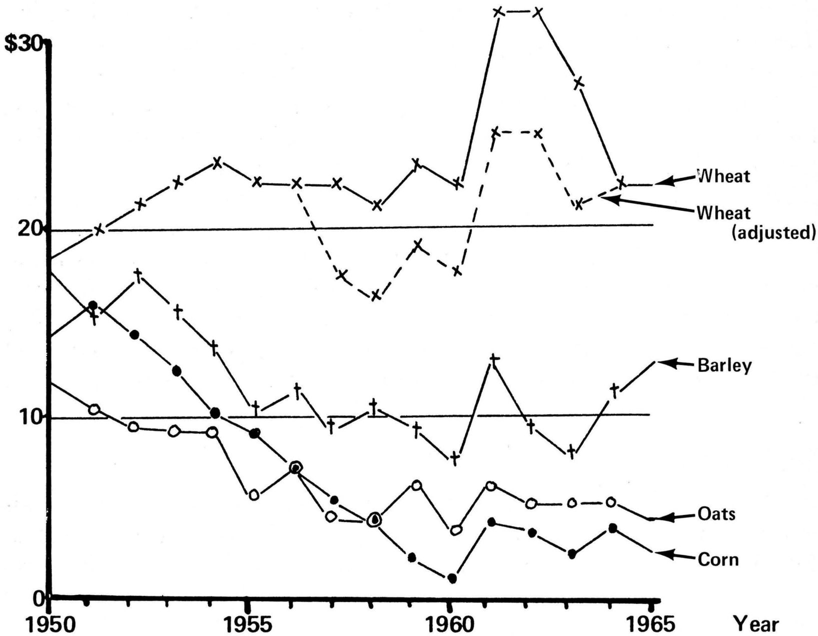

Figure 9. Estimated net returns per acre by crop, North Dakota, 1950 to 1965.

held by wheat. The net return per acre line for wheat, using actual wheat prices, indicates that the absolute advantage held by wheat in North Dakota has been getting stronger.

Wheat ($9.61) registered the largest technological gains in North Dakota (Table 8). Varietal improvement was the most important

Table 8. Changes in net returns per acre due to technological factors and price effects for selected crops in North Dakota from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Barley	–4.81[c]	3.93	.58	– .30	14.84	18.94	–4.10	–4.40
Wheat[a]	1.84	5.43	2.34	9.61	12.43	18.63	–6.20	+3.41
Wheat[b]	2.13	6.05	2.68	10.86	11.42	17.84	–6.42	+4.44

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] The negative net incremental value for barley (other factors) was due to problems of analytic separation. The total technological value for North Dakota barley was accepted for between state comparisons.

single contributor to net returns per acre for both wheat and barley. The negative effect of other factors was large enough to give a total negative effect to barley technology for the 1950 to 1965 period.

Using adjusted prices, negative price effects dominated the period for both crops. Net returns per acre for wheat, after technological effects and price effects are totaled, were increased by $3.41 from their 1950 net returns per acre level. Barley net returns per acre were reduced $4.30 over the same period. Wheat gained $4.44 in net returns per acre using actual market prices. The dominant position held by wheat in North Dakota has not been seriously challenged. Good technological gains made by wheat have more than offset negative price effects that prevailed in the market during the 1950 to 1965 period. Barley has lost in absolute advantage relative to wheat.

South Dakota

The four crops evaluated in South Dakota are barley, corn, oats and wheat. Corn is the dominant crop (Fig. 10). Wheat is second; barley, third. The adjusted net return line for wheat indicates that wheat

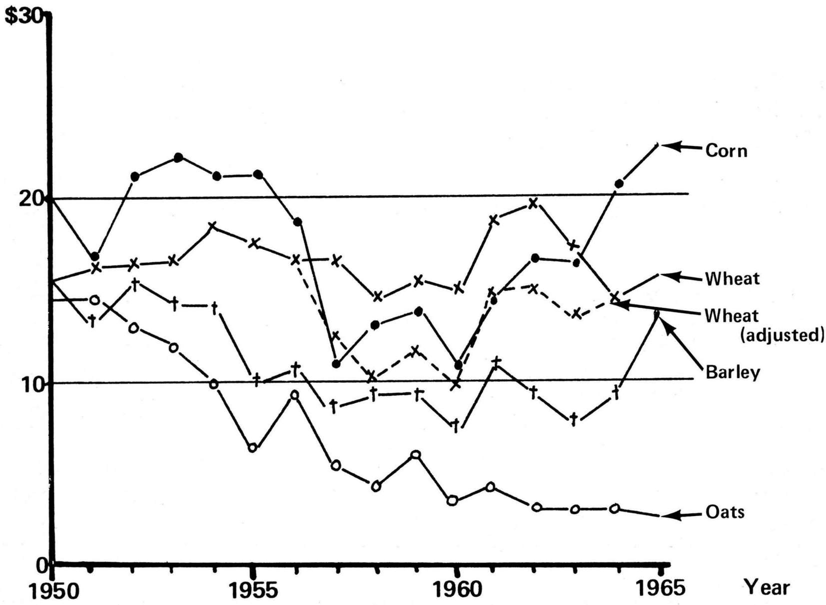

Figure 10. Estimated net returns per acre by crop, South Dakota, 1950 to 1965.

Table 9. Changes in net returns per acre due to technological factors and price effects for selected crops in South Dakota, 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti- lizer	Total	Posi- tive	Nega- tive	Aggre- gate	
	(dollars per acre)							
Barley	−1.84	2.67	1.18	2.01	12.46	16.98	−4.52	−2.51
Corn	.65	4.18	4.41	9.24	14.90	21.64	−6.74	+2.50
Wheat[a]	− .74	2.70	1.80	3.76	9.18	12.60	−3.42	+ .34
Wheat[b]	− .63	2.90	2.01	4.28	7.60	11.54	−3.94	+ .32

[a] Price adjusted 1957–1963.
[b] Actual output prices.

challenged the absolute advantage held by corn in the late 1950s and early 1960s. Corn improved its net return position over wheat from 1963 to 1965. Barley, ranked third, has not changed its position relative to corn but has gained slightly relative to wheat. If actual market prices are used for wheat, it held an absolute advantage over corn from 1957 to 1963.

Corn ($9.24) received the largest technological push in South Dakota (Table 9). Varietal improvement and fertilizer were about equal contributors to corn net returns per acre. Varietal improvement was the single most important contributor to net returns for barley and wheat. Negative technological effects from other factors were experienced by barley and wheat.

Using adjusted prices, negative price effects dominated the period for all crops. Corn was the hardest hit with aggregate price effects being a negative $6.74. Net returns per acre for corn, after technological effects and price effects are totaled, were increased by $2.50 from the 1950 net return per acre level. Wheat net returns per acre for the same period were increased 34¢, using adjusted prices. Barley had a net reduction of $2.51 in net returns per acre.

Lake States

Oats in the Lake States (and barley in Michigan and Minnesota) based on technological change estimates have not been economically competitive with the other crops evaluated. Net return per acre values for the two crops are included in the figure for each state but no analyses are made of technological effects.

Michigan

The five crops evaluated in Michgan are barley, corn, oats, wheat and soybeans. Corn is dominant. (Fig. 11). Wheat and soybeans are

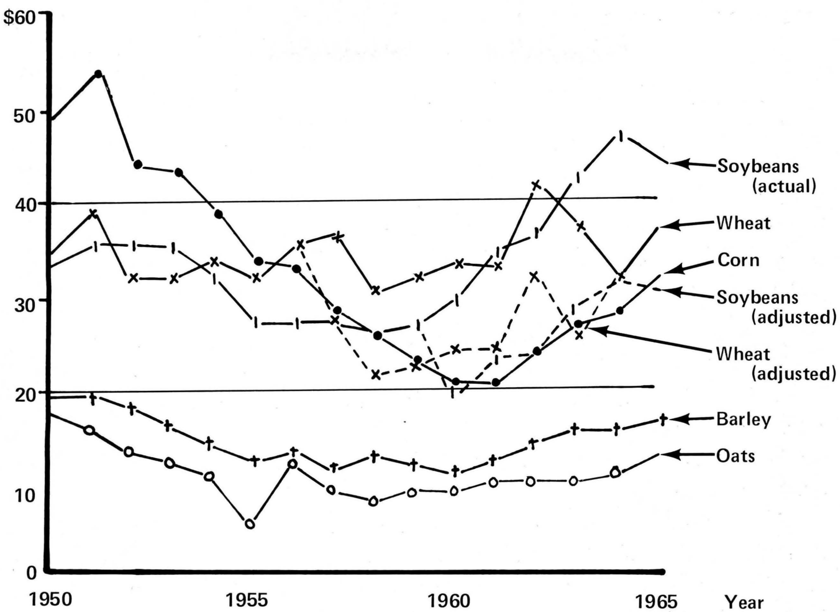

Figure 11. Estimated net returns per acre by crop, Michigan, 1950 to 1965.

tied for second in absolute advantage. The adjusted net return lines for soybeans and wheat indicate that both crops have earned net returns per acre equal to those of corn since 1955. If actual market prices are used, wheat and soybeans both have strongly outcompeted corn in the last part of the period.

Wheat ($12.42) registered the largest net technological gains in Michigan (Table 10). Varietal improvement was the most important contributor to net returns per acre for all crops.

Using adjusted prices, negative price effects dominated the period for each crop. Corn's $19.91 per acre loss was the largest for the three crops. Soybeans experienced a positive aggregate price effect of $1.09 when actual market prices were used. Negative price effects eliminated the net return gains obtained from technology for corn (net returns per acre were reduced $15.92). Using adjusted prices, wheat had positive net return gains of $3.60 after technology and price effects were totaled. Soybeans lost $2.71 for the period when adjusted prices were used. Soybeans gained $12.06 in net returns per acre when actual prices were used.

Table 10. Changes in net returns per acre due to technological factors and price effects for selected crops in Michigan, 1950 to 1965.

Crop	Technological values: Other factors	Var. imp.	Ferti-lizer	Total	Price effects: Posi-tive	Nega-tive	Aggre-gate	Change in net returns
	(dollars per acre)							
Corn	1.04	7.19	−4.24	3.99	12.48	32.39	−19.91	−15.92
Wheat[a]	−1.74	13.03	1.13	12.42	26.95	35.77	− 8.82	+ 3.60
Wheat[b]	−1.67	14.45	1.49	14.27	22.27	32.63	−10.36	+ 3.91
Soybeans[c]	2.03	6.19	1.36	9.58	13.57	25.86	−12.29	− 2.71
Soybeans[b]	2.54	6.82	1.61	10.97	19.06	17.97	+ 1.09	+12.06

[a] Price adjusted 1957–1963.
[b] Actual output prices.
[c] Price adjusted 1960–1965.

Minnesota

The five crops evaluated in Minnesota are barley, corn, oats, wheat and soybeans. Corn is dominant (Fig. 12). Soybeans are second, wheat, third. The adjusted net return lines for soybeans and wheat indicate that both crops have challenged the absolute advantage held by corn.

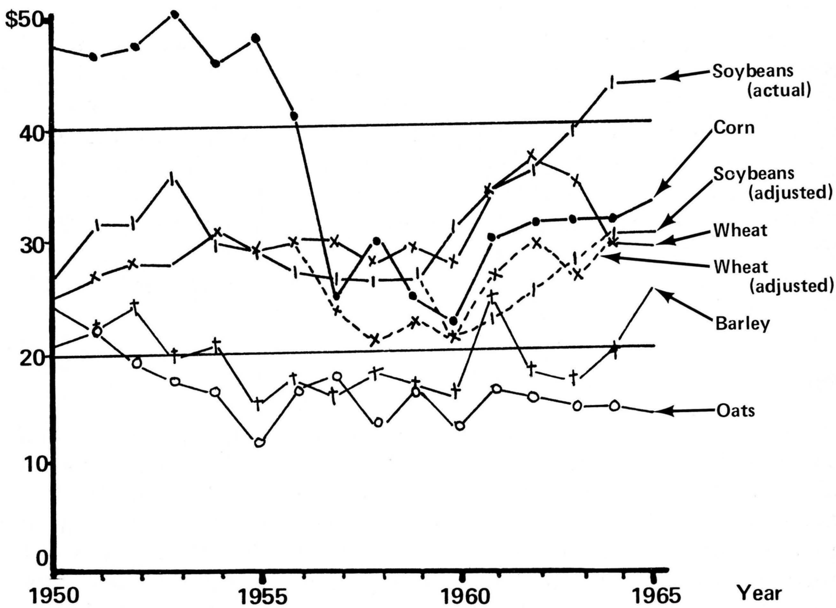

Figure 12. Estimated net returns per acre by crop, Minnesota, 1950 to 1965.

Table 11. **Changes in net returns per acre due to technological factors and price effects for selected crops in Minnesota, 1950 to 1965.**

Crop	Technological values: Other factors	Var. imp.	Ferti-lizer	Total	Price effects: Posi-tive	Nega-tive	Aggre-gate	Change in net returns
	(dollars per acre)							
Corn	−3.36[d]	5.83	.24	2.71	18.78	37.06	−18.28	−15.57
Wheat[a]	−3.73[d]	14.65	−.91	10.01	15.20	21.30	− 6.10	+ 3.91
Wheat[b]	−3.80[d]	15.80	−.66	11.34	12.42	19.85	− 7.43	+ 3.91
Soybeans[c]	.38	9.51	.75	10.64	14.05	21.87	− 7.82	+ 2.82
Soybeans[b]	.71	10.12	.73	11.56	21.58	16.78	+ 4.80	+16.36

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] Price adjusted 1960-1965.

[d] The negative net incremental value for corn and wheat (other factors) was due to problems of analytic separation. The total technological values for the two Minnesota crops were accepted for between crop and between state comparisons.

Wheat and soybeans both had about the same technological gain in net returns per acre, $10.01 and $10.64, respectively (Table 11). Varietal improvement was the largest single contributor to net returns per acre for all three crops.

