IMPACTS OF BIOTECHNOLOGY ON FINANCIAL SURVIVAL OF COTTON FARMS IN THE TEXAS HIGH PLAINS

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Abstract

The objective of this study was to evaluate the short-run economic impacts of biotechnological advances relating to plant stress reduction on the profitability and financial viability of cotton farms in the Texas High Plains Region (THPR). The study area was divided into two distinct sub-regions: Transition Area and Southern High Plains.

To evaluate the potential impacts of plant stress and biotechnology on the profitability and financial viability of THPR cotton farms, two representative model farms (one for each sub-region) were constructed and implemented in FLIPSIM (Farm Level Income and Policy Simulation Model). Two sets of models were run: (1) baseline models and (2) biotech models. The baseline models used historical crop yields and prices, while the biotech models used estimates of crop yields which accounted for expected effects of biotechnology. These models were run at various levels of intermediate and long-term debt (IT/LT).

The baseline models show that the representative farms were profitable and viable over the ten-year horizon (January 1,1995 to December 31, 2004) only at lower levels of debt. The biotech models show that the implementation of biotechnology increases the profitability and financial viability of all THPR farms in the short-run. However, the representative farms still suffer from profitability and financial viability problems at high debt levels with the implementation of biotechnology. Farm incomes do not keep up with the expected rate of inflation as indicated by negative changes in real net worth over the ten-year time horizon. Additionally, return on equity is less than return on assets for the baseline and biotech models for all debt levels, therefore indicating that the cost of debt is higher than the return on assets.

Introduction

Plant stress is a problem that affects all crop production. Grime (1981) defines plant stress as "external constraints which limit the rate of dry matter production" (p.183). Heinrichs (1988) considers stress as "any abiotic or biotic factor of the environment that affects plant physiology, chemistry, growth, and/or development in such a way that plants perform below the average for a region" (p.10). Heinrichs (1988) divides plant stress into two categories, abiotic and biotic. Abiotic (or physico-chemical) stresses consist of: (1) the physical and chemical properties of soils, (2) moisture deficit and excess, (3) temperature extremes, (4) electromagnetic energy, (5) plant growth regulators and pesticides, (6) air pollution, and (7) mechanical damage. Biotic (caused by living organisms) stress consists of: (1) insects, (2) plant competitors, and (3) plant pathogens.

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Stress damage can further be divided into primary and secondary categories. Primary stress injures a plant by the physical strain it produces. When a stress injures a plant, not by physical strain, but by producing or giving way to a second stress, secondary stress injury occurs. Thus, the primary stress itself may not be injurious to a plant but may produce a secondary stress which is injurious. For example, high temperatures (primary stress) may not injure the plant but may produce a moisture deficit (secondary stress) which may lead to plant damage.

These stresses physically damage the structure of the crop plant and affect its potential to adequately develop. Specifically, these stresses reduce the yield performance of plants, resulting in an overall crop yield reduction. The resulting loss in yield leads to losses in potential income. Consequently, crop producers realize lower net operating income (or net cash flow) than if stress were not present.

The loss or reduction in net operating income has a direct effect on crop producers' overall risk positions. This loss or reduction in net operating income results in an increase in producers' business risk, which is the risk associated with the variability of expected net cash flows generated by an asset regardless of how it is financed. Business risk is measured by the coefficient of variation of net cash flows:

$$BR = \frac{\sigma}{c} , \qquad (1)$$

where BR is business risk, σ is the standard deviation of net cash flows and c is expected net cash flows (Gabriel and Baker, 1980).

The loss or reduction in net operating income may also affect a producer's financial risk. Financial risk being the risk of losing equity capital and borrowing capacity arising from fixed contractual obligations associated with liabilities. Financial risk may be expressed as:

$$FR = \frac{\sigma}{c} * \frac{I}{c - I} , \qquad (2)$$

where FR is financial risk, I is fixed debt servicing, and σ and c are as previously defined. As shown in equation 2, financial risk is determined by the degree of business risk inherent in the firm σ/c, and the relation I/(c-I) which is determined by the financing decision (Gabriel and Baker, 1980).

