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The "Miracle" of U.S. Agriculture

Terry L. Roe and Munisamy Gopinath

Introduction

This story is about the economic miracle of U. S. agriculture. Most of it focuses on agriculture and its linkages to the rest of the U. S. economy following WWII. But we start with a brief overview of its evolution.

The Story Begins

In 1870, almost half the U. S. labor force was employed in agriculture. As the economy developed, agricultural output continued to grow, but other sectors of the economy expanded even faster. The result was a decline in agriculture's share of the total value of goods and services produced by the economy. By the start of World War I, agriculture employed less than 1/3 of the total labor force.

This adjustment was not only the result of the industrial revolution and the growth of non-farm jobs. It was greatly aided by the increase in agricultural production that made U. S. food cheaper than in other industrial countries. This meant a larger proportion of American income could be spent on other goods and services.

The industrial revolution depended on imports of new capital goods and capital flows from abroad. At the turn of the century, U. S. foreign debt was nearly 20 percent of the total economy's production of goods and services.

Agriculture played a major role in earning the foreign exchange that made these imports and debt repayment possible. Agricultural exports accounted for over half of the total value of U. S. exports at the turn of the century. However, following WWI, European war debt repayment caused the dollar to appreciate in value. This in turn raised the real price of U. S. farm products for

foreign buyers. At the same time, many of the world's economies were becoming more protectionist. Jeffery Sachs and Andrew Warner argue that "the global capitalist system peaked around 1910, but subsequently disintegrated in the first half of the twentieth century, between the outbreak of WWI and the end of WWII."

This "global capitalist market economy" has only begun to re-emerge since the early 1950s, and

only especially so since about the mid-1980s.

In the early 1900s, agriculture was almost three times more dependent on foreign markets than other sectors of the U. S. economy. The appreciation of the dollar and other protectionist policies caused America to be a net importer of agricultural products from 1926 through 1944. Even so, agriculture continued to supply labor to the

(See *Miracle* page 2)

Price Risk Management by Minnesota Farmers

Darin K. Hanson and Glenn Pederson

The management of market price risk is an integral part of operating a successful farm business. Its importance has recently increased. Increased price volatility associated with shifts in export demand and in international monetary conditions is expected to result in substantial variability in annual farm income.

By managing price risk, farmers are better able to stabilize farm income and to ensure that funds will be available to fulfill both business- and family-related financial obligations. In this article, we summarize the price risk management decisions and strategies of farmers who are dealing with this situation.

Two traditional ways to manage price risk in grains are forward pricing and participation in government programs. Forward pricing includes the use of

forward contracts, futures contracts, and/or options contracts. By using these marketing tools, farmers can either "lock-in" a specific price or guarantee a minimum price level when the crop is ready to be sold.

In the past, the target prices and loan rates of the government subsidy programs could be used like forward prices. Because there were no transactions costs, such as margin accounts or option premiums, the price risk management advantages embodied in government programs were attractive substitutes. This

(See *Price Risk* page 5)

(Miracle continued from page 1)

rest of the economy and to serve as a major user of industrial goods and services. Agriculture remained a job creator for the rest of the economy.

Around 1950 the growth in total factor productivity in agriculture began to pass that of the rest of the economy. Growth in total factor productivity means technological change that causes output to grow even though prices and all inputs—land, labor, mechanical, and chemical—are held constant. It is at this point of growth that we pick up our more detailed story of modern American agriculture.

The Modern Miracle

A major element of our story is the reemergence of agriculture as an important export sector. This growth is characterized by a capacity to provide a wide array of food of increasing variety and quality, and to achieve this in the face of long-term declining

real prices for its products. This performance was largely due to a high rate of growth in agriculture's total factor productivity.

Figure 1 shows the growth since 1948 of gross domestic product (GDP), the revenue left over after payments have been made to all economy-wide factors of production, such as hired labor, fertilizer, energy, livestock feed, and so forth. Thus, GDP measures the total returns to resources that are, for the most part, specific to agriculture, such as family labor, farm buildings and equipment, and land.

Notice that agriculture's GDP remained fairly constant, in real terms, until the mid-1960s. Because there was a net migration of labor out of agriculture and because farms grew in fixed resources per farm, returns to family labor trended upward, albeit at a slower rate than per capita non-farm income. Notice too the rise in the growth of GDP starting in the late

1960s. The rate of growth over the period 1968-91 averaged about 1.9 percent per year, although there has been considerable variation from year to year.