Using adjusted prices, negative price effects dominated the period for each crop. However, when actual soybean prices were used, the price effect was positive. Corn was the hardest hit with aggregate price effects being a negative $18.28. Net returns for corn, after the technological effects and price effects are totaled, were reduced by $15.57 from their 1950 net returns per acre level. Wheat and sobean net returns per acre for the same period were increased $3.91 and $2.82, respectively, with adjusted prices. Soybeans gained $16.36 per acre in net returns for the 16-year period with actual market prices.

Wisconsin

The four crops evaluated in Wisconsin are corn, oats, wheat and soybeans. Corn is dominant (Fig. 13). Wheat is second; soybeans (slightly ahead of oats), third. The adjusted net return lines for soybeans and wheat indicate that neither crop has seriously challenged the absolute advantage held by corn. If actual market prices are used, wheat has improved its position relative to corn, especially during the 1957 to 1963 period. Soybeans (at market price) gained slightly on corn during the latter part of the 1950 to 1965 period.

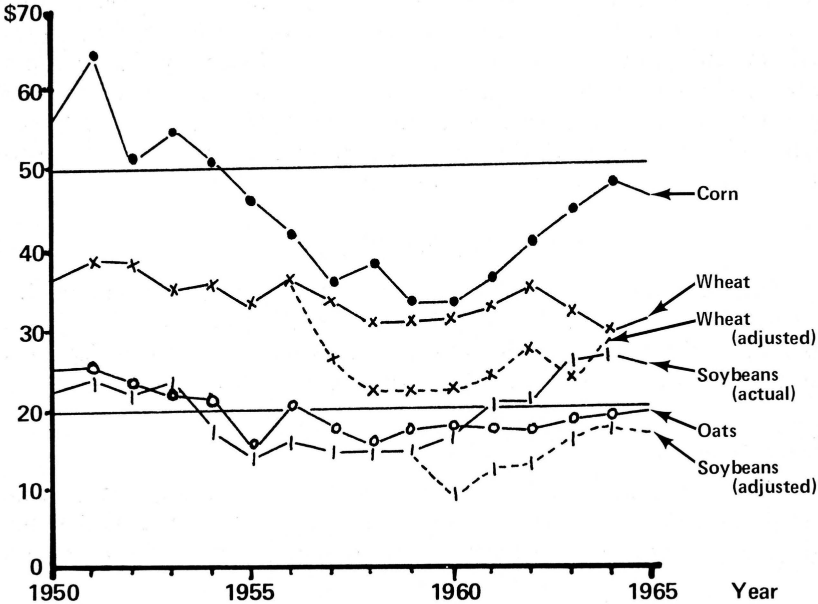

Figure 13. Estimated net returns per acre by crop, Wisconsin, 1950 to 1965.

Corn ($12.67) received the largest technological push in Wisconsin (Table 12). Varietal improvement and fertilizer were the most important technological contributors to corn net returns per acre.

Table 12. Changes in net returns per acre due to technological factors and price effects for selected crops in Wisconsin from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Fertilizer	Total	Positive	Negative	Aggregate	
	(dollars per acre)							
Corn	–4.54[d]	9.68	7.53	12.67	18.44	42.08	–23.64	–10.97
Wheat[a]	2.73	1.15	– .73	3.15	19.17	28.68	– 9.51	– 6.36
Wheat[b]	3.15	1.31	– .79	3.67	12.95	22.94	– 9.99	– 6.32
Soybeans[c]	–5.90[d]	9.60	1.28	4.98	8.22	19.43	–11.21	– 6.23
Soybeans[b]	–6.23[d]	10.54	1.02	5.33	11.29	13.45	– 2.16	+ 3.17

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] Price adjusted 1960–1965.

[d] The negative net incremental values for corn and soybeans (other factors) were caused by problems of analytic separation. The total technological values for the two Wisconsin crops were accepted for between crop and between state comparisons.

Using adjusted prices, negative price effects dominated the period for each crop. Corn was hit hardest with aggregate price effects being a negative $23.64. Net returns per acre for corn, after technological effects and price effects are totaled, were reduced by $10.97 from their 1950 net returns per acre level. Wheat and soybean net returns per acre for the same period were reduced $6.36 and $6.23, respectively, with adjusted prices. Soybeans gained $3.17 per acre in net returns for the 16 years with actual market prices.

Southern Plains

Oats (and barley in Texas) have not been economically competitive in the Southern Plains with the other crops evaluated. Net return per acre values for the two crops are included on the figure for each state but no analyses are made of the technological effects.

Oklahoma

The five crops evaluated in Oklahoma are barley, corn, grain sorghum, oats and wheat. Wheat is the dominant crop in Oklahoma (Fig. 14). Corn is second, barley third and grain sorghum fourth.

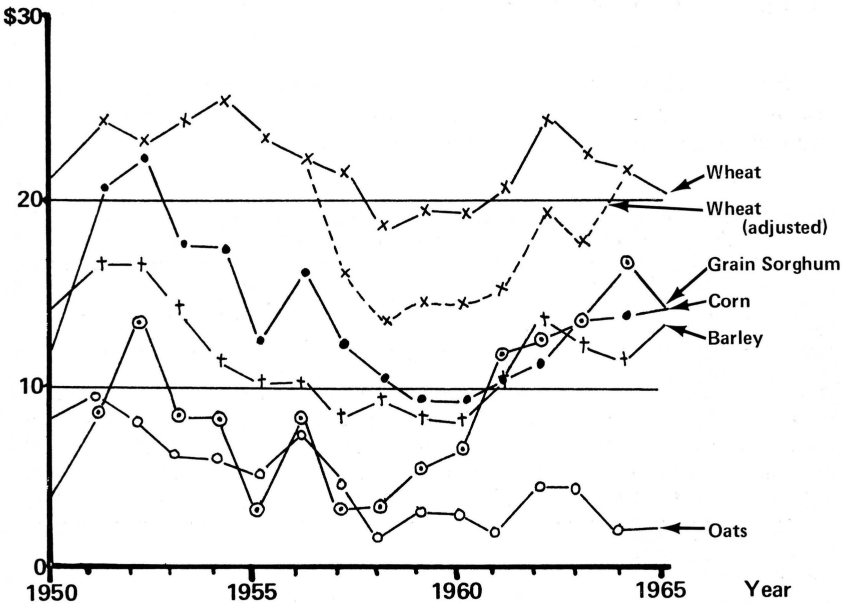

Figure 14. Estimated net returns per acre by crop, Oklahoma, 1950 to 1965.

When the adjusted net return per acre line is used for wheat, there is no indication that corn is challenging the absolute advantage held by wheat. The net return line for wheat, using actual market prices, indicates that the absolute advantage held by wheat in Oklahoma is strong. The largest relative gains in absolute advantage have been made by grain sorghum.

Grain sorghum registered the largest technological gains in Oklahoma at $9.25 per acre compared to about $3 per acre for the other crops (Table 13). Varietal improvement was the largest single technological contributor to grain sorghum ($7.36).

Negative price effects for the period prevailed for all crops except grain sorghum. Wheat was the hardest hit with aggregate price effects (adjusted wheat prices) being a negative $5.83. Barley was next with aggregate price effects being a negative $4.29. Net returns for wheat, after technological effects and price effects are totaled, were reduced by $3 from their 1950 net return per acre level. Barley experienced a reduction of $1.29 over the same period. Both corn ($1.07) and grain sorghum ($9.62) realized a net gain for the period.

The dominant position held by wheat in Oklahoma has only been moderately challenged by the other three crops in the 1950 to 1965 period. Wheat (also corn and barley) has received moderate technological gains. Grain sorghum received large technological gains and probably sometime in the future will be challenging the absolute advantage held by wheat. Negative price effects erased the technological gains for all crops except grain sorghum and corn.

Table 13. Changes in net returns per acre due to technological factors and price effects for selected crops in Oklahoma from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Barley	−2.72[c]	3.22	2.50	3.00	10.03	14.32	−4.29	−1.29
Corn	−4.40[c]	8.03	−.29	3.34	18.36	20.63	−2.27	+1.07
Grain Sorghum	1.52	7.36	.37	9.25	20.20	19.83	+ .37	+9.62
Wheat[a]	−4.78[c]	1.72	5.89	2.83	13.74	19.57	−5.83	−3.00
Wheat[b]	−5.00[c]	1.91	6.42	3.33	9.16	15.49	−6.33	−3.00

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] The negative net incremental values for barley, corn and wheat (other factors) was due to problems of analytic separation. The total technological values for the three Oklahoma crops were accepted for between crop and between state comparisons.

Texas

The five crops evaluated in Texas are barley, corn, grain sorghum, oats and wheat. Grain sorghum is dominant (Fig. 15), wheat second and corn third.

The absolute advantage held by grain sorghum in Texas has been increasing since 1956, when compared to wheat at adjusted prices. If actual wheat prices are used, the relative gain in absolute advantage by grain sorghum is somewhat smaller. Grain sorghum net returns per acre have been increasing relative to corn net returns since 1956. Corn has had about the same net returns per acre as wheat, when the adjusted wheat net return line and the corn net return line are compared.

Grain sorghum ($17.58) registered the largest technological gains in Texas (Table 14). Varietal improvement and other factors were the largest technological contributors to grain sorghum net returns per acre.

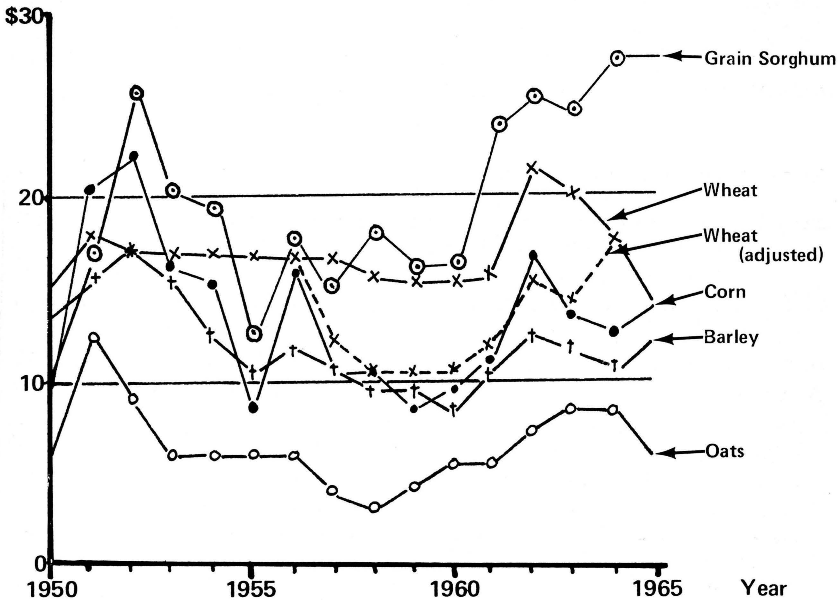

Figure 15. Estimated net returns per acre by crop, Texas, 1950 to 1965.

Table 14. Changes in net returns per acre due to technological factors and price effects for selected crops in Texas from 1950 to 1965.

Crop	Technological values				Price effects			Change in net returns
	Other factors	Var. imp.	Ferti-lizer	Total	Posi-tive	Nega-tive	Aggre-gate	
	(dollars per acre)							
Corn	–5.24[c]	6.19	1.61	2.56	20.48	21.27	– .79	+ 1.77
Grain Sorghum	7.71	7.14	2.73	17.58	25.47	26.72	–1.25	+16.33
Wheat[a]	– .05	– .35[c]	4.23	3.83	12.60	17.53	–4.93	– 1.10
Wheat[b]	.11	– .37[c]	4.90	4.64	8.88	14.61	–5.73	– 1.09

[a] Price adjusted 1957–1963.

[b] Actual output prices.

[c] The negative net incremental values for wheat (varietal improvement) and corn (other factors) were due to problems of analytic separation. The total technological values for the two Texas crops were accepted for between crop and between state comparisons.

Negative price effects dominated the period for each crop. Wheat was the hardest hit with aggregate price effects (at adjusted wheat prices) being a negative $4.93. Positive and negative price effects were nearly equal for corn during the period (–79¢). Net returns for grain sorghum, after the technological effects and price effects are totaled, were increased by $16.33 from their 1950 net return per acre level. Corn experienced an increase of $1.77 over the same period. Wheat had a net change of a negative $1.10.

INTERSTATE ANALYSIS

(Dominant Crops)

In each state there is a crop that has dominated the net returns per acre comparisons made within the state. The dominant state crop could be a feed grain, wheat or soybeans. Iowa corn was selected to make between-state comparisons of changes in comparative advantage. Changes in comparative advantage are determined by subtracting the net returns per acre for the dominant state crop from the net returns per acre of Iowa corn. These "index" numbers can be positive, negative or zero depending on the net return relationship that exists between Iowa corn and the dominant state crop (Table 15).

In states where wheat is the dominant crop, two index number evaluations are made. One evaluation is made with actual market wheat prices and the other evaluation is made with wheat prices that were adjusted for the 1957 to 1963 period. Soybeans are not included in this portion of the interstate analysis because soybeans were not the dominant crop in any of the 14 states.

Corn Belt

The dominant crop in each of the Corn Belt states is corn. The economic position of Indiana and Ohio corn, relative to Iowa corn, did not change. Missouri corn slightly reduced the comparative advantage of Iowa corn during the 1950–1965 period.

Table 15. Interstate analysis; the dominant crop in 13 states compared with Iowa corn (figures give net return differences per acre).