The reduction in net operating income may make meeting financial obligations (repayment of debt) more difficult if not impossible. Therefore, plant stress has a direct negative effect on a producer's profitability, making the financial viability or survival of the farming business increasingly difficult. Over time if a producer is faced with financial adversity because of profitability problems (over-bearing financial and business risk) he may be forced into bankruptcy. Through the use of biotechnology in agriculture, these losses and the risk inherent in them may be reduced.

Biotechnology has been defined as, "any technique that uses living organisms or substances from those organisms to make or modify a product, to improve plants or animals, or to develop micro-organisms for specific uses" (Office of Technology Assessment, 1989, p.183). There are many potentially beneficial applications of biotechnology in plant agriculture. Biotechnology techniques can be used to increase a plant's ability to resist pests and disease, to tolerate environmental stress, and/or to enhance food qualities, such as flavor, texture, shelf-life, and nutritional content (Caswell et al., 1994). Thus, with the use of biotechnology in plant agriculture, it is possible that crop plants such as wheat, cotton, corn, and grain sorghum could be genetically engineered to resist biotic and abiotic stresses. This may result in increased profitability and decreased risk position by producers, thus increasing their financial viability.

The adoption of improved crop production technologies, including biotechnology, by producers is becoming increasingly more important. With reduced government support of the agricultural sector, it is important to consider the adoption of advanced technology to enable producers to become more efficient and thus, increase their probability of survival.

The Specific Situation

Texas leads the nation in the production of upland cotton (United States Department of Agriculture, 1995). In 1995, cash receipts from the sale of all crops in Texas totaled $4.825 billion; cash receipts from the sale of cotton totaled $1.667 billion, representing 34.5% of total crop receipts (United States Department of Agriculture, 1995). Most of the cotton produced in Texas is produced in the Texas High Plains Region (THPR), a 55-county area shown in Figure 1. Cotton production in the THPR for 1995 was 2.832 million bales which accounted for 63.5% of the total Texas cotton production (United States Department of Agriculture, 1995).

Each year environmental stresses cause reductions in crop yields, which result in the loss of potential net operating income for producers. In particular, moisture excess and deficits and temperature extremes are two of the most common stresses affecting crop plants. At the farm level, losses due to precipitation and thermal stress in the THPR are estimated to be $139.1 annually, with 63% ($87.6 million) of the losses occurring in cotton (Middleton, et al., 1995).

Recent production trends in the THPR show the importance for both the development of crop varieties which can withstand the factors of plant stress and the need to evaluate the economic impacts of such crop varieties on the profitability and financial viability of agricultural operations in the region. Planted and harvested acres of cotton grown under irrigated and dryland conditions in the THPR are given in Table 1 for the years 1990-1995. Abandonment of cotton acres under irrigated and dryland conditions increased significantly in 1992 due to adverse weather conditions. Extreme weather conditions early in the season caused the loss of the cotton stand, and as a result nearly one million acres of cotton were lost and re-planted to grain sorghum production.

The loss of crops, as occurred in 1992, increases the variability of net operating income or net cash flows to crop producers. This increases producer's business risk, and potentially their financial risk through fixed debt obligations. This increased variability of net operating income and increased risk position, due to plant stress problems, potentially endangers the financial viability of producers in the THPR.

The objective of this study was to evaluate the short-run economic impacts of biotechnological advances related to plant stress reduction. Specifically the profitability and financial viability of cotton farms in the THPR were estimated under baseline and biotechnology scenarios.