Table 1 shows annual average rates of growth of GDP for the U. S. economy as a whole and for agriculture. Over the entire 1949-1991 period, agriculture's average rate of growth was only about 0.25 percent per year, while the economy as a whole averaged about 3.1 percent.

Accompanying agriculture's more recent growth in real GDP is its reemergence as a major export sector. Figure 2 shows that the United States was a small net importer of agricultural products through 1956, and remained a relatively small net exporter until the late 1960s. Then, in the early 1970s, agriculture emerged as a major net exporter, with its rate of growth averaging 6.8 percent per year, over three times its rate of growth in GDP. Currently, agriculture accounts for almost 8.5 percent of total U. S. exports of goods and services, even though its share in the total economy is only 1 percent.

What is even more surprising is that this performance occurred at a time of declining real prices received by farmers, shown in Figure 3. With the exception of two "oil-shock" episodes during the 1970s, the index of real prices received by farms has declined to only slightly over 30 percent of its value in the early 1950s. The real price index of manufacturers remains above 85 percent, while the real price index of services has risen to nearly 140 percent of its value of those earlier years.

Figure 1. U.S. Agriculture Since 1948: Gross Domestic Product

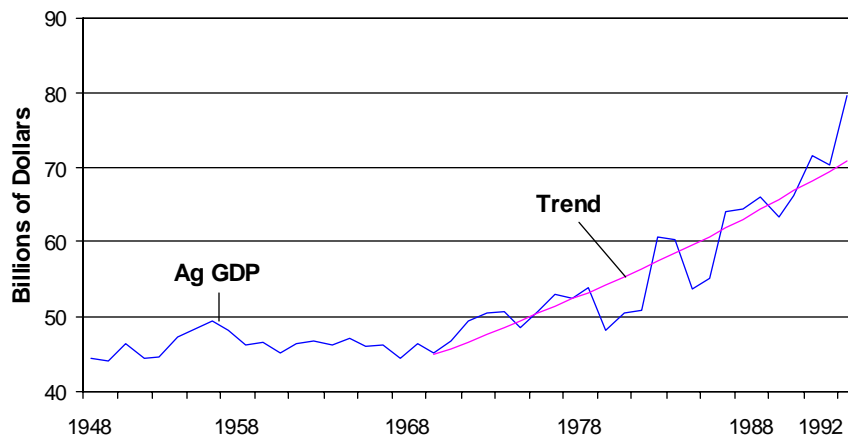


Table 1. Growth Decomposition of the U. S. Economy, Agriculture, and Food Processing, Various Years; in Percent

	Economy				Agriculture				Food Processing			
	US GDP (1)	Residual (2)	Price Index (3)	Total Inputs (4)	Ag. GDP (5)	Residual (6)	Price Index (7)	Total Inputs (8)	Food GDP (9)	Residual (10)	Price Index (11)	Total Inputs (12)
1949-53	5.39	1.78	0.65	2.86	-2.44	1.2	-4.04	0.4				
1954-58	1.67	0.32	0.35	1.00	-1.8	1.9	-4.99	0.1				
1959-63	3.92	1.55	0.19	2.15	0.14	2.54	-2.4	0	1.05	1.00	-1.79	1.84
1964-68	4.78	0.68	0.10	3.97	0.39	3.03	-1.95	-0.69	1.64	0.33	-1.02	2.33
1969-73	3.18	0.62	-0.04	2.59	8.97	3.45	5.71	-0.19	3.52	0.52	1.54	1.46
1974-78	2.57	-0.20	0.15	2.61	-2.73	-0.54	-4.18	1.99	1.84	-0.29	-0.51	2.64
1979-83	1.10	-0.65	0.17	1.59	-4.56	-0.25	-2.86	-1.45	-1.46	0.90	-2.27	-0.09
1984-88	3.86	0.80	0.00	3.03	0.78	4.16	-2.17	-1.21	0.78	0.79	-1.15	1.14
1989-91/92*	1.40	0.45	-0.04	0.98	5.65	4.68	0.03	0.94	-0.64	-0.29	-0.94	0.59
Average:												
1949-92	3.134	0.598	0.175	2.338	0.249	2.128	-1.961	-0.057				
1959-92	3.017	0.465	0.079	2.458	0.967	2.303	-1.187	-0.149	1.059	0.467	-0.874	1.466

*Columns 1 to 4 go through the year 1992. The remainder go through year 1991.