Year	Ill. corn	Ind. corn	Mo. corn	Ohio corn	Kansas wheat actual prices	Kansas wheat adj. prices	Nebr. corn	N.D. wheat actual
	(dollars per acre)							
1950	+ 3	− 2	−25	− 1	−36	−36	−35	−46
1951	+ 6	− 4	−18	0	−40	−40	−38	−49
1952	+ 4	− 8	−22	− 8	−34	−34	−39	−41
1953	+ 3	−11	−23	−10	−35	−35	−33	−42
1954	+ 4	−13	−19	−13	−30	−30	−28	−38
1955	0	−16	−27	−16	−33	−33	−28	−39
1956	+ 4	−12	−21	−10	−27	−27	−20	−32
1957	+ 7	− 7	−15	− 1	−12	−17	−12	−17
1958	+ 7	− 9	−17	− 7	−17	−24	−15	−21
1959	+ 8	− 9	−15	− 7	−12	−18	−14	−13
1960	+ 4	−12	−16	−10	−12	−18	−14	−13
1961	+ 5	−15	−17	−12	−16	−23	−13	−11
1962	+ 8	−12	−15	− 9	− 9	−16	−11	− 9
1963	+11	− 9	−12	− 4	−12	−19	−10	−13
1964	+13	− 8	−13	− 5	−20	−20	−10	−20
1965	+12	−11	−17	− 4	−23	−23	− 8	−23

Year	N.D. wheat adj.	S.D. corn	Mich. corn	Minn. corn	Wisc. corn	Okla. wheat actual	Okla. wheat adj.	Texas grain sorghum
	(dollars per acre)							
1950	−46	−44	−14	−15	− 5	−42	−42	−52
1951	−49	−52	−16	−22	− 5	−45	−45	−51
1952	−41	−41	−18	−16	−11	−39	−39	−38
1953	−42	−42	−21	−14	− 8	−40	−40	−43
1954	−38	−40	−23	−15	−10	−35	−35	−42
1955	−39	−40	−28	−14	−16	−38	−38	−50
1956	−32	−37	−22	−15	−12	−32	−32	−38
1957	−22	−29	−11	−16	− 3	−18	−23	−25
1958	−26	−29	−17	−12	− 3	−23	−28	−25
1959	−19	−24	−14	−12	− 3	−17	−22	−22
1960	−19	−25	−15	−13	− 2	−16	−21	−20
1961	−17	−28	−21	−12	− 6	−21	−27	−18
1962	−15	−25	−16	−11	− 1	−16	−21	−15
1963	−19	−23	−12	−10	+ 4	−17	−23	−15
1964	−20	−22	−14	−13	+ 3	−21	−21	−15
1965	−23	−24	−14	−14	+ 1	−28	−28	−19

Illinois

Illinois corn has positive index numbers from 1950 to 1965. Illinois corn has slightly improved its comparative advantage relative to Iowa corn. The largest improvement was from 1963 to 1965.

The intrastate evaluation indicates that other factors and fertilizer were partially responsible for the improved competitive position attained by Illinois corn. Varietal improvement gains slightly favored Iowa corn. Illinois corn had a net gain over Iowa corn of $12.01 in net returns per acre from technological sources.

Indiana

Indiana corn has negative index numbers from 1950 to 1965. The negative index numbers indicate that Iowa corn has higher net returns per acre than Indiana corn. There is no indication that Indiana corn has reduced the comparative advantage held by Iowa corn.

The intrastate evaluation indicates that varietal improvement technological gains for Iowa corn offset the total technological gains made by Indiana corn. Iowa corn held a $2.67 net technological gain edge over Indiana corn.

Missouri

Missouri corn has negative index numbers from 1950 to 1965. Missouri corn has reduced the comparative advantage held by Iowa corn. Missouri corn improved its position relative to Iowa corn mainly in the last nine years of the 1950 to 1965 period. The net return per acre differences between Missouri corn and Iowa corn ranged from a high of $25 per acre in 1950 to a low of $12 per acre in 1963.

The intrastate evaluation indicates that Iowa corn net technological gains were larger than the net technological gains made by Missouri corn. The net return advantage by Iowa corn was completely eliminated by large negative price effects. Iowa corn had a net loss of $7.16 per acre more in the 1950 to 1965 period than did Missouri corn. After the technological and price effects were totaled for the two states, Missouri corn had somewhat reduced the comparative advantage held by Iowa corn.

Ohio

Ohio corn has negative index numbers from 1950 to 1965. The net returns per acre differences between Iowa corn and Ohio corn ranged from a low of zero (0) difference per acre in 1951 to a high of $16 per acre in 1955. There is no indication that Ohio corn has reduced the comparative advantage held by Iowa corn.

The intrastate evaluation indicates that Iowa corn and Ohio corn net technological gains were about equal during the 1950 to 1965 period. Negative price effects during the 16 years were somewhat larger in Ohio. The result is that over the total period the comparative advantage held by Iowa corn has not been challenged by Ohio corn.

Northern Plains

The dominant crop was wheat in Kansas and North Dakota and corn in Nebraska and South Dakota. Both the corn and wheat producing states improved their net returns per acre position relative to Iowa corn. The improvement was relatively larger for Nebraska and North Dakota.

Kansas

Kansas wheat has negative index numbers from 1950 to 1965 for both actual and adjusted prices. The index numbers are getting smaller which indicates that Kansas wheat has been reducing the comparative advantage held by Iowa corn. It should be pointed out that since 1965 wheat prices have fallen sharply. It would be expected that the comparative advantage held by Iowa corn during the 1950 to 1956 period would closely parallel the wheat-corn net return relationships that have prevailed from 1965 to 1968.

The intrastate evaluation indicates that Iowa corn and Kansas wheat net technological gains were about equal during the 1950 to 1965 period. Large negative price effects for Iowa corn relative to Kansas wheat during the 1950 to 1965 period enabled wheat to reduce the comparative advantage held by Iowa corn.

Nebraska

Nebraska corn has negative index numbers from 1950 to 1965. The net return per acre differences between Nebraska corn and Iowa corn ranged from a high of $39 per acre in 1952 to a low of $8 per acre in 1965. The size of the reduction in comparative advantage of Iowa corn by Nebraska corn was one of the largest calculated for the 13 states evaluated.

The intrastate evaluation indicates that other factors, mainly irrigation and fertilizer usage, were partially responsible for the improved competitive position attained by Nebraska corn. Varietal improvement gains slightly favored Iowa corn. Nebraska corn had a net gain over Iowa corn of $13.41 in net returns per acre from technological sources. Nebraska corn had a $14.23 per acre advantage over

Iowa corn from negative price effect sources. After net technological gains and negative price effects were totaled for the two states, Nebraska corn has reduced the comparative advantage held by Iowa corn $27.64 per acre since 1950.

North Dakota

North Dakota wheat has negative index numbers from 1950 to 1965. Net returns per acre from Iowa corn were much larger than the net returns per acre received from North Dakota wheat. The index numbers are getting smaller which indicates that North Dakota wheat has been reducing the comparative advantage held by Iowa corn.

Wheat prices have fallen sharply since 1965. It would be expected that the comparative advantage held by Iowa corn during the 1950 to 1956 period would closely represent the wheat-corn net returns per acre relationships that have prevailed between the two crops from 1965 to 1968.

The intrastate evaluation indicates that North Dakota wheat net technological gains were larger than the net technological gains made by Iowa corn. The net technological gains plus large negative price effects for Iowa corn relative to North Dakota wheat during the 1950 to 1965 period enabled wheat to reduce the comparative advantage held by Iowa corn.

South Dakota

South Dakota corn has negative index numbers from 1950 to 1965. The net return per acre differences between South Dakota corn and Iowa corn ranged from a high of $52 per acre in 1951 to a low of $22 per acre in 1964.

The intrastate evaluation indicates that South Dakota corn had a net gain over Iowa corn of $3.57 in net returns per acre from technological sources. Negative price effects during the 1950 to 1965 period were smaller ($15.50) in South Dakota. After net technological gains and negative price effects were totaled for the two states, South Dakota corn has reduced the comparative advantage held by Iowa corn $19.07 per acre since 1950.

Lake States

Corn is the dominant crop in each of the Lake States. All three states in the Lake Region reduced the comparative advantage of Iowa corn. Wisconsin corn was the only dominant crop outside of Illinois corn that had net returns per acre higher than Iowa corn *(1963–65)*.

Michigan

Michigan corn has negative index numbers from 1950 to 1965. The net returns per acre differences between Iowa corn and Michigan corn ranged from a high of $28 per acre in 1955 to a low of $11 per acre in 1959. Michigan corn has reduced very slightly the comparative advantage held by Iowa corn.

The intrastate evaluation indicates that Iowa corn net technological gains were larger than net technological gains made by Michigan corn. This net return advantage for Iowa corn was eliminated by larger negative price effects accruing to Iowa corn over the 1950 to 1965 period. The result is that the comparative advantage loss by Iowa corn was almost insignificant.

Minnesota

Minnesota corn has negative index numbers from 1950 to 1965. The net returns per acre differences between Minnesota corn and Iowa corn ranged from a high of $22 per acre in 1951 to a low of $10 per acre in 1963. There is no indication that Minnesota corn has reduced the comparative advantage held by Iowa corn during the period.

The intrastate evaluation indicates that Iowa corn net technological gains were larger than the net technological gains made by Minnesota corn. This net return advanage for Iowa corn was eliminated by larger negative price effects accruing to Iowa corn over the 1950 to 1965 period.

Wisconsin

Wisconsin corn has negative index numbers from 1950 to 1962 and positive index numbers from 1963 to 1965. The net return per acre differences between Wisconsin corn and Iowa corn ranged from a high of negative $16 per acre in 1955 to a positive figure of $4 per acre in 1963. Wisconsin corn reduced the comparative advantage held by Iowa corn from 1950 to 1962. During the 1963 to 1965 period, Wisconsin corn held a comparative advantage over Iowa corn.

The intrastate evaluation indicates that Wisconsin corn had a net gain over Iowa corn of $7 in net returns per acre from technological sources. Negative price effects during the 1950 to 1965 period were $1.40 per acre higher in Wisconsin. After net technological gains and negative price effects were totaled for the two states, Wisconsin corn reduced the comparative advantage held by Iowa corn from 1950 to 1962 and attained a comparative advantage in the 1963 to 1965 period.

Southern Plains

The dominant crop was wheat in Oklahoma and grain sorghum in Texas. Both states have steadily improved their competitive position relative to Iowa corn. Texas grain sorghum reduced the comparative advantage relatively more than did Oklahoma wheat.

Oklahoma

Oklahoma wheat has negative index numbers from 1950 to 1965. The index numbers are getting smaller which indicates that Oklahoma wheat has been reducing the comparative advantage held by Iowa corn.

The intrastate evaluation indicates that Iowa corn net technological gains were slightly larger than net technological gains made by Oklahoma wheat. The net return per acre advantage gained from technology by Iowa corn was eliminated by large negative price effects. Iowa corn had a net loss of $13.57 per acre more in the 1950 to 1965 period than did Oklahoma wheat.

Texas

Texas grain sorghum has negative index numbers from 1950 to 1965. The negative index numbers for Texas grain sorghum have been getting smaller at a rate faster than any other crop analyzed in the 14-state area. The net returns per acre differences between Texas grain sorghum and Iowa corn ranged from a high of $52 per acre in 1950 to a low of $15 per acre in 1962 to 1964. The comparative advantage reduction by Texas grain sorghum was $33 per acre from 1950 to 1965. The size of the reduction in the comparative advantage of Iowa corn by Texas grain sorghum was the largest calculated for the 13 states evaluated.

The intrastate evaluation indicates that fertilizer and other factors were partially responsible for the improved competitive position attained by Texas grain sorghum. Varietal improvement gains were about equal in both states. Texas grain sorghum had a net gain over Iowa corn of $11.91 in net returns per acre from technological sources. Texas grain sorghum had a $20.99 per acre advantage over Iowa corn from negative price effect sources. After net technological gains and negative price effects were totaled for the two states, Texas grain sorghum has reduced the comparative advantage held by Iowa corn $32.90 per acre from 1950 to 1965.

INTERSTATE ANALYSIS

(Intercrop Evaluation)

The interstate analysis (dominant crops) compared the dominant crop in each state with Iowa corn. It was assumed that after the crops in a state were ranked according to absolute advantage that homogeneity of crop production existed across the entire state.

In many states on certain soil types and in certain local situations, a secondary crop could be the dominant crop in a local area. This section evaluates some of the general intercrop trends and their geographic implications.

Barley and Oats

The net returns per acre for barley and oats were generally low compared with the other competing feed grains produced in the 14-state area. Oats were not included in any of the intrastate evaluations because of low net returns per acre. Oat acreage was declining in all states except North and South Dakota. Oat acreage was stable in South Dakota but a slight upward trend was indicated in North Dakota.

Barley was included in three intrastate evaluations (North Dakota, Oklahoma and South Dakota). Barley acreage was declining in every state where it was evaluated, except in Oklahoma where it was approximately stable. Net returns per acre relative to the dominant state crop were declining in North and South Dakota. Barley maintained its competitive position relative to wheat in Oklahoma. The total technological gain for barley ranged from a high of $3 per acre in Oklahoma to a low of 30¢ in North Dakota. The technological improvement realized by barley and oats in every state was low relative to the dominant state crop or to the dominant feed grain produced. Barley and oats rarely have a geographic comparative advantage in any of the 14 states evaluated.

Corn

Corn was the dominant crop in 10 of the 14 states evaluated. The two states where corn was not competitive or was losing its competitive position were North Dakota and Texas. Corn was a strong economic competitor in both Kansas and Oklahoma (dominant wheat states) during the 1950 to 1965 period. It was an important crop in most of the states evaluated and one would expect corn to continue to hold a dominant position in the Corn Belt, Lake States and probably South Dakota.

Grain Sorghum

Grain sorghum is a competitive crop in 4 of the 14 states evaluated. It was the dominant crop in Texas and improved its economic position relative to the dominant state crop in Oklahoma, Kansas and Nebraska. Grain sorghum made rapid yield and net return per acre gains from 1958 to 1965. It has definite locational advantages in certain parts of Oklahoma, Kansas and Nebraska. Grain sorghum is challenging corn in most dryland feed grain production areas capable of grain sorghum production. Grain sorghum will continue to improve its competitive position relative to other feed grains unless other technologically improved feed grain varieties are found.