Methods and Procedures

The short-run impacts of biotechnological advances on the profitability and financial viability of cotton farms in the Texas High Plains Region were evaluated using FLIPSIM (Farm Level Income and Policy Simulation Model). FLIPSIM is a recursive programming-simulation model developed to describe and predict the effects of alternative agricultural policies and economic conditions on the income flows, resource use, and financial characteristics of a specified farm over a ten-year planning horizon. FLIPSIM is capable of simulating the annual functions of a crop or dairy farm, such as production, marketing, financial growth and decay, machinery depreciation and replacement, family consumption, incurring fixed and variable costs, and participation in farm programs (Richardson et al., 1992).

The Texas High Plains Region was divided into four sub-regions (Figure 1). Most of the cotton grown in the THPR is grown in the Southern High Plains and Transition

Area. Farm operations in the Northern High Plains and Northern Low Plains consist mostly of wheat farms and were not considered in this study. A representative farm was constructed for both the Southern High Plains and Transition Area using the 1992 Census of Agriculture (U.S. Department of Commerce, 1992). Farm size for the Transition Area and Southern High Plains was 858 and 921 acres, respectively, and was calculated by taking an average across all counties in each sub-region. The Transition Area farm consisted of 264 acres of irrigated cotton, 60 acres of dryland cotton, 91 acres of irrigated sorghum, 65 acres of dryland sorghum, 77 acres of irrigated wheat, 91 acres of dryland wheat, and 210 acres of irrigated corn. The Southern High Plains farm consisted of 318 acres of irrigated cotton, 419 acres of dryland cotton, 50 acres of irrigated sorghum, 112 acres of dryland sorghum, and 22 acres of dryland wheat.

Baseline models using historical crop yields and prices for each region were run to provide a basis of comparison to results from the models with biotechnology changes. Biotechnology (biotech) models were run using estimates of mean yields and distribution of yields obtained from a survey of leading crop scientist working in the biotechnology field in the Lubbock, Texas area. The survey participants were provided with a detrended historical mean yield and yield standard deviation of each crop in each sub-region. They were asked to give their estimation of the "minimum," "maximum," and "most likely" future crop yield and yield standard deviation for each crop, in each sub-region. Using the Triangular Distribution Procedure (Young, 1983) a new "biotech" mean yield and distribution of yield was calculated for each crop, in each sub-region.

The baseline and biotech models were run at various levels of intermediate-term and long-term debt, to determine how farm profitability changes as the farm's debt structure changes. Intermediate-term debt relates to debt on machinery and equipment, while long-term debt relates to debt on investments in real estate, For example, a debt level of 25/50 refers to 25% intermediate-term debt and 50% long-term debt.

The effects of biotechnology were evaluated using the FLIPSIM model to determine how farm profitability and financial viability change at various levels of intermediate and long-term debt. FLIPSIM provides information relating to the viability of a representative farm at the end of each iteration, such as the probability of survival, ending leverage ratio, ending net worth, ending farm size, total assets, total debt, net present value, and whether the farm remained solvent for ten-year time horizon (Richardson and Smith, date unknown). By repeating each scenario for 50 iterations, the model generates the necessary information to estimate the probability distributions of the key variables. The means of the key output distributions can then be used to compare the economic impacts of selected policy and technology scenarios on representative farms (Richardson and Smith, date unknown). Additionally, the FLIPSIM model provides information that can be used to estimate the level of business and financial risk in the operation.

Important assumptions made in the FLIPSIM models include: (1) all model farms are required to take out a minimum family living expense of $25,000 with a marginal propensity to consume of 20%, (2) farms are required to sell land in order to remain solvent over the time horizon when long-term assets to long-term equity falls below 15%, (3) 1995 government program provisions are in effect, and (4) the ten-year time horizon is for the period of January 1, 1995 to December 31, 2004.