The forces behind these trends emanate from both demand and supply effects. As real incomes grow, the amount of new income consumers spend on services rises relative to that spent on food. So even if the demand for and expenditure on food rises, it does not rise as fast as the demand for services.

In spite of this decline in agriculture's terms of trade with the rest of the U. S. economy, the supply of food has grown faster than demand, and agriculture's real GDP has tended upward. Clearly, access to foreign markets has been critical. What is it that keeps U. S. agriculture competitive in these markets? Do the factors that cause agriculture to be competitive in foreign markets also help the competitiveness of the food processing industry?

What Keeps U. S. Agriculture Competitive?

We can answer that question by decomposing GDP growth into its sources and analyzing these sources in detail. Look at Table 1 again. Growth in total resources (column 4) explains about 75 percent of the annual rate of growth in the American economy. Favorable changes in the country's terms of trade with the rest of the world account for a mere 5.4 percent. About 19.6 percent is caused by "other factors," the most notable of which is technological change, which we refer to here as growth in total factor productivity. More simply, but a bit inaccurately, had there been no change in the level of resources available to the economy, had prices remained unchanged, the U. S. economy would have grown by about 0.6 percent per year due to technological change alone.

Now compare this outcome with that of agriculture alone. The negative price numbers reveal what Figure 3 suggests; namely, all else constant, declining terms of trade faced by agriculture would have caused agriculture's GDP to decrease, on average, by about 1.96 percent per year (column 7). Over this period, agriculture lost some resources, as the smaller negative numbers indicate in column 8. Hired and family labor accounts for the majority of these, while the resources that flowed into agriculture include purchased inputs and capital. The net effect on GDP was a small negative decline of about 0.06 percent per year.

But the overall growth in GDP is positive. This is because of agriculture's total factor productivity

Figure 2. Net Agricultural Trade, Exports Minus Imports 1950-95

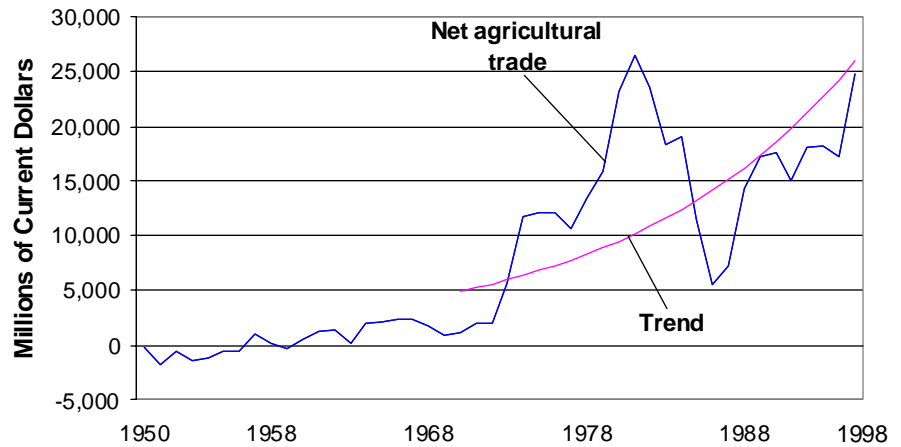
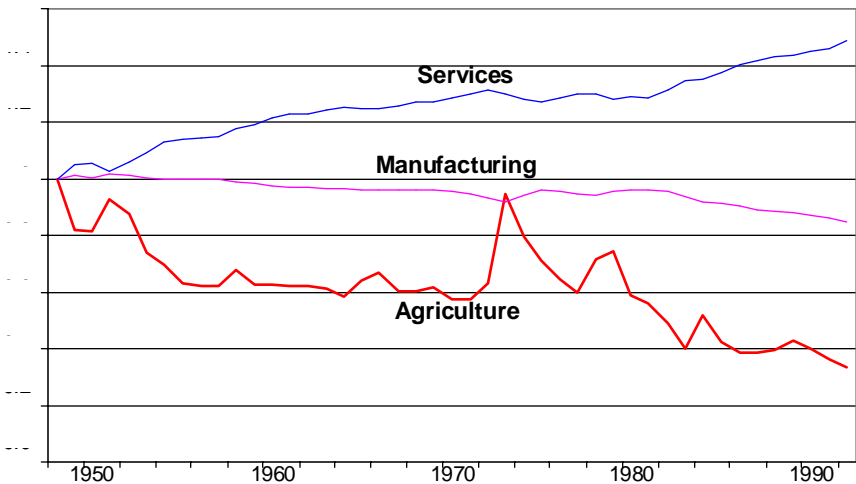