Soybeans

Soybeans are a competitive crop in 9 of the 14 states evaluated. Corn is the dominant state crop in all of the states where soybeans were produced. Soybeans improved their economic position relative to corn in each of the nine states. Undoubtedly, they are economically superior to corn in certain local areas of the Corn Belt and the Lake States (except Wisconsin). Soybeans were evaluated in Nebraska and Wisconsin but it is doubtful whether they had a definite locational advantage in very extensive areas of either state.

When actual soybean output prices were used, soybeans had an absolute advantage in six of the eight Corn Belt and Lake States from 1963 to 1965. Soybeans (at adjusted output prices) were extremely strong competitors relative to corn during the latter part of the 16 years and soybeans have definite locational advantages on certain soil types and in certain sections of at least seven states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio). Soybean acreages have been increasing rapidly in each of these seven states. It is very possible that in the 1965 to 1975 period, soybeans will enlarge the level of equivalence or comparative advantage over corn in some areas of the seven states.

Wheat

Wheat was produced in all of the 14 states evaluated. It was the dominant state crop in Kansas, Oklahoma and North Dakota and a strong competitor in Nebraska, South Dakota and Texas. Wheat definitely had locational absolute advantages in certain sections of each of these three states.

Wheat was produced as a secondary or minor crop in Corn Belt and Lake States. Iowa and Wisconsin had total state wheat acreages of less than 1% of total harvested cropland acres. It is possible that small geographical areas of certain isolated soil types in the remaining Corn Belt and Lake States could have a locational advantage in wheat production.

When either actual or adjusted wheat prices were used in the analyses, wheat was generally ranked third in absolute advantage behind corn and soybeans in Corn Belt and Lake States. There is no indication that wheat will improve its competitive position relative to corn and soybeans.

Hard red spring wheat is produced in the Northern Plains and hard red winter wheat in the Southern Plains. Soft red spring wheat is produced in Corn Belt and Lake States areas. The intrastate analysis indicates that soft wheats have realized a slightly larger total technological gain over the 1950 to 1965 period than have hard wheats. Hard wheats have gained slightly on Iowa corn but neither soft nor hard wheats have seriously challenged the absolute advantage of dominant state crops (especially in Corn Belt and Lake States).

SUPPORTING DATA FOR INTRASTATE AND INTERSTATE EVALUATIONS

In some states, the average net returns per acre relationships between two crops were nearly equal for part or all of the 1950 to 1965 period. In several states oats and barley were not competitive with other feed grains produced. Data available from USDA and Agricultural Census reports were used to help make and support decisions on dominant crop selections in states where two crops were close economic competitors and to substantiate the overall crop rankings in each state.

The supporting data presented in this section include the following:

1. The percentage of total cropland harvested or land utilized by each crop for the four regions evaluated.

2. A series of average land prices for each state for the 1950 to 1965 period used in a regression analysis with the net returns per acre data.

3. Land price analyses of selected states over the 1950 to 1965 period, using a series of index numbers to indicate farm scale changes in each state (with 1950 as the base year).

Land Utilization by Crops by Regions

Corn Belt. Land utilization by Corn Belt crops supports the intrastate and intercrop analyses. Oat acreage (and barley acreage in Missouri) has been steadily declining over the 1950–1965 period. Soybean acreage has been rapidly expanding in all five Corn Belt states (Table 16).

Northern Plains. In general, land in the Northern Plains is utilized as expected by major crops. Oat acreage increased in North Dakota but oat and barley acreages are decreasing in the remaining states (Table 17).

Table 16. Percentage distribution of cropland harvested for selected crops and percentage of land in cropland, Corn Belt, for census years 1950 to 1964.

State and year	Barley	Corn	Oats	Soybeans	Wheat	Total	% of land in farms that is cropland
Illinois							
				percent			
1950		43.3	17.9	15.4	9.1	85.7	77.3
1954		41.3	15.0	19.3	7.4	83.0	78.1
1959		46.5	10.0	22.5	7.8	86.8	79.0
1964		45.3	5.2	27.8	9.6	87.9	79.7
Indiana							
1950		40.6	12.1	12.8	15.4	80.9	70.3
1954		40.8	10.9	16.5	11.4	79.6	71.9
1959		44.5	7.8	20.2	10.7	83.2	73.4
1964		43.6	4.5	28.3	12.4	88.8	73.7
Iowa							
1950		50.2	27.1	5.8	1.7	84.8	76.0
1954		45.7	26.3	9.4	.5	81.9	76.3
1959		54.2	18.4	10.2	.7	83.5	78.0
1964		50.8	11.2	20.9	.5	83.4	78.1
Missouri							
1950	.6	30.5	10.9	7.2	13.2	62.4	53.4
1954	2.2	23.0	10.6	13.8	9.3	58.9	51.8
1959	1.7	32.2	4.9	18.1	12.1	69.0	54.8
1964	.5	25.6	2.6	23.5	13.2	65.4	54.9
Ohio							
1950		31.5	11.8	8.0	21.7	73.0	66.3
1954		32.7	10.4	10.5	16.4	70.0	64.0
1959		35.1	10.9	14.6	12.6	73.2	66.1
1964		32.5	6.8	18.9	15.1	73.3	67.3

Table 17. Percentage distribution of cropland harvested for selected crops and percentage of land in cropland, Northern Plains, for census years 1950 to 1964.

State and year	Barley	Corn	Grain Sorghum	Oats	Soy-beans	Wheat	Total	% of land in farms that is cropland
					percent			
Kansas								
1950	.9	11.0	10.5	3.6		62.3	87.4	60.6
1954	2.0	9.5	25.3	4.8		44.2	83.8	59.1
1959	4.3	9.1	23.4	3.2		48.0	83.7	59.1
1964	2.2	7.2	21.8	1.6		49.7	80.3	58.5
Nebraska								
1950	1.5	37.1	.6	10.8	.1	20.1	70.2	50.0
1954	1.1	33.8	2.7	11.7	1.0	15.7	66.0	48.2
1959	1.7	35.7	7.7	7.0	.8	16.6	69.5	47.8
1964	.5	24.4	12.8	4.0	3.3	17.9	62.9	46.2
North Dakota								
1950	8.0	5.8		7.8		50.1	71.7	67.1
1954	14.3	5.8		9.8		35.7	65.6	66.1
1959	19.4	6.8		8.3		33.2	67.7	66.8
1964	14.0	5.5		11.2		35.4	66.1	64.2
South Dakota								
1950	6.0	18.6		16.1		22.4	63.1	44.3
1954	2.7	18.9		21.9		14.6	58.1	43.7
1959	3.0	17.3		14.2		13.2	47.7	42.7
1964	1.5	17.6		16.5		14.4	50.0	41.1

Lake States. Support of the intrastate analyses is less definite in the Lake States. Oat acreage is declining in all three states but the percentage of cropland in oats is relatively large in Minnesota and Wisconsin. The intrastate economic analyses would indicate that a faster rate of decline would be expected (Table 18).

Southern Plains. Land utilization by crops in the Southern Plains supports the intrastate and intercrop economic analyses. Feed grain competitiveness in the future will be governed by the availability of water. The percent of land that is cropland is relatively small in both Oklahoma and Texas (Table 19).

Table 18. Percentage distribution of cropland harvested for selected crops and percentage of land in cropland, Lake States, for census years 1950 to 1964.

State and year	Barley	Corn	Oats	Soybeans	Wheat	Total	% of land in farms that is cropland
				percent			
Michigan							
1950	1.3	16.3	17.2	.8	16.0	51.6	63.9
1954	.9	20.0	15.8	1.8	13.0	51.5	65.5
1959	1.1	23.3	11.9	3.1	15.0	54.4	67.4
1964	.4	22.3	9.5	4.7	13.8	50.7	69.5
Minnesota							
1950	5.3	24.5	23.7	3.8	6.3	57.3	68.3
1954	5.5	24.5	25.3	9.8	3.5	65.1	68.7
1959	5.0	31.3	18.9	11.6	5.0	66.8	71.2
1964	3.1	24.9	17.4	15.9	5.4	61.3	72.2
Wisconsin							
1950		26.4	27.2	.2	1.0	54.8	55.6
1954		26.4	27.8	.6	.6	55.4	56.3
1959		29.4	24.8	1.0	.6	55.8	57.9
1964		27.3	21.2	1.4	.6	50.5	59.1

Table 19. Percentage distribution of cropland harvested for selected crops and percentage of land in cropland, Southern Plains, for census years 1950 to 1964.

State and year	Barley	Corn	Grain Sorghum	Oats	Wheat	Total	% of land in farms that is cropland
				percent			
Oklahoma							
1950	.3	9.0	4.5	3.9	52.7	70.4	44.5
1954	2.5	2.7	6.0	7.9	43.6	62.7	40.6
1959	6.8	2.4	8.0	5.5	48.1	70.8	39.2
1964	5.3	1.1	6.5	2.6	49.1	64.6	36.1
Texas							
1950	.4	8.2	12.1	3.7	20.0	44.4	26.1
1954	.5	7.4	22.6	3.0	12.1	45.6	25.1
1959	1.2	6.4	30.2	3.9	13.6	55.3	24.2
1964	.9	4.0	22.6	3.7	16.1	47.3	24.2

Land Price Analysis

Land values were obtained from Agricultural Census reports for the census years between 1950 and 1965. The land values were considered to be indicators of the land price levels in each of the 14 states. Errors that might have occurred in the estimation of land

Table 20. **Agricultural land values by states, 1950 to 1965 (in dollars per acre)**

Year	Ill.	Ind.	Iowa	Kan.	Mich.	Minn.	Mo.
				(dollars per acre)			
1950	174	137	161	66	99	84	64
1954	231	195	199	79	133	108	81
1959	316	266	254	100	193	154	112
1964	357	318	272	122	233	166	150
Year	**Nebr.**	**N.D.**	**Ohio**	**Okla.**	**S.D.**	**Texas**	**Wisc.**
				(dollars per acre)			
1950	58	29	136	51	31	46	89
1954	72	36	185	63	39	62	101
1959	89	52	247	84	51	82	132
1964	107	67	295	121	62	112	155

Source: U.S. Agricultural Census 1950, 1954, 1959, 1964.

values will be considered similar across all 14 states. The land values for each state will be used as land prices for the land price analysis.

Land prices (values) have been increasing in every state during the 1950 to 1965 period (Table 20).

Land prices using a linear trend between census years were estimated for each year during the 1950 to 1965 period for each of the 14 states. An average land price for the 16 years was calculated. A regression analysis was run, using the average land price in each state as the dependent variable and the average net return per acre of the two dominant crops in each state as the independent variable to determine if land quality (productivity of land as measured by net returns per acre) and land prices between states were related. The function was estimated as follows:

$$\underset{\text{(average)}}{\text{Land Price}} = -58.67572 + \underset{(0.65414)}{6.11449} \text{ (Net Returns Per Acre)}$$

$R^2 = 0.87924$

Net returns per acre indicate the average net returns per acre obtained from the two crops that were selected as most "dominant" in each state and the number in parentheses is the estimated standard error of the regression coefficient. The R-squared value indicates there is a strong relationship between average land prices and average net returns per acre among the 14 states. The net returns per acre coefficient is highly significant.

The regression line intersects the net returns per acre axis at about the $9.50 average net return per acre point. This implies that on the average there was a fixed land charge (for taxes and management overhead) of $9.50 per acre for land that was 100% cropland.

Assuming that the net return per acre of tract (to compensate for noncropland areas) was about 70% of the computed returns, the slope could be increased to 8.75. The x-axis intercept value would be reduced to about $6.65 per acre.

Assuming this fixed charge is independent of land productivity, we could subtract $6.65 from the previously adjusted average returns per acre and secure a ratio line through the origin with a slope of 8.75. This implies a residual net return rate on land investment of nearly 12%. Undoubtedly, a portion of this average rate of return would have to be allocated to management.

Average agricultural land price levels were generally proportional to land quality (land productivity as measured by the average net return per acre of the two dominant state crops) among states over the 16 years. The agricultural land price analysis indicates that average levels of land prices were consistent with average field crop activity returns and consequently generally substantiate the absolute and relative ranking of field crop enterprises in each of the 14 states for the 1950 to 1965 period.

Land Price Analysis of Selected States Over 1950-1965 Period

Intrastate land price analyses were made for five states, using adjusted net returns per acre calculated for the dominant state crop. The five states and the dominant state crops are Iowa (corn), Wisconsin (corn), North Dakota (wheat), Nebraska (corn) and Texas (grain sorghum).

The supply cost analyses assumed that crop yields and costs were those experienced by an average farm with average efficiency for each of the crops produced in the 14 states. This means farm size changes were not considered when field crop enterprises were evaluated. Fairly rapid farm size changes have been taking place over the 1950 to 1965 period as indicated in Table 21.

The intrastate land price analysis will incorporate farm size changes into the land price analysis to determine if the adjusted net returns per acre received by the producer justifies the increasing prices being paid for land during the 1950–1965 period.

The assumptions, based on consultations with farm management specialists, made for this land price analysis are as follows:

Producers increase their farm size by 100%.

Farm size change decreases machinery, labor and related equipment costs (other factors costs) by 10% from previous level before size change.

Farm size change increases yields from 5% per acre in 1950 at the rate of .5% per year to 12.5% in 1965.

Table 21. Average farm size and farm sizes changes in percent by states for the census years 1950 to 1965. (Farm size is in acres and percentage size change figures are 1950 = 100%.