Results

To better understand the results of this study, proper definitions of the FLIPSIM variables are provided as follows:

- **The probability of survival** is defined as the probability that the farm will remain solvent over the ten-year horizon (January 1, 1995 to December 31, 2004).
- **The probability of an economic success** is defined as the probability that the Net Present Value of net farm income over the ten-year horizon is greater than zero, or that the rate of return to the farm is greater than the discount rate.
- **The probability of decreasing real equity** is the probability of the farm having decreasing equity over the ten-year horizon, after adjusting for inflation.
- **Average annual net cash farm income** is defined as gross receipts minus all cash production cost, including interest. Net cash farm income is used to pay family living expenses, principal payments, income taxes, and machinery replacement costs.
- **Average annual net farm income** is defined as net cash farm income minus depreciation.
- **Real change in net worth** is defined as the overall percentage change in the operators net worth from January 1, 1995 through December 31, 2004.

In this study, the profitability of representative farms is measured by average annual net farm income, while the viability of representative farms is measured by the probability of survival.

Transition Area

Results for the Transition Area are shown in Tables 2 and 3. The Transition Area farm without biotechnology is profitable and capable of survival over the ten-year horizon at all debt levels, except the 50/50 debt level. The implementation of biotechnology increases the farm's probability of survival to 100% at all levels of debt, except the 50/50 debt level, where the probability of survival is increased from 56% to 90%. Average annual net farm income is also increased with biotechnology. At the 10/10 debt level average annual net farm income is increased by $21,015 (54%). At the 50/50 debt level average annual net farm income is increased by $22,744 (205%).

Real change in net worth over the ten-year horizon increases with the implementation of biotechnology from -13.31% to -0.33% at the 10/10 level of debt. At the 50/50 debt level, the real change in net worth increases from -82.09% to -41.44% with the implementation of biotechnology. While the real change in net worth over the time horizon remains negative with biotechnology, the percentage loss in real net worth is less when compared to the results without biotechnology.

Return on assets increases with the implementation of biotechnology from 2.5% to 3.7% at the 10/10 debt level and from 3.6% to 4.9% at the 50/50 debt level. Even with biotechnology return on assets are greater than returns on equity across all levels of debt, implying that debt does not add to the profitability of the farming operation. An exception is at the 50/50 debt level in the baseline model where the return on equity is 14.8%, while return on assets is 3.6%. The reason return on equity is greater than return on assets at this debt level is because the farm is forced to sell 24.1 acres of land to remain solvent. A comparison of return on assets and return on equity indicates that the use of debt under both baseline and biotechnology scenarios is not profitable.

The farm's risk measures also improve with biotechnology. At the 10/10 debt level, total risk decreases from 0.272 to 0.205, business risk from 0.221 to 0.177, and financial risk from 0.051 to 0.028. At the 50/50 debt level, total and financial risk goes from being negative to positive with biotechnology. A negative sign for financial and total risk results when the expected net cash flow after debt obligations are met is negative.

Southern High Plains

Results for the Southern High Plains are shown in Tables 4 and 5. The Southern High Plains farm without biotechnology is profitable and capable of survival over the ten-year horizon at all levels of debt. The implementation of biotechnology increases the farm's probability of survival to 100% at all levels of debt, except the 50/50 debt level, where the probability of survival is increased from 81% to 96%. Average annual net cash farm income and average annual net farm income is also increased with biotechnology. At the 10/10 debt level, average annual net farm income is increased by $9,371 (18%). At the 50/50 debt level, average annual net farm income is increased by $10,046 (146%).

Real change in net worth over the ten-year horizon increases with the implementation of biotechnology from -5.04% to 1.04% at the 10/10 level of debt, while at the 50/50 debt level the real change in net worth increases from -52.60% to -34.80%. Return on assets with biotechnology increases from 3.4% to 4.1% at the 10/10 debt level and from 4.5% to 5.3% at the 50/50 debt level. Even with biotechnology, return on assets is greater than return on equity at all levels of debt. In the baseline model the farm was forced to sell 8.5 acres of land to remain solvent at the 50/50 debt level. As with the Transition Area farm, the use of debt is not profitable under both the baseline and biotechnology scenarios.