Figure 3. Domestic Terms of Trade: Real Agriculture, Manufacturing, and Services Price Indexes



(column 6), which averaged over 2.3 percent per year. This is the major source of agriculture's outstanding performance in recent decades.

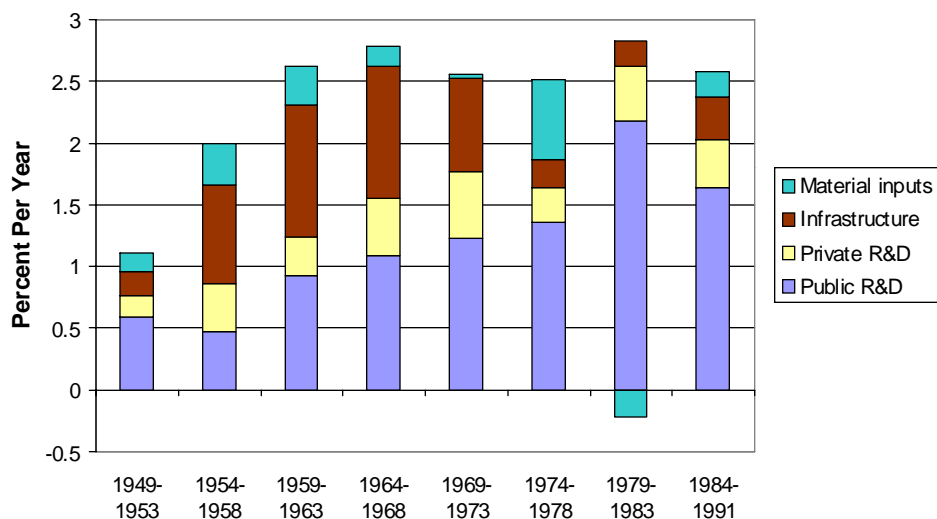
Figure 4 shows the determinants of growth in factor productivity. The bars measure agriculture's level of total factor productivity after random "statistical noise" has been removed from the numbers in Table 1. Growth in productivity peaked in the mid-1960s and has remained fairly constant since that time.

The partition of the bars provides the explanation for their height. Notice the important role played by investments in public research and development (R&D) in agriculture. This accounts for nearly 2/3 of average total factor productivity. Notice too the important role played by infrastructure, such as investments in roads and

rural electrification. This source reached its peak in the early 1960s, and now plays a much smaller role. Private investments in agriculture-related R&D is almost equal in importance with the efficiencies found in inputs of machinery, chemical and biological technologies not accounted for by research and development.

So the strength of modern American agriculture lies in part in those investments that increase the sector's total factor productivity. Growth in factor productivity (which helps farmers compete for economy-wide resources) also helps to keep the sector competitive in world markets. Of course, policies that give access to these markets are a prerequisite. Otherwise, farmers would face even more rapid declines in prices.

Figure 4. Sources of Growth in U. S. Agricultural Total Factor Productivity



Growth in agriculture's GDP is less than its growth in total productivity. Does this imply that some of agriculture's efficiency gains are passed on to the rest of the domestic world economy? The answer is yes. To see how this happens, consider the food processing sector.

Agriculture and Food Processing

The single largest input subcategory of total costs of processing food is primary agricultural inputs, such as wheat in flour-based products or beef in meat products. This subcategory, averaging over all food products, accounts for about 26 percent of the total cost of processing food. Processed food is a growing share of foreign trade, accounting for about 56 percent of total U. S. agricultural exports in 1993 compared to 35 percent in 1980. Increasing the competitiveness of the food processing sector in world markets thus indirectly increases the competitiveness of agriculture. The reverse is also true.