Year	Ill.	Ind.	Iowa	Kan.	Mich.	Minn.	Mo.
				(Acres and (percent))			
1950	159	118	169	370	111	184	153
	(100)	(100)	(100)	(100)	(100)	(100)	(100)
1954	173	125	177	416	119	195	170
	(109)	(106)	(105)	(112)	(107)	(106)	(111)
1959	196	145	194	481	132	211	197
	(123)	(123)	(115)	(130)	(119)	(115)	(129)
1964	225	161	219	544	145	235	222
	(145)	(141)	(133)	(151)	(134)	(131)	(150)

Year	Nebr.	N.D.	Ohio	Okla.	S.D.	Texas	Wisc.
				(Acres and (percent))			
1950	443	630	105	253	674	439	138
	(100)	(100)	(100)	(100)	(100)	(100)	(100)
1954	471	676	113	300	719	498	147
	(106)	(107)	(108)	(119)	(107)	(113)	(107)
1959	528	755	132	378	805	631	161
	(119)	(120)	(126)	(149)	(122)	(144)	(117)
1964	596	875	146	407	917	691	172
	(137)	(143)	(144)	(164)	(140)	(160)	(127)

Source: U.S. Agricultural Census 1950, 1954, 1959, 1964.

The producer attributes yield increases and cost reductions over the total farming unit to the marginal or "add-on" land, which means multiplying the marginal net returns per acre gained over the old net returns per acre by two.

Net returns per acre of the selected crops were adjusted for the census-year end points (1950 and 1964) of the post-year period. The total amount of the net returns per acre adjustment and the land price (value) for the five state-dominant crops are presented in Table 22. The rate of return attributable to the "add-on" acres is also given for each state-dominant crop.

Table 22. Net return per acre adjustment, land price and rate of return for "add-on" acres for selected states and dominant crop, 1950 and 1964.

Year	Additional net return/acre	Land price per acre	Rate of return
	($)	($)	(%)
	Iowa (Corn)		
1950	11.46	161	7.12
1964	23.16	272	8.50
	Nebraska (Corn)		
1950	7.40	58	12.76
1964	20.25	107	18.92
	North Dakota (Wheat)		
1950	8.56	29	29.52
1964	10.96	67	16.36
	Texas (Grain Sorghum)		
1950	4.10	46	8.91
1964	13.50	112	12.05
	Wisconsin (Corn)		
1950	11.10	89	12.47
1964	23.00	155	14.84

The analysis of the selected state-dominant crops indicates that the short-run rate of return in all five states was relatively high compared to the expected land mortgage interest rate. It must be pointed out that the land values used are probably low compared to the actual market prices paid for land. If the land prices were adjusted to reflect estimated (by farm management specialists) reasonable increases (Iowa and Texas land values times 1.5; Nebraska, North Dakota and Wisconsin land values times 2), the rate of return from the "add-on" land would be decreased by one-third in Iowa (1950—4.74 and 1964—5.68) and Texas (1950—5.94 and 1964—8.04) and by one-half in Nebraska (1950—6.38 and 1964—9.46), North Dakota (1950—14.76 and 1964—8.18) and Wisconsin (1950—6.24 and 1964—7.42). Even if the land values were increased as indicated to reflect actual market land prices, the rate of return in all five states probably would still cover the mortgage cost.

Producers acquire additional land in the short run if the calculated rate of return will cover the mortgage cost. It would seem that the calculations of the producer are based on the computed marginal returns expected from the additional land. The changes in land prices between 1950 and 1964 were not large enough compared to the calculated additional net returns per acre expected from the increased farm scale to discourage farm scale adjustments. After the land price adjustments, the marginal return rate ranged from 4.74% in 1950 for Iowa corn land to 9.46% in 1964 for Nebraska corn land to those producers that enlarged (approximately doubled) their production base from an average size as depicted by the earlier net returns per acre calculations.

It is concluded that, with farm scale adjustments (using average net returns as previously calculated as the base), the land value increases over time, across the 14 states, are about in proportion to the adjusted net returns per acre calculated for the "add-on" or marginal land units. It follows that the actual level of land prices (increases) was consistent with marginal gains made on the additional unit per year over the 1950 to 1965 period (or for the calculated sample years 1950 and 1964). In the short run if the producer has a rate of return on the additional land larger than the mortgage cost of the land, then he will purchase the additional unit.

The land market responds to marginal returns received from "add-on" units. The average land prices and the average net returns per acre over the 1950 to 1965 period between states were consistent. It was concluded that the between and intrastate land analysis indicated a strong relationship existed between net returns per acre and land values during the postwar period.

FIELD CROP ANALYSIS EVALUATION

The intrastate field crop analysis indicated that the three individual technologies evaluated affected the net returns per acre received from the state crops in differing degrees. The effects of fertilizer were large in one state and small in another. The same was generally true for varietal improvement and other factors. Varietal improvement was the largest single contributor to net returns per acre in a majority of the 14 states. The intrastate analysis indicated that the absolute advantage held by a dominant state crop in several of the states was being challenged by a second crop. The major challengers were grain sorghum in Nebraska, Kansas and Oklahoma and soybeans in the Corn Belt and in Michigan and Minnesota.

The interstate dominant field crop analysis indicated that several dominant state crops reduced the comparative advantage held by Iowa corn during the 1950 and 1965 period. The comparative advantage shifts (between the states and Iowa crop) ranged from a zero shift in Indiana and Ohio to a $33 per acre reduction in comparative advantage by Texas grain sorghum.

The intercrop evaluation between states indicated that grain sorghum was becoming more competitive in the southern areas and soybeans were improving in the Corn Belt. The intercrop evaluation indicated that soft wheat areas had experienced relative technological gains on hard wheat areas.

The collateral evidence for the field crop analysis supported the absolute crop ranking within a state and, therefore, the comparative advantage comparisons made with Iowa corn. The land price (value) analysis (between states) indicated that an average state land price for the 1950–65 period was highly associated with the average net return per acre of the two dominant state crops. The over-time, within-state land price analysis, incorporating assumed farm scale changes for five sample states and their dominant crops, indicated that the high land prices paid by producers during the postwar period were justified by the calculated rate of return received from the marginal or "add-on" units of land. The within-state land price analysis assumed the "add-on" units were added to a land unit that was realizing state-average net returns per acre as calculated in the intrastate field crop analysis.

The field crop analysis indicated three rather specific points:

1. Illinois was the first major corn producing state to adopt the newer single-cross corn hybrids. This is implied by the strong technology push realized by Illinois corn during the 1960 to 1965 period from each of the three individual technologies. It is believed that most of the net technological gains realized by Illionis corn came after 1960. Nebraska corn had large technology gains during the period but these gains were attributed to increased irrigation of corn as indicated by the large returns realized by other factors.

2. Soybeans and grain sorghum made rather large net returns per acre gains in their respective production areas. Both crops were challenging the absolute advantage held by the dominant state crops. Grain sorghum had an absolute advantage in Texas over a majority of the 1950–1965 period so it was selected as the dominant state crop. When actual soybean market prices were used in the net returns per acre calculations, soybeans had an absolute advantage in six Corn Belt and Lake States from 1963 to 1965.

3. The field crop analyses indicated that oat and barley acreages and net returns per acre declined rapidly in a majority of the 14 states evaluated. Net returns per acre calculations indicated that oat and barley production in specific states (Iowa, Minnesota, South Dakota and Wisconsin) probably should have been decreasing faster than current rates indicated.

What implications can be drawn from this analysis of technological changes during the 1960–1965 period—both for the past and near future? In the competition of feed grain supply, oats and barley have lost ground while grain sorghum has made a major advance on corn. This has resulted in a reduction in the economic position of resources in the Northern Plains and northern portions of the Lake States and a significant strengthening of the position of the Southern Plains. Although wheat has made some gains in comparative disadvantage relative to corn, this may be erased in the future if the wheat price structure is merged with feed grains. It would appear that the eastern part of the Corn Belt is experiencing a relative disadvantage in fertilizer response on corn. The soil types and nutrient deficiencies place these areas at some disadvantage in fertilzer usage. Perhaps a gradual shift to soybeans will temper this loss in competitive strength.

Varietal improvement and fertilizer response have been important contributors for the Corn Belt states and the Plains below the Dakotas. Future technological gains in "other factors" should provide further gains in the latter area. Chemical control of weeds and soil moisture losses should be most productive in the hotter and drier areas of the Plains. Without a major genetic gain in the small grains (wheat, oats, barley), the Northern Plains will continue to be under pressure from the Southern Plains and the Corn Belt in the future.

LIVESTOCK AND POULTRY ANALYSIS

Analyses of the effects of technological changes influencing livestock-feed relationships are made on the basis of their effects on supply costs for animal products and cross-elasticity effects (if any) on the demand side. The five livestock classes or products evaluated are beef cattle, hogs, broilers, eggs and fluid milk.

Direct feed conversion data are used to analyze the physical feed conversion changes that have occurred for beef, pork, milk and eggs. A regression analysis is used for broilers. The livestock-feed conversion part of the analysis is based on the assumption that if the conversion ability of a particular livestock class increases, then the supply costs of the animal products produced will be reduced. Qualitative nonfeed production cost changes are used for beef, pork, eggs and milk to indicate nonfeed cost changes that have occurred during the postwar period. The supply costs for one animal class, if changed, will affect the relative positions between the competing animal products.

Beef and pork are studied jointly because they are significant substitutes in demand. Broilers, eggs and milk are considered independent in demand. The livestock and poultry analysis assumes that a competitive market structure exists.

The livestock and animal products analysis is as follows:

1. Changes in livestock-feed relationships including other produc-

tion costs are noted between the prewar period (1922–41) and the postwar period (1950–65).

2. Consideration of the five livestock classes and the relationships between the commodities in the 1950 to 1965 period are made using available secondary data.

3. The directional patterns and geographic implications of technological changes made by the livestock classes during the 1950 to 1965 period are determined.

DIRECTIONAL CHANGES BETWEEN PREWAR AND POSTWAR PERIODS

Data used to determine the changes of livestock-feed conversion ability of beef cattle, hogs, broilers, layers (eggs) and cows (fluid milk) were obtained from U.S.D.A. sources.

Pounds of feed needed to produce a pound of beef, pork, eggs and milk were obtained so changes in physical feed conversion ability by these livestock classes could be analyzed (Table 23).

The prewar and postwar comparisons are broken down into a feed conversion cost (using feed conversion data and assuming input costs are relatively constant or decreasing) and a nonfeed cost analysis for each animal product. It must be stressed that the livestock and poultry analysis is concerned only with the actual or implied technological changes that have occurred between the two periods and during the postwar period and not the total economic forces affecting the enterprises. The following general directional trends are noted between the two periods.

Feed Conversion Costs

Beef and pork. Feed conversion ratios indicate that feed conversion cost changes were nearly equivalent for beef and pork between the two periods. There is no indication that relative feed conversion cost changes have favored either beef or pork under the assumption of constant quality or grade of products.

Eggs. The feed conversion ratios indicate that there has been about a 10% reduction in egg-feed conversion costs between the two periods. The 10% reduction in supply costs for eggs is equivalent to a price reduction of 2 or 3¢ per dozen between the two periods. This supply cost reduction normally would cause an egg industry volume increase but, because there is an inelastic demand for eggs, it is doubtful that a significant volume increase did occur.

Table 23. Average feed consumed by livestock and poultry, including pasture, per pound of production, by different animal classes. 1922–1941[a] and 1950–65[b].

Year	Lbs. feed per lb. beef	Lbs. feed per lb. broiler	Lbs. feed per lb. eggs[c]	Lbs. feed per lb. milk	Lbs. feed per lb. pork
			(Pounds)		
1922	11.07		4.56	1.19	5.51
1923	10.83		5.28	1.18	5.61
1924	10.64		4.80	1.09	5.31
1925	10.92		5.04	1.07	5.65
1926	11.04		5.04	1.04	5.52
1927	10.68		5.28	1.05	5.35
1928	10.70		5.04	1.04	5.42
1929	9.33		5.88	.95	5.42
1930	8.77		4.56	.95	5.04
1931	10.06		4.96	1.01	5.12
1932	9.63		5.28	1.00	5.44
1933	8.26	5.28	4.80	.97	5.26
1934	8.94	4.88	4.32	1.07	5.11
1935	8.37	5.28	4.96	.99	5.42
1936	8.77	4.83	4.16	1.04	4.94
1937	9.91	5.01	4.56	1.07	5.28
1938	9.18	4.65	4.72	1.04	5.12
1939	9.50	4.80	4.72	1.07	5.06
1940	10.10	4.89	4.88	1.05	5.23
1941	10.17	4.66	5.04	1.12	5.16
1950	9.66	3.74	4.80	1.12	5.31
1951	9.65	3.66	4.80	1.12	5.47
1952	9.13	3.59	4.80	1.06	4.89
1953	8.92	3.51	4.64	1.06	5.54
1954	9.13	3.40	4.32	1.07	5.12
1955	9.04	3.31	4.48	1.09	5.36
1956	9.94	3.24	4.56	1.10	5.16
1957	10.36	3.39	4.48	1.13	5.17
1958	10.23	3.21	4.40	1.06	5.48
1959	10.53	3.00	4.24	1.09	5.56
1960	9.95	2.89	4.16	1.16	5.73
1961	10.00	3.01	4.24	1.16	5.96
1962	9.89	2.97	4.08	1.14	5.77
1963	9.86	3.06	4.08	1.15	5.64
1964	10.40	2.88	4.00	1.14	5.93
1965	10.97	3.06	4.08	1.15	6.03

[a] U.S.D.A., Production Research Report No. 21, Consumption of Feed by Livestock, 1909–56, Table 76, P. 126.

[b] U.S.D.A., Agricultural Statistics 1967, Table 539, P. 431.

[c] Eight eggs on the average are equivalent to one pound.

Milk. The pounds of feed consumed per pound of milk produced data do not indicate that any feed conversion cost efficiencies were achieved between the two periods.