The farm's risk measures also improve with biotechnology. Total risk decreases from 0.237 to 0.176, business risk decreases from 0.199 to 0.162, and financial risk decreases from 0.038 to 0.014, at the 10/10 debt level. At the 50/50 debt level, total risk decreases from 13.01 to 1.149, business risk decreases from 0.443 to 0.328, and financial risk decreases from 12.57 to 0.821.

Conclusions

Results of the baseline models show that THPR cotton farms are profitable and viable only at lower levels of debt. Results of the biotech scenarios show that the implementation of biotechnology increases both the profitability and financial viability of THPR cotton farms. However, THPR farms continue to have profitability and financial viability problems at higher debt levels, even with biotechnology. Results show both representative farms having negative changes in real net worth over the ten-year horizon across all debt levels, even when having a positive average annual net farm income. The only positive real change in net worth over the ten-year horizon occurs in the Southern High Plains with the implementation of biotechnology at the 10/10 debt level.

There are several reasons for the negative changes in real net worth over the ten-year horizon. Specifically, farm incomes do not keep up with the expected rate of inflation. Another reason the representative farms show negative real changes in net worth is that return on assets is less than the cost of debt across all debt levels. This leads to the conclusion that the use of debt is not profitable for THPR cotton farms. Further, this implies that the optimal level of debt for THPR cotton farms is zero.

The results of this study show both representative farms exhibiting relatively low rates of return on assets. These findings are consistent with several previous studies. Dodson (1994) found return on assets ranging from 3.2% to 9.0% as debt is increased from 1% to 60%. The average cost of debt was found to be 9.4%. Angirasa, Davis, and Banker (1993) found Southern High Plains farms with gross sales of $40,000 to $249,000 to have return on assets of 2.36%, 0.49%, and 1.49% for 1987, 1988, and 1989, respectively. Moss, Featherstone, and Baker (1987) found the expected rate of return to farm assets over the period 1926 to 1984 to be 4.65%.

The overall results of this study indicate that the implementation of biotechnology, in the short-run, could be beneficial at the farm level. This study did not take into account possible effects on commodity prices if all farms adopted biotechnology. Therefore, in the long-run the positive effects of biotechnology could be less than those indicated in this analysis.

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Table 1. Acres of irrigated and dryland cotton in the Texas High Plains Region, 1990-1995.

Crop Year	Cotton Acreage Planted	Cotton Acreage Harvested	Acres Abandoned
	(1,000 acres)		(Percent)
Irrigated:			
1990	1,610	1,552	3.6
1991	1,854	1,715	7.5
1992	1,449	535	63.1
1993	1,693	1,638	3.3
1994	1,738	1,681	3.3
1995	1,981	1,839	7.2
1990-95			14.7
Dryland:			
1990	2,017	1,642	18.6
1991	2,106	1,590	24.5
1992	2,190	1,372	37.4
1993	2,016	1,783	11.6
1994	1,938	1,780	8.2
1995	2,144	1,913	10.8
1990-95			18.5

Source: Texas Agricultural Statistics Service, Texas Crop Statistics, 1991,1993. United States Department of Agriculture, Agricultural Statistics, 1995.

Table 2. Results of the financial viability for the Transition Area cotton farm

Debt LT/IT	Probability of Survival	Probability of an Economic Success	Probability of Decreasing Real Income	Real Change in Net Worth (1995-2004)
Baseline				
10/10	100	78	85	-13.31%
10/25	100	57	92	-19.29%
10/50	100	22	97	-32.37%
25/10	100	59	93	-19.64%
25/25	100	39	95	-27.47%
25/50	98	11	99	-42.47%
50/10	100	29	97	-34.33%
50/25	96	16	99	-44.79%
50/50	56	3	100	-82.09%
Biotech				
10/10	100	99	59	-0.33%
10/25	100	91	64	-4.09%
10/50	100	58	77	-13.75%
25/10	100	93	65	-4.32%
25/25	100	84	75	-9.76%
25/50	100	39	84	-21.76%
50/10	100	74	77	-14.86%
50/25	100	44	84	-22.89%
50/50	90	21	95	-41.44%