Columns 9-12 of Table 1 show the growth decomposition of the U. S. food processing sector. The sector experienced an average rate of growth of 1.06 percent per year, only slightly higher than that of agriculture over the same period. Its rate of growth in total factor productivity of 0.47 percent per year, however, is far less than agriculture, and equals that of the rest of the economy. As in the case of agriculture, growth in food processing GDP has been negatively affected by declining output prices. All else constant, these can be thought of as causing its GDP to fall by about 0.9 percent per year. Its

major source of growth has been in the increased employment of capital and material resources, which in total (and all else constant) would have caused its GDP to grow by 1.47 percent per year.

The key link is in the materials input category. The last entry in column 7 shows that the index for prices received by farmers (-1.19%) declined by about twice that experienced by the food processing sector (-0.87%). This price decline translates into a 0.31% (0.26 x 1.19) average annual decline in the procurement costs to the food processing sector. This is on par with the food processing sector's growth in productivity.

Thus, because of declining prices, over half of the gains from growth in agriculture's total factor productivity does not show up in higher payments to family labor, buildings, equipment, and land. Instead, this gain has been passed on to the food processing sector through lower prices for material inputs.

Did these gains stay in the food processing sector? No, the output price decline faced by the food processing sector (0.87 - 0.31 = 0.56%) is even greater than its growth in factor productivity (0.47%). Hence, the ultimate beneficiaries of the efficiency gains in agriculture and food processing are consumers (retail and wholesale trade, hotels and restaurants).

Looking closer, we find that food processing sub-sectors procuring grains and other crops as primary inputs have had the highest rate of growth in factor productivity. This coincides with the sub-sectors of primary agriculture that have also had the highest growth rate

in efficiency gains. It is through these growth linkages that agriculture has sustained and increased its competitiveness in domestic and world markets. By passing these gains on to the rest of the economy, agriculture has contributed to the growth of the U. S. economy.

Conclusion

This article has summarized some of the key results of a two-year long empirical study of how U. S. agriculture can retain and/or increase its competitiveness in the domestic and world markets. We found the keys to competitiveness are:

- Continued investments by the public sector in agricultural R&D,
- private sector investment in R&D,
- the maintenance of an efficient distribution and infrastructural system,
- the pursuit of domestic economic policy that makes it easier for agriculture to adjust to changing market conditions,
- economic policy that provides access to world markets, and
- investment in human capital.

Posed another way, could the miracle of agriculture have been even greater, even more socially profitable? The answer is yes!

Had rural child and adult education programs been on an even par with their urban counterparts during the post-war period, agricultural GDP per farm household would have been far higher and agriculture would have adjusted more quickly to new market conditions with less need of expensive farm programs.

Both the public and the private sector continued to under-invest in agriculturally related R&D. Social profitability of these investments have been estimated to yield returns of 50% per dollar invested per year.

Continued emphasis must be placed on opening world markets to U. S. farm and food processors. Evidence suggests that agriculture's growth in factor productivity in the mid-1990s is falling due to declines in real public investments in R&D, which has not been compensated for by the slight rise in private R&D investments. This may be the biggest threat to the future competitiveness of American agriculture.

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advantage was confirmed in a 1984 survey, which found that farmers considered government programs to be a more important method of managing grain price risk than was forward pricing.

Passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR) fundamentally changed the relationship between grain prices and government support to farmers. In effect, FAIR decouples government commodity payments to farmers from market prices. In addition, FAIR calls for an end to direct government subsidies by 2002. Given the demonstrated importance of government programs in farmers' price risk management plans, dramatic changes in the use of the various forward pricing tools could occur if government support is in fact eliminated.

We report here the results of a 1997 survey of southern Minnesota grain farmers. We sought to identify the major factors influencing farmers' forward pricing behavior as well as their views about future forward pricing behavior as changes in government programs occur. Finally, we wanted to evaluate farmer interest in consulting services that assist in the development of grain marketing plans.

The Survey

A mail survey was sent to a random sample of 800 grain farmers in southern Minnesota in March 1997. A total of 378 responses were usable. Farmers were asked about their use of price risk management methods and their views on issues regarding grain marketing.

Eighty percent of the responding farmers indicated that at least half of their total farm sales were from grain (principally soybeans and corn). The large number of respondents using forward, futures, and options contracts suggests that managing commodity price risk is an important objective (Table 1). About 74% of the respondents use forward contracts, 22% use futures, and 18% use options to control price risk.