Broilers. The broiler analyses involve the price relationship between chickens and corn in the prewar period (equation a. below) and between broilers and broiler rations in the postwar period (equation b. below). The converision rate is assumed to have been 6 lbs. of corn to 1 lb. of chicken for the first period and declining from about 4 to 2.8 lbs. of broiler ration to 1 lb. of broiler in the later period. The constant term is expected to be positive to indicate the nonfeed costs. The regression equations with "t" ratio in parenthesis were estimated as follows:

a. $$\text{Price}_{\text{Chicken}} = 12.43 + \underset{(3.5)}{10.388}\ \text{Price}_{\text{Corn}} - \underset{(2.6)}{0.324}\ \text{time}$$

$R^2 = 0.670$

b.[5] $$\text{Price}_{\text{Broilers}} = 12.08 + 4.0\ \text{Price}_{\text{Broiler Ration}} - 0.07\ \text{time}\ \text{Price}_{\text{Broiler Ration}} - \underset{(15.8)}{0.78}\ \text{time}$$

$r^2 = 0.889$

The r-squared value indicates a strong correlation between the price of chickens (broilers) and feed and time. All regression coefficients are significant at the 5% level. The feed price term indicates that rather large feed conversion efficiency gains were made between the two periods and during the postwar period. The efficiency gains tend to indicate that there were reductions in supply costs between the two periods. This should indicate that the broiler industry experienced retail price reductions and output increases.

The regression analyses made on beef, pork, eggs and milk indicate that animal-feed relationships are weak and distorted. For the feed conversion part of the analysis, the data contained in Table 23 for the two periods generally substantiates this conclusion that no significant pattern in feed efficiency changes could be determined for beef, pork and milk. The feed conversion evidence for eggs indicated that actual feed conversion efficiencies did occur between the periods.

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[5] The coefficients in the postwar broiler equation are partially estimated and partially actual coefficients. The constant term and the time term were estimated assuming a 4.0 feed conversion rate on the $\text{Price}_{\text{Broiler Ration}}$ term and a .07 coefficient of yearly change on the (time x $\text{Price}_{\text{Broiler Ration}}$) term. The two actual parameters were assumed known and consistent *with feed conversion data.*

Nonfeed Costs

Beef and Pork. Both beef and pork have realized implied nonfeed cost scale efficiency benefits between the two periods. An economies of scale study in 1965 on nonfeed costs in cattle feeding indicated that the total nonfeed costs per pound of gain decreased from $6.89 to $4.24 per head as feedlot capacity went from 300 to 15,000 head.[6] This implies that nonfeed scale economies existed in the postwar period in cattle feeding. Indications are that important technological gains were made in the beef cattle industry in the nonfeed costs area between the two periods. A postwar study on the the variation in costs per cwt. of hogs produced with three sizes of swine enterprises indicates that nonfeed costs decreased from $5.85 to $4.31 per cwt. as number of sows farrowed twice a year went from under 25 to over 50.[7] If nonfeed scale economies existed in postwar hog production, then this probably implies that prewar economies were not being realized. This also would indicate that important technological gains were made in the hog industry in the nonfeed cost area between the two periods. There is no definite indication that either beef or hogs enjoyed a significant relative gain in the nonfeed cost area between the two periods.

Eggs. Data on nonfeed cost changes between the two periods are not available in an explicit form. Because of the inelastic demand for eggs, egg industry volume changes have been small. This would indicate that nonfeed technological changes in the egg industry have not greatly aided the egg producers in the 14-state area. Nonfeed cost gains have been achieved because fewer layers are now needed to produce the same number of eggs. The rate of lay per layer during the year has increased from an average of 125 eggs per year in the prewar period to an average lay of 195 eggs per layer during the postwar period.[8] Other economy of scale gains from substitution of capital for labor imply nonfeed cost gains between the two periods.

[6] Samuel H. Logan, "Economies of Scale in Cattle Feeding," Supplemental Study No. 3 to Technical Study No. 1, Organization and Competition in the Livestock and Meat Industry, National Commission on Food Marketing, June, 1966, Table I, P. 7.

[7] R. Bauman, "Economies of Size and Economic Efficiency in the Hog Enterprise," Purdue Research Bulletin 699, 1957.

[8] Agricultural Statistics, 1921–1969.

Milk. Implicit nonfeed cost gains have been achieved by milk cows. Inelastic demand also prevails for milk which indicates the nonfeed cost gains made by the milk industry eventually aid the consumer and not the producer. Milk production per cow is used as one indicator of nonfeed cost changes. Milk production per cow has increased from an average of 4500 pounds of milk per cow in the prewar period to approximately 7000 pounds of milk per cow in the 1950–1965 period.[9] Other economy of scale gains from substitution of capital for labor imply nonfeed technology gains between the two periods.

Broilers. Using the constant terms in the a. and b. equations, there is strong evidence that actual nonfeed production costs have declined. Using the average of the wholesale price index for the two periods as a deflater, there is a definite indication that real cost has declined between the two periods. The time coefficient indicates that nonfeed production costs have decreased from 1/3¢ to 3/4¢ per pound per year between the two periods.

POSTWAR LIVESTOCK-POULTRY ANALYSIS

Beef, pork, eggs and milk livestock-feed relationships over the 1960 to 1965 period are analyzed in qualitative terms, using the 1950–1965 livestock-feed conversion rates and direct nonfeed cost data to determine if the directional changes indicated between prewar and postwar periods continued or changed in the latter period.

The b. equation in the regression analysis is used for broilers. The postwar livestock-feed conversion ratios are analyzed to determine which animal class had implied supply cost changes because of improved feed conversion rates and nonfeed production cost changes. The direct price effects and the indirect effects of the cross-elasticity on final product demands (and production) are considered, tempered by the discussion presented in the following section.

Relevant to the livestock-poultry analysis of the competing animal products is the assumption that beef consumption over time creates certain problems with a demand-oriented analysis. Once consumers achieve any level of beef consumption, they are reluctant to substitute a "lesser" meat for the beef. This means that consumers will readily substitute beef for pork but not pork for beef. The result is that if beef prices decline, then the cross-elasticity coefficient between beef and pork is relevant. But if pork prices decline, the cross-elasticity coefficient with beef is not necessarily significant.

In general, for the livestock-animal products analysis, only in the situations where beef supply costs are reduced relatively more than

[9] Agricultural Statistics, 1921–1969.

pork supply costs will the cross-elasticity of demand effects be evaluated. If pork experiences supply-cost reductions greater than those consistently experienced by the beef industry, there is no evaluation of the cross-elasticity effects. Broilers, with much lower prices than beef or pork, are assumed to be independent in demand for minor changes in the range of price differences.

Postwar Analysis

Each of the five animal product classes are analyzed for technology changes over the 1950 to 1965 period independent of directional trends established between the two periods. In general, the demand for animal products has increased since 1950. The main reasons for the animal product demand growth are the increases in per capita incomes and the general population growth. Taste changes are involved and are partly the result of increased income. This means substituting beef for pork or using the variety and convenience of broilers which depends partly on the relative income level of the consumer.

Beef and Pork. The two animal products are analyzed together because of the competitive relationship that exists between them in demand. Attempts to determine if beef or pork had made relative feed efficiency gains on the competing product indicated that both animal products had no significant feed efficiency changes during the postwar period. However, beef was upgraded approximately one grade (mainly during the postwar period) which was equivalent to a relative supply reduction of about $1.50 per cwt. on a live-weight basis.

The beef and pork nonfeed costs studies used in the between-period analysis indicated that economies of scale in the nonfeed area were being realized by beef and pork producers in the postwar period. Indications are that the actual nonfeed production cost changes of the two products were similar, which implies that the relative supply cost positions of the two products were not altered in the postwar period.

Some nonfeed technological progress was made over the period by both beef and pork but the relative gains were about the same and neutral between beef and pork on industry volume and comparative advantage changes. Although the technology changes were similar (except for the grade change in beef), it is believed that rather large final product demand changes during the postwar period favored beef. The demand for beef increased faster than the demand for pork because of higher per capita incomes.

The national net increase in beef consumption per capita due to technological changes only amounted to about 2% during the post-war period. Due to cross-elasticity of demand effects, this means a 1% reduction in pork consumed per capita. One might conjecture that in the specialized beef producing areas, the 2% national increase in per capita consumption induced a potential effect of an 8 to 10% increase in beef production. Hog production in the central Corn Belt probably was not affected by the national per capita consumption decrease, but in the more marginal hog producing areas (western Corn Belt, for example) hog production possibly was reduced as much as 3 to 4%. These estimates are independent of all other economic forces affecting the production trends considered.

Broilers. The feed-into-broiler conversion ratio in the b. equation indicated a definite improvement in broiler-feed efficiency during the postwar period. Broilers had large physical feed efficiency gains compared to the other poultry and animal products in the 1950–1965 period. The feed efficiency gain (supply cost reduction) amounted to approximately 25% from 1950 to 1965.

The b. equation indicates that nonfeed production costs decreased about ¾¢ per pound per year during the 1950–1965 period. A relevant factor price index (hourly wages of food marketing employees) increased about 6% per year over the same period. Indications are that real supply cost reductions in both feed efficiency and nonfeed production cost of about 12¢ per pound (on a live-weight basis) were realized by broilers. The result of the supply cost reduction is increased volume and lower retail broiler prices. Because of the demand structure of broilers, nearly all of the efficiency gains accrue to the consumer in the form of lower retail broiler prices. The per capita consumption of broilers (chicken) nearly doubled between 1950 and 1965.

From 1937 to 1965 the pounds of feed needed to produce 1 lb. of live broiler dropped by almost 2 lbs. Two pounds of feed at 4¢ per pound means an 8¢ reduction in live cost. If the live-to-retail conversion rate is .7 per pound, then the retail reduction is 11.4¢ per pound. Taking the demand coefficient for live broilers (—.3)[10] times the 11.4¢ equals a 3.4 lb. per capita increase in broiler meat consumption (and production) due to feed efficiency gains from the prewar period to 1965. Indications are that the .78¢ per year reduction in nonfeed costs was relevant up to about 1958–1960. After 1960 the nonfeed cost reductions were near zero. This indicates that the estimated coefficient would be about —.40 for a period from 1950 to 1968 and that nonfeed costs have been reduced about 4¢ per pound on a

[10] Demand function for live broilers by James B. Hassler, "The U.S. Feed Concentrate-Livestock Economy's Demand Structure, 1949–59," Research Bulletin 203, Nebraska Agricultural Experiment Station, University of Nebraska, Lincoln, Nebraska, October 1962, had a slope relative to price of —.3.

live-weight basis over the postwar period. This would amount to about a 1.5 to 2 lbs. per capita increase in broiler consumption for the period from reductions in nonfeed costs. Combined effects would be a net increase in broiler production per capita retail equivalent of slightly more than 5 lbs.

Lower broiler meat prices would have little effect on the consumption of beef. There may be some cross-elasticity of demand effects between broilers and pork, such that pork consumption would have been reduced slightly. In general, the cross-elasticity of demand effect of broilers on the consumption of beef and pork would be practically negligible. Resources shifted into broiler production during the postwar period if opportunity costs were greater in broiler production than in other competing enterprises.

Eggs. Feed into egg conversion ratios indicated a definite improvement in egg-feed efficiency during the 1950–1965 period. The efficiency gain (supply cost reduction) amounted to approximately 20% from 1950 to 1965. The 20% reduction in supply costs during the post-war period is equivalent to a price reduction of approximately 5¢ per dozen for the 16 years. The implication was that reduced supply costs resulted in lower egg prices.

All egg industry volume increases and technology effects were passed on to the consumer in the form of lower egg prices because of inelastic demand. Capital or nonfeed cost improvements have been made in the form of management and economies of scale gains in laying hens but all feed and nonfeed efficiency gains in the egg industry eventually get passed on to the consumer and not to the egg producer. Egg price changes would have little or no cross-elasticity of demand effects on the other four animal products.

Milk. Feed-into-milk conversion efficiency changes were generally insignificant during the 1950–1965 period. Indications are that technological gains in the form of feed supply cost reductions were practically nonexistent. Milk production per cow increased 66% from 1950 to 1965. This indicates that in the nonfeed cost area actual management and economy of scale gains were realized over the period but the gains were erased by increasing factor costs. Due to the inelastic demand for milk, little or no cross-elasticity of demand effect from milk supply changes would be experienced by the other four animal products.

Effect of Livestock-Poultry Analysis on Locational Comparative Advantage Changes

Supply cost changes stemming from livestock-poultry-feed conversion changes and nonfeed cost changes (technological changes) have implications for locational gains and losses. The magnitude of the animal class location shifts is determined by the relative shifts along the demand schedules and the implied production effects.

Beef and Pork. States or areas producing feed grains that are reducing the comparative advantage of the Corn Belt feed grains enjoyed further increases in locational comparative advantage from beef production activities. Indications are that pork production is still concentrated in the Corn Belt area.

It is possible that more of the increases in beef production have shifted slightly westward into the feed grain areas of the Northern (Nebraska and Kansas) and Southern Plains. Relatively strong feed grain technology improvement and the resulting increased feed grain production have improved the competitive position of these areas. Furthermore, because of the increasing demand by consumers for animal products, this would be an indication that the feed grain producing areas would be gaining a slight advantage on the food grain producing areas.

Broilers. Significant supply cost reductions have occurred in the broiler industry during the 1950 to 1965 period.

As the supply costs of the broiler industry decreased, new equilibrium positions at lower prices and increased quantities were attained. The group that gained the most in the broiler case was the consumer. It was estimated that broiler consumption increased about 5 pounds per capita because of feed and nonfeed efficiency gains over the 1940–1965 period. The feed grain producers lost an income activity from their enterprise structure or from their area but experienced a greater demand for feed grains from the poultry areas, now more generally relocated outside the feed grain producing areas. The supply cost reduction experienced by the broiler industry has encouraged locational shifts, not within the 14-state area studied, but to locations outside the 14-state area evaluated.

Eggs. Postwar egg-feed conversion ratios indicated there was supply cost reduction in the egg industry during the period. There is no strong indication that the technological improvement gains made by eggs have caused any locational comparative advantage shifts in the egg industry. Eggs are produced near the major consumption centers throughout the Midwest. The directional patterns and geographic implications for the egg industry must be considered inconclusive.