The types of forward contracts are summarized in Table 2. Cash contracts are used by more farmers by far than any of the other forward contracting methods. About 73% report using forward cash contracts. The forward basis contract is the next most popular type, accounting for 14% of

all the farmers using forward contracts. The least popular forward contract is the minimum price contract.

In general, futures and options can be used to lock in grain prices in two different situations. The selling price can be locked in before the grain is actually produced to ensure a favorable price at the time of harvest—a "harvest hedge." Alternatively, these marketing tools can be used to lock in prices for grain that is stored for a period of time after harvest—a "storage hedge."

Of the 378 farmers responding to the survey, 15% report using futures contracts for harvest hedges and 14% report using futures for storage hedges. We found that similar proportions of farmers use options contracts for these same purposes.

Farmers were also asked whether they will use futures and options during the next five years. About 28% report that futures contracts will be used and 26% said that options contracts will be used.

Who Uses Forward Pricing?

How do the characteristics of farmers and their farming operations affect their decisions to use forward pricing? Based on previous studies of farmer marketing behavior and on our perception of what was measurable, we selected a few key characteristics for examination: annual gross farm income, level of farm debt, farm operator age, and farm operator education. The survey results show that forward pricing is indeed influenced by each of these characteristics.

Annual gross farm income is a general indicator of farm size, since it reflects the total amount of revenue generated during a given year. We

found that a greater proportion of the larger farming operations use forward pricing than do smaller farms (Table 3). This is particularly true for the use of futures and options contracts. Nearly 40% of the farmers reporting gross farm income greater than \$250,000 use these forward pricing tools, compared to 10% of the farmers with gross farm incomes less than \$100,000.

Why might the relative frequency of using these forward pricing methods increase along with gross farm income? There are several alternative explanations. Farmers running larger farming operations may carry more debt, they may be younger and have larger nondebt fixed obligations, or they may have a better understanding of these marketing tools. Thus, the size (as measured by gross farm income) is clearly related to marketing strategy, but the economic meaning is still not clear. To help, we explored other factors that may be related to size.

We measured farm debt level by the traditional total debt/total asset ratio. Our survey suggests that as debt levels rise, a greater proportion of farmers use forward pricing (Table 3). About 32% of the farmers with debt/asset ratios of 0.60-1.00 use futures contracts to manage price risk, while only 14% of the farmers with debt ratios less than 0.30 do so.

One possible reason is the necessity for farmers carrying higher debt levels to guarantee a level of revenue that is adequate to cover business expenses and scheduled amounts of debt repayment. Increasingly, loan contracts require borrowers to use some form of forward pricing in order

Table 1. Use of Forward Pricing

Method	Percent of All Respondents	Average Percent of Total Grain Production Contracted
Forward Contracting	74	35
Futures	22	22
Options	18	19

*Measures the percentage of total grain production.

Table 2. Types of Forward Contracts Used by Farmers

Method	No. Using	Percent
Cash Contract	276	73
Basis Contract	54	14
Deferred Price Contract	34	9
Hedge-to-Arrive Contract	43	11
Minimum Price Contract	29	8

to get a loan or to qualify for a lower interest rate. This is because of the implied reduction in credit risk.

Our analysis suggests that the age of the farm operator also affects forward pricing decisions. In general, older farmers use forward pricing contracts less frequently (Table 3). This is especially true for farmers over the age of 60. We found that no farmers older than 65 used futures or options.

The education level of the farm operator also seems to influence the decision to use forward pricing, especially futures and options contracts (Table 3). Among farmers who had graduated from college, 39% use futures contracts, while only 16% of the farmers with a high school diploma use either futures or options contracts.

Opinions About Hedging

Farmers were asked about their knowledge of, and opinions about, the use of futures and options contracts as hedging tools. Farmers currently using these tools indicate an understanding of the mechanics of these markets, feel comfortable in dealing with commodity brokers, feel that the use of these tools can reduce risk in their farming operations, and believe that these methods can increase farm income. Table 4 summarizes farmer responses.

Almost all the survey respondents participated in government programs during the past three years. Given the expected similarity of risk management objectives of farmers using forward pricing contracts and/or government programs, the surveyed farmers were asked to indicate if past government support had reduced their need to use forward pricing contracts. About 47% of the farmers indicated that the programs replaced their need for futures and options hedging strategies.

Many farmers indicated that they expect government support to diminish in the future and that additional use of forward pricing will be needed to substitute for the risk-reducing role of government programs. About 72% indicate that forward pricing alternatives will be necessary in the future when government support diminishes.

Demand for Consulting Services in Marketing

The survey also evaluated the expressed demand for marketing

Table 3. Gross Farm Income (GFI) and Forward Pricing

	% Using Forward Contracts	% Using Futures Contracts	% Using Options Contracts
Gross Farm Income			
\$0 to \$100,000	62	9	6
\$100,001 to \$250,000	74	20	15
>\$250,001	84	37	32
Debt-to-Asset Ratio			
.0-0.30	63	14	9
0.30-0.60	83	29	27
0.60-1.00	87	32	26
Age Category			
<31 years	91	27	18
31-40	81	28	26
41-50	75	24	19
51-60	75	23	18
>60 years	58	9	6
Education			
8th grade	50	0	0
some high school	64	7	0
high school grad	69	16	12
technical/vocational	74	23	23
some college	87	28	29
college grad	82	39	23

consulting services. These types of services may provide advice about appropriate marketing strategies and brokerage services, as well as advice on the timing of market transactions. While only 16% of the responding farmers currently hire this type of service, many of the farmers not currently using marketing consulting services expressed an interest in using them in the future. In response to the question, "Would you consider using a marketing consulting service for your farming operation?" 32% of the farmers answered "yes." Based on these responses, we estimated the average amount this group of farmers would willingly pay for these services is about \$2.79 per acre.

Conclusion

The response to this marketing survey provided useful data for examining the methods farmers use to market grain, the set of factors that are thought to influence their marketing decisions, and the opinions farmers have about the use of marketing tools to hedge commodity price risk. The results indicate that a large percentage of farmers forward price grain production with forward contracts, futures, and options. Forward contracting is clearly the

dominant method, but there are significant differences in how those forward contracts are being priced.

Our analysis of the characteristics of the farmers and their farming operations suggests that several factors may influence the choice of a particular forward pricing strategy and the type of forward pricing contract that is used. Farmers who are most likely to use futures and options contracts operate larger farms, carry higher relative debt positions, have higher levels of formal education, and are younger. These results are generally consistent with previous survey findings in other regions of the United States.

Surveyed farmers anticipate that direct government support payments will diminish in the future and other methods will be needed to manage grain market price risk and stabilize farm incomes. Many farmers even suggest that the use of grain marketing consultants could be a feasible alternative to single-handedly developing their own grain marketing strategies.

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Table 4. Opinions About Forward Pricing Alternatives

	Percent of those respondents now using futures to hedge			Percent of those respondents not now using futures		
	Agree	Disagree	Not Sure	Agree	Disagree	Not Sure
I understand how to use futures as a method for marketing my grain	97	0	3	51	29	20
I feel comfortable developing a relationship with a commodity broker	85	7	8	36	39	26
The pressure of maintaining a margin on a futures account is too great	36	58	6	56	23	21
I approve of the futures market	92	6	3	52	28	20
My 'local basis' is too unstable to effectively use the futures market	15	78	7	32	36	33
Futures restrict me from taking advantage of rising commodity prices	17	78	6	28	47	25
I receive a fair price from my local elevator/co-op in comparison to the price I would receive from the futures market	44	39	17	56	16	28
The use of futures in my marketing plan would result in higher farm income	57	22	21	25	32	43
The use of futures in my marketing plan would reduce risk in my farming operation	67	24	10	39	30	31
The possibility that my local elevator/co-op will go bankrupt makes futures contracting a better marketing alternative	13	75	13	14	56	29
Futures (and options) are too restrictive because they only allow me to contract increments of 5,000 (and 1,000) bu.	21	69	10	31	34	35
I understand how to use options as a method for marketing my grain	95	5	0	42	33	26
The cost of the option premium is too great to justify the purchase of these types of contracts	13	81	5	42	25	33
I approve of the options market	90	3	6	45	18	37
My local basis is too unstable to effectively use the options market	3	86	11	23	36	41
The use of options in my marketing plan would result in higher farm income	57	16	27	20	26	55
The use of options in my marketing plan would reduce risk in my farming operation	83	10	8	38	20	42
Options (and futures) are too restrictive because they only allow me to contract increments of 5000 (and 1000) bu.	14	79	6	32	33	35

* Non-hedgers are those farmers who do not use futures.

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