Milk. Milk-feed conversion efficiency changes were insignificant during the postwar period. Milk production was located near the large consumption centers in the 14 states and in the Lake States area. There was no strong evidence that the locational comparative advantage for milk production was shifting locations within the 14-state area. Milk is similar to eggs in that generally the directional patterns and geographic implications for the milk industry must be considered inconclusive.

Summary of Locational Analysis

The directional patterns of locational comparative advantage shifts indicate that the Plains area has probably increased its locational comparative advantage in beef production. There was no strong indication that the locational comparative advantage held by the central Corn Belt in pork production had been reduced. There are no large locational comparative advantage changes or shifts apparent in the egg or milk industries. Broiler production has largely shifted to areas outside the 14-state area studied.

MARKETING MARGIN ANALYSIS

The marketing margin analysis assumes that the value of an animal or wheat product at the farm level equals the value of the animal or wheat product at the retail level minus the processing and distribution costs (the marketing margin). The marketing margin analysis assumes a competitive cost system exists.

A regression analysis is made of the changes in marketing costs or the changes in supply cost (caused by technology changes) of five livestock-animal product classes between the farm level and the retail level in the marketing system. The wheat margin analysis used direct farm value-retail price spreads. The five livestock-animal product classes evaluated are beef, pork, broilers, eggs and fluid milk. The analysis is done on a prewar period (1922–1941) and a postwar period (1947–1964 or 1950–1967).

Changes in the marketing margins between the two time periods will indicate which livestock-animal product class (or wheat) has gained relative to competing enterprises. Farm values and prices and retail values and prices obtained from U.S.D.A. sources (data available on request) are used to establish the livestock-animal and wheat products margin relationships.

Three estimating equations, a., b. and c., are computed for beef, pork and eggs. The a. equation represents the prewar period 1922 to 1941; the b. equations the postwar period 1947 to 1964 and the c. equations the postwar period 1950 to 1967. Two estimating equations are computed for broilers and milk. The broiler and milk equations are lettered using the same identification system. All equations lettered a. and b. utilize annual data. The c. equation uses either quarterly or monthly data. The equations with "t" ratio in parentheses indicated that a competitive market structure did exist during the prewar and postwar periods. The wheat analysis used direct wheat-bread price spreads for the a. and c. periods.

The marketing margin analysis is broken down into two parts: *An analysis* of each of the five livestock-animal product classes and wheat (bread) between the prewar and the postwar period or periods independent of the competitive relationship between products.

An evaluation of the direct and indirect effects of any shifts in the relative positions of the processing and distribution costs.

Beef

Three farm-rental price analyses are made for beef. The c. equation utilizes U.S.D.A. quarterly data. The farm level prices are converted to a retail weight basis for choice grade carcasses. The net farm value of beef is approximately the value of 2.08 (1947–1962) or 2.25 (after 1963) lbs.of choice grade beef less the value of the by-products.

Theoretically, the coefficient of value at the retail level should be approximately equal to one. The constant term in the regression function should be negative to indicate processing and distribution costs, as well as a by-product allowance. The time coefficient, if negative, indicates that the farm-retail margin has tended to increase through time. If the time coefficient is positive, it indicates that the marketing margin has decreased through time. The time trend coefficient is the most important coefficient in the marketing margin analysis. The other regression coefficients will not be mentioned in the discussion of the livestock-animal product classes unless the coefficients contribute support to the margin analyses.

The a., b. and c. equations for farm-retail beef are estimated as follows:

a. $$\text{Value}_{\text{Farm}} = -6.95 + \underset{(12.3)}{0.76}\ \text{Value}_{\text{Retail}}$$
$R^2 = 0.89$

b. $$\text{Value}_{\text{Farm}} = -13.40 + \underset{(26.6)}{0.88}\ \text{Value}_{\text{Retail}} - \underset{(14.4)}{0.96}\ \text{time}$$
$R^2 = 0.98$

c. $$\text{Value}_{\text{Farm}} = -16.82 + \underset{(32.5)}{0.91}\ \text{Value}_{\text{Retail}} - \underset{(17.2)}{0.66}\ \text{time}$$
$R^2 = 0.94$

The high R-squared values for all three equations indicate that there is a strong association between farm value and retail value of cattle and beef carcasses on a retail weight basis. All regression coefficients are highly significant except the time coefficient in the a. equation. The time coefficient was dropped from the a. equation because of this reason. Using the constant terms in the a. and c. equations and the average of the wholesale price index for the two periods as a deflater, there is no strong indication that actual processing costs have risen faster than the wholesale price index between the two periods. Real costs were about constant.

The time coefficient is negative for the b. and c. equations, which indicates that the farm retail spread tended to increase during the postwar period. These increases appear to be the results of increasing supply costs (due to higher factor prices) of labor, material and transportation for marketing and processing. The supply cost increases (in current dollar values) amounted to .66 to .69¢ per pound of beef or about 4% annually.

It is believed that most of the increases in marketing supply costs occurred at the retail level because of increased demand for product services. It is not likely that marketing costs have gone up faster during the postwar period than a relevant factor price index. The hourly earnings of food marketing employees have increased at about 6% per year since 1950. If this wage rate increase and the wholesale price index increase (1% per year since 1950) are averaged, a 3.5% per year general price index is obtained. Indications are that there have been no significant marketing and distribution efficiency changes for beef during the postwar period.

Pork

Three farm-retail price analyses were made for pork. The c. equation utilizes U.S.D.A. quarterly data. The farm level prices were converted to a retail weight basis for choice grade pork. The retail price of pork per pound is the weighted average price of ham, bacon, loins, picnics, sausage, butts, spareribs and bacon squares. At the farm level, it takes about 2 lbs. of live hog to make 1 lb. of retail cuts (excluding lard). The net farm value of hogs is the average price of 2 lbs. of live hog less the value of by-products.

The theoretical basis assumes that the farm value should be equal to the retail value minus marketing and processing costs. In the regression function, the coefficients of the retail value should be equal to one. It is also assumed that the constant term should be negative to indicate processing costs as well as the by-product allowance.

The a., b. and c. equations for farm-retail pork are estimated as follows:

$$\text{a. Value}_{\text{Farm}} = -8.71 + \underset{(14.1)}{0.75}\ \text{Value}_{\text{Retail}} + \underset{(2.9)}{0.15}\ \text{time}$$
$$R^2 = 0.93$$

$$\text{b. Value}_{\text{Farm}} = -19.77 + \underset{(11.5)}{0.99}\ \text{Value}_{\text{Retail}} \underset{(12.2)}{-0.68}\ \text{time}$$
$$R^2 = 0.95$$

$$\text{c. Value}_{\text{Farm}} = -22.90 + \underset{(25.0)}{1.01}\ \text{Value}_{\text{Retail}} \underset{(11.8)}{-0.54}\ \text{time}$$
$$R^2 = 0.90$$

The high R-squared values for all three equations indicate that there is a strong association between farm value and retail value of pork and time on a retail weight basis. All regression coefficients are significant at the 5% level. Using the constant terms in the a. and c. equations and the average of the wholesale price index for the two periods as deflater, there is no strong indication that actual processing costs have risen faster than the wholesale price index between the two periods.

The time coefficient is positive in the a. equation which means the actual farm-retail pork marketing and processing costs were decreasing during the period. The time coefficient is negative for the b. and c. equations which indicates that the farm-retail spread tended to increase during the postwar period. These increases appear to be the result of increasing factor prices and the costs involved with providing additional consumer services.

The supply cost increases (in current dollar value) amounted to from .54 to .68¢ per pound of pork or from 2.4 to 3.2% annually depending on the postwar period evaluation. Actual marketing costs during the postwar period have not increased faster than the factor price index. Real costs were stable.

It is believed that most of the increases in marketing supply costs have been occurring at the retail level. Indications are that the postwar period was slightly more efficient than the prewar period in the marketing and distribution sector. No significant change in marketing and distribution efficiency was noted for pork during the postwar period.

Broilers

One farm-retail price analysis was made for broilers. The prewar regression function was not computed because of limited broiler production in the 1920 to 1930 period. The c. equation utilizes U.S.D.A.

monthly data. The broiler evaluation is concerned with the price of live broilers per pound at the farm level related to the price of broilers per pound at the retail level and time. It is assumed that the yield rate is about .70 between the farm and retail forms.

The theoretical basis assumes that the farm value should be equal to the retail value minus marketing and processing costs. In the regression function, the coefficient of the retail value should be equal to about .70. It is also assumed that the constant term should be negative to indicate processing and marketing costs.

The c. equation for farm-retail broilers is estimated as follows:

$$\text{c. Price}_{\text{Farm}} = -10.54 + \underset{(27.2)}{0.63}\ \text{Price}_{\text{Retail}}$$

$R^2 = 0.97$

The high R-squared value for the equation indicates that there is a strong association between the farm price and the retail price of broilers. The time coefficient was not significant, which means the actual farm-retail broiler marketing and processing supply costs tended to be approximately stable during the postwar period. This indicates that marketing efficiency probably increased at a percentage rate equal to the factor price index (3 to 4%). If the factor price index increased at a 3% rate per year, then the constant term indicates that there was about a ⅓¢ per pound per year improvement in broiler prices due to marketing efficiency increases during the postwar period. This technological improvement was passed on to consumers with a net increase in per capita consumption (production) of about .10 lb. per capita per year.[11]

Eggs

Two farm-retail price analyses are made for eggs. The egg evaluation is concerned with the price of eggs per dozen at the farm level in relation to the price per dozen eggs at the retail level and time. No farm-retail conversion is necessary because all egg usage is on a shell egg equivalent basis.

The theoretical basis assumes that the farm value should be equal to the retail value minus marketing and processing costs. Theoretically, the coefficient of retail egg price should be slightly less than one and the constant term should be negative to indicate the marketing and processing costs.

[11] Demand function for live broilers by James B. Hassler, *The U.S. Feed Concentrate-Livestock Economy's Demand Structure, 1949–59,* Research Bulletin 203, Nebraska Agricultural Experiment Station, University of Nebraska, Lincoln, October 1962, had a slope relative to price of —.3.

The a. and c. equations for farm-retail eggs are estimated as follows:

$$\text{a. } \underset{\text{Farm}}{\text{Value}} = -6.78 + \underset{(25.0)}{0.83} \underset{\text{Retail}}{\text{Value}} + \underset{(2.3)}{0.10} \text{ time}$$

$R^2 = 0.99$

$$\text{c. } \underset{\text{Farm}}{\text{Value}} = -6.79 + \underset{(47.4)}{0.74} \underset{\text{Retail}}{\text{Value}} + \underset{(2.1)}{0.05} \text{ time}$$

$R^2 = 0.93$

The correlation coefficient indicates a strong association between the farm value and the retail value of eggs and time. The retail egg value coefficient is somewhat lower than expected. This can be explained by the different prices received at the farm level for eggs to be consumed and eggs to be used in processed products (the term also reflects processing losses). The time coefficient is positive in both equations which means the actual farm-retail egg marketing and processing supply costs tended to be reduced during the two periods.

Indications are that marketing efficiencies increased between the two time periods and during the postwar period at a rate approximately equal to the general price index change per year (2-3%). With a very inelastic demand function for eggs, no significant net quantity effects occurred, only reduced prices to the consumer.

Milk

Two farm-retail price analyses are made for fluid milk. The analysis is concerned with the price of milk at the farm level in relation to the price of milk at the retail level and time. No farm-to-retail milk conversion is necessary because only fluid milk is evaluated.

The theoretical basis assumes that the farm value should be equal to the retail value minus marketing and processing costs. In the regression function, the coefficient of the retail value should be approximately equal to one. It is also assumed that the constant term should be negative to indicate processing and marketing costs.

The a. and b. equations for fluid milk are estimated as follows:

$$\text{a. } \underset{\text{Farm}}{\text{Value}} = -9.88 + \underset{(38.4)}{0.80} \underset{\text{Retail}}{\text{Value}} + \underset{(7.8)}{0.28} \text{ time}$$

$R^2 = 0.99$

$$\text{b. } \underset{\text{Farm}}{\text{Value}} = -15.89 + \underset{(16.9)}{1.02} \underset{\text{Retail}}{\text{Value}} - \underset{(9.7)}{0.47} \text{ time}$$

$R^2 = 0.98$

The high R-squared values for both equations indicate that there is a strong association between the farm value and the retail value of milk and time. All regression coefficients are significant at the 5% level. Using the constant terms in the a. and b. equations and the average of the wholesale price index for the two periods as a deflater, there is a strong indication that actual processing costs have not risen nearly as fast as the wholesale price index between the two periods. Real costs appear to have declined.

The time coefficient is positive in the a. equation which means the actual farm-retail milk marketing and processing supply costs were decreasing during the prewar period. The time coefficient is negative for the b. equation which indicates that the actual farm-retail margin spread tended to increase during the postwar period. The postwar increases appear to be the result of increased factor prices.

Indications are that the increased marketing costs during the postwar period were approximately equal to the rise in the general price index. This means there were no real marketing efficiency gains or losses during the postwar period.

It is believed that most of the increases in marketing and processing supply costs have been occurring at the retail level. Many of the margin spreading costs have been caused by the addition of many consummer "demands" in the area of packaging and services.

Wheat

A prewar farm value-retail price wheat evaluation using data available from U.S.D.A. sources indicated that marketing margins were increasing at about 2% per year during the 1922 to 1941 period. The farm value of wheat in a 1 lb. loaf of white bread was subtracted from the retail bread price to obtain the marketing spread. Using an average marketing spread for prewar and postwar periods and the average of the wholesale price index for the two periods as a deflater, there is no strong indication that actual processing costs have risen faster than the wholesale price index between the two periods. This indicates that real costs were about constant between the two periods.

The farm value-retail price wheat evaluation was also made for the 1950 to 1967 period. The actual marketing margin increased at a rate of 3.5% per year from 11.9¢ per one pound loaf in 1950 to 19.4¢ per 1 lb. loaf in 1967. The major portion of the increase in the marketing spread was accounted for by increased wages and salaries in the baker-wholesaler spread. Indications are that certain factors have tended to reduce the size of the marketing spread during the postwar period.

It is not likely that marketing and processing costs have increased faster during the postwar period than a relevant factor price index. The hourly earnings of food marketing employees have increased at about 6% per year since 1950. If this wage rate increase and the wholesale price index increase (1% per year since 1950) are averaged, a 3.5% per year general price index is obtained. Indications are that there have been no significant marketing and distribution efficiency changes for wheat during the postwar period.

Effects of Marketing Margin Changes on Livestock Classes

Comparisons made between the prewar period (1922–1941) and the postwar period (1947–1964 or 1950–1967) for each animal product and wheat should indicate whether gains or losses were made relative to a competing product. If a product has realized reduced marketing and processing costs, then certain locations will be favored because of locational comparative advantage. If an animal or wheat product has realized increased marketing and processing costs between and during the two periods, then directional shifts in comparative advantage can be detected. This section will indicate the effect of marketing and processing supply cost changes on the price relationships among competing livestock and wheat enterprises, on the volume changes in the market and in the industry and the effects that the supply cost changes (technology change) have on the competitive strength of two competing areas.

The final product demand relationships among the five animal products follow the discussion presented in the livestock and poultry analysis section. Beef and pork are the only two products assumed to have significant cross-elasticity. Broiler prices have moved so low as to have erased further price cross-elasticity effects with beef or pork. Eggs and fluid milk have no cross-elasticity of demand effect on each other or on the three meat products. Wheat has no significant cross-elasticity of demand effect on livestock-poultry products.

Beef and Pork

When beef and pork marketing margin changes are compared between the prewar and the postwar period, relative price relationship differences are very minor. The relative position of beef compared to pork has changed only very slightly within and between the two evaluation periods. The effects of the supply cost changes (due to technology changes) have been relatively neutral for each of these animal products.

The volume changes that have occurred in the beef and pork industries during the two evaluation periods were in response to short-run supply variations or consumer demand shifts. Population, income and taste changes affected the final product demand for beef and pork relatively more than any marketing margin changes due to technology.

Broilers

The marketing margin changes of broilers during the postwar period indicate decreasing marketing and processing costs have been experienced by the broiler industry. The result was a real income gain by the consumer and an annual net increase in broiler production levels of about .10 retail pound per capita.

Because it is thought that the volume and the price changes experienced by the broiler industry have little effect on the beef or pork industries, no attempt will be made to quantify the effect on these two competing enterprises. If cross-elasticity effects could be measured, they probably would show a depressing effect on pork prices and production. The technological changes in the broiler industry have induced certain locational changes in comparative advantage, primarily to producing areas outside the study area.

Eggs

The marketing margin changes experienced by the egg industry between the prewar and postwar periods and during the latter period were quite similar. The theoretical marketing margin evaluation indicates that the egg industry has increased marketing efficiency during both evaluation periods. Retail egg prices (fresh or processed) should have been declining slightly during both periods because of supply cost changes in the egg industry that were induced by technological changes. Because eggs are not direct competitors with the other animal products evaluated, the only clear conclusion is that the consumer has had real income gains due to relatively lower retail egg prices. Because of locational advantages of nearby fresh egg production, much of the production gains were realized in areas outside the study area.

Fluid Milk

The milk industry experienced small marketing margin reductions from the prewar to the postwar period. Postwar anlaysis indicated that there were no real marketing and processing cost changes during the period. The volume changes that have occurred in the milk industry during the postwar period were in response to short-run supply variations or consumer demand shifts and not to technological changes in processing and distribution.

Wheat

The wheat industry experienced no real marketing and processing cost efficiencies between the prewar and postwar periods or during the latter period. Actual farm-retail spread values increased during the postwar period at a rate approximately equal to a general price index for the same period. Indications are that no real efficiency or income gains or losses were experienced by the consumer during the period. Generally the volume changes that have occurred in the wheat industry during the postwar period were in response to short-run supply variations and income and taste changes affecting demand for wheat products relatively more than any marketing margin changes due to technology.

INTEGRATED AGGREGATE ANALYSIS

The effects of technological change (supply cost changes) on field crop, livestock-animal product and marketing margin relationships are brought together in this section to determine relative aggregate changes in competitive strength in the Midwest area. The livestock-animal product relationships and the marketing margin changes used U.S. data so only implied technological changes are evaluated. The technological effects suggested by the results of the three anlayses are used to determine the implied contribution of technology to income changes. The relative effect of other economic forces versus the technological effect will be indicated in a gross sense.

The three analyses indicated that enterprise specialization was increasing in both the field crop and livestock areas during the postwar period. The effect of this specialization trend will be included in the aggregate analysis.

Results of the aggregate analysis are used to indicate possible farm policy changes or improvements. General policy evaluations are made to appraise whether more rapid technology adoption should be encouraged or accelerated by special agricultural programs.

This section is in the following parts:

1. A combined field crop and livestock analysis to indicate the extent of the technological changes experienced by the four regions.

2. An evaluation to indicate why certain geographic locations have been losing or gaining competitive strength over the period.

3. A general policy evaluation.

Aggregate Analysis

Aggregate technological effects must be put into perspective with the overall economic forces that have taken place during the postwar period. The most general and significantly large technological progress occurred in field crop production. With most crops, a 2 to 4% annual yield increase per acre dominated the rate of population growth domestically. The obvious result *(with lower unit supply costs)* was a reduction in price levels and continuing over-capacity to produce without a reduction in planted acreage. The general agricultural problem stemming from productivity gains will not be discussed. Rather the interest is in the conditional differential effects stemming from technology on competitive strength between enterprises and areas.

The massive shifts in relative demands for final products or population growth are not considered to be the result of technological changes within agriculture. Technological influence was strong during the postwar period in the 14-state area but it was a relatively minor influence when compared to the overall factors that stimulated economic adjustments. Subjectively, probably no more than 10% of the total increased economic activity during the postwar period in the Midwest at the farm level was induced by technological changes and the remaining 90% was due to shifts in demand and other economic forces. The aggregate analysis is concerned mainly with the changes and effects caused by technology.

The aggregate effect of technological change induced certain comparative advantage shifts within the 14-state study area. The feed-grain livestock absolute advantage held by the Corn Belt has been strongly challenged by a reduction of the comparative disadvantage in Nebraska, Kansas and the Southern Plains States. Relative technological improvement gains in feed grain and beef production areas are mainly responsible for the reduction in comparative disadvantage.

The technological gains for feed grains (especially grain sorghum) showed up as relative increases in net returns per acre and the beef gains were in the form of a one-grade quality improvement. The crop gains amounted on the average to about $5 to $12 per acre and the beef gain was approximately $1.50 per cwt.

North Dakota, South Dakota and the Lake States have only slightly reduced their comparative disadvantage relative to the Corn Belt. Technological changes in the field crop area are mainly responsible for the small relative improvement made by the Dakotas and the Lake States. Indications are that livestock production had made generally insignificant relative gains in the five-state area during the postwar period. It should be noted that all five livestock classes had significant actual or implied nonfeed production cost gains during the postwar period.

The Corn Belt retained the locational comparative advantage in pork production. Soybean production increased sharply in the Corn Belt area under the influence of significant varietal improvement. Other economic forces did not favor pork but these forces are largely responsible for the increased demand for soybean production.

Poultry (broilers and eggs) experienced the largest gains from technological change. A 12¢ reduction in broiler supply costs and a 5¢ per dozen reduction in egg costs was induced by technology during the post-war period. Approximately 4 lbs. of the 16 lbs. per capita increase in broiler consumption during the postwar period was due to technology. The main broiler production areas are outside the 14-state area but the increased broiler production probably would slightly advantage the feed grain producing areas.

Although other economic forces and not technology were mainly responsible for increased livestock production, the feed grain areas again gained competitive advantages over the northern states and the specialized wheat areas.

All analyses indicated that there had been increased specialization in the Midwest during the postwar period. What was the effect of technological change and other economic forces on the adjustment problems of technologically favored and unfavored areas? Indications are that certain highly specialized areas that could not adjust their enterprise composition (North Dakota wheat, for example) were probably definitely hurt by the postwar pattern of the economic forces. Areas that could adjust to the changing economic patterns made large relative gains. The specialized beef producing areas of the Plains states would be an example of an area that was favored by technological change. A 2-3% increase in demand or volume on the national level generated possibly a 10% volume gain in the specialized beef areas.

It is concluded from the aggregate technology analysis that technological changes in the form of increased feed grain and beef production are responsible for the competitive gains made by Kansas, Nebraska and the Southern Plains (relative to the Corn Belt) during the postwar period. These areas have a comparative advantage in beef production and they have strongly challenged the feed grain comparative advantage held by the Corn Belt. The Corn Belt is able to retain a strong competitive position relative to the remaining Midwest areas because of the increased productivity of soybeans.

The Lake states and North and South Dakota realized only minor competitive improvements from technological change. Most technological advancements were in the field crop area. Implications are that the five states were unable to capitalize to any great degree on the technological improvements that accrued to livestock during the postwar period.

The aggregate technological change evaluation would indicate that slight comparative advantage shifts had occurred in the 14-state area during the 1950–1965 period that favored the poultry and feed grain-livestock producer and slightly disadvantaged the wheat and milk producer.

Indications are that the highly specialized areas that were favored by technological and other economic forces made large relative gains during the postwar period. Technologically unfavored areas definitely were economically hindered or had rather large adjustment problems during the postwar period.

Analysis of Geographic Location Changes

The indications from the aggregate analysis are that about five states have not enjoyed the relative income increases from technological change during the 1950 to 1965 period that were enjoyed by the remainder of the states evaluated. Two states in the Northern Plains region, North Dakota and South Dakota, and all the Lake States seem to have lagged behind the remaining 9 states.

Wheat is the dominant crop in North Daktoa. Because of this, North Dakota wheat producers have not been able to benefit from the competitive advantages gained by feed grain producers in feed grain marketing through the livestock enterprises. Increased consumer incomes also mean less demand for cereal products and higher demand for animal products. Secondary feed grain enterprises in North Dakota indicate insignificant growth relative to the Corn Belt states because of limited potential for technological change adoption.

South Dakota corn net returns per acre grew relative to those for Iowa corn but the yield base in South Dakota is over 30 bu. per acre lower than in the Corn Belt. The gains from technology were small in South Dakota compared to those for the other dominant feed grain producing areas. Barley and wheat in South Dakota had little income improvement from technological changes. Low fertilizer application rates and low feed grain yields in South Dakota relative to rates and yields in the Corn Belt and states to the south would indicate that South Dakota is lagging in ability to expand livestock production unless feed is transported into the state.

Michigan and Minnesota feed grains have a small absolute advantage over the competing crops wheat and soybeans. Corn is the dominant crop in both states but only by virture of its strong showing during the early part of the 1950 to 1965 period. Corn has not realized the technological gains in either state that have been experienced by wheat or soybeans. The percentage of corn acreage in both states is small compared to that in the Corn Belt States. Oat and barley acreages were large in both states and neither crop was economically competitive during the 1950 to 1965 period. Neither state has gained the maximum benefits from the increased demand for feed grains and livestock products because of generally low feed grain response to technological changes.

The other Lake State, Wisconsin, is lagging behind the remaining states for a slightly different reason. Technological gains by Wisconsin corn (the dominant crop) were relatively large compared to gains in other states but the total corn acreage was small. Wheat and soybeans in Wisconsin realized small technological gains compared to the other two Lake States. So in total, Wisconsin is not realizing the magnitude of technological or income improvements that are being realized by the neighboring Corn Belt states. Wisconsin has a large dairy industry and because milk competitiveness is lagging behind that of other animal products, this would indicate that Wisconsin has not shared equally in net income gains from livestock and poultry technology realized by the remaining nine-state area.

The Southern Plains, Kansas and Nebraska experienced large technological advances in feed grain (grain sorghum) production during the postwar period. Indications are that the income positions of producers were further improved because of increased livestock production stemming from increases in demand for animal products. The ability of the Corn Belt to maintain its competitive position was largely due to the increased productivity of soybeans.

The overall analyses seems to indicate that the states that enjoyed the largest income advance from technology were Oklahoma, Texas, Kansas and Nebraska. North Dakota, South Dakota and the Lake States' technologically-induced income seemed to be lagging behind that in the remaining nine states. The relative income position of producers in the Corn Belt had changed only slightly.

General Policy Implications

The general policy implications of technology are determined by the magnitude of the changes in farm operator income caused by technological change experienced by producers in the states being evaluated. This section will assess the implied income changes that have taken place during the study period.

Agricultural producers were confronted with large numbers of technological innovations during the 1950 to 1965 period. Decisions on whether to adopt a new technological change were numerous during this period. The availability of technology during the 1950s and 1960s indirectly generated a stress period of readjustment for many agricultural producers.

The overall policy issue is analyzed in terms of how much of the technology available in agriculture is the result of public-sponsored research.

The field crop and livestock analyses indicate that technology availability was not the problem so much as the inability of certain geographical locations to use the available technology. The field crop analysis indicates that certain crops (wheat, oats and barley) in a majority of the states have lagged behind the remaining crops in the varietal improvement and yield potential area. If crops can be genetically improved, then fertilizer application, irrigation and other supporting technologies can be utilized to improve the competitiveness of the crop. Certain capital forms could be more fully utilized by the crop production and use areas (transformation by livestock) if the yields of these crops were increased to a more profitable level.

If the technological evidence was strong that a state or area should be adopting new available technologies then should there be income subsidies to aid the underdeveloped area? Also, if public-supported technological advancements cause shifts in comparative advantage, is this sufficient grounds for income transfers? The author feels that if this were the case, then income transfers would be justified. However, slight net returns per acre lags in field crop activities were the exception and not the rule. Furthermore there is no definite evidence in this study that any area or state studied has had such serious income lags that it had serious losses in competitiveness, so the questions do not seem to be valid policy issues.

It is concluded that publicly sponsored research (developing technological innovations) was not responsible for income disparities in the Midwest.

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