Table 3. Results of the profitability for the Transition Area cotton farm

Debt LT/IT	Avg. Annual Net Farm Income	Return on Assets	Return on Equity	Avg. Annual Business Risk	Avg. Annual Financial Risk	Avg. Annual Total Risk
Baseline						
10/10	$38,713	2.5%	1.5%	0.221	0.051	0.272
10/25	$29,545	2.7%	0.6%	0.265	0.116	0.381
10/50	$13,738	3.0%	-1.8%	0.339	0.501	0.840
25/10	$28,913	2.7%	0.5%	0.266	0.101	0.367
25/25	$19,105	2.8%	-0.9%	0.313	0.188	0.501
25/50	$ 4,370	3.2%	-4.1%	0.396	1.617	2.013
50/10	$11,606	2.9%	-2.3%	0.355	0.347	0.702
50/25	$ 3,075	3.2%	-8.2%	0.408	1.071	1.479
50/50	-$11,110	3.6%	14.8%	0.597	-1.239	-0.642
Biotech						
10/10	$59,728	3.7%	3.2%	0.177	0.028	0.205
10/25	$52,224	3.9%	2.8%	0.211	0.063	0.274
10/50	$36,836	4.3%	1.4%	0.267	0.176	0.443
25/10	$51,567	3.9%	2.7%	0.212	0.057	0.269
25/25	$42,410	4.1%	2.0%	0.246	0.110	0.356
25/50	$26,828	4.5%	0.1%	0.303	0.375	0.678
50/10	$34,933	4.1%	1.2%	0.273	0.148	0.421
50/25	$25,535	4.4%	0.2%	0.311	0.300	0.611
50/50	$11,634	4.9%	-3.5%	0.380	2.931	3.311

Table 4. Results of the financial viability for the Southern High Plains cotton farm

Debt LT/IT	Probability of Survival	Probability of an Economic Success	Probability of Decreasing Real Income	Real Change in Net Worth (1995-2004)
Baseline				
10/10	100	93	67	-5.04%
10/25	100	81	76	-9.21%
10/50	100	57	90	-18.85%
25/10	100	84	77	- 9.92%
25/25	100	71	85	-15.52%
25/50	99	34	94	-27.51%
50/10	100	63	91	-21.97%
50/25	99	38	94	-30.04%
50/50	81	9	96	-52.06%
Biotech				
10/10	100	99	43	-1.04%
10/25	100	96	56	-2.11%
10/50	100	78	75	-10.32%
25/10	100	97	59	-2.65%
25/25	100	89	73	-7.25%
25/50	100	59	86	-17.67%
50/10	100	81	78	-12.57%
50/25	100	63	86	-19.63%
50/50	96	24	96	-34.80%

Table 5. Results of the profitability for the Southern High Plains cotton farm

Debt LT/IT	Avg. Annual Net Farm Income	Return on Assets	Return on Equity	Avg. Annual Business Risk	Avg. Annual Financial Risk	Avg. Annual Total Risk
Baseline						
10/10	$52,250	3.4%	2.9%	0.199	0.038	0.273
10/25	$45,088	3.6%	2.3%	0.235	0.079	0.314
10/50	$31,233	3.9%	0.8%	0.296	0.251	0.547
25/10	$43,715	3.6%	2.2%	0.240	0.073	0.313
25/25	$35,394	3.7%	1.3%	0.279	0.143	0.422
25/50	$21,614	4.1%	-1.0%	0.338	0.492	0.830
50/10	$27,241	3.8%	0.2%	0.315	0.189	0.504
50/25	$19,231	4.1%	-0.6%	0.351	0.423	0.774
50/50	$ 6,896	4.5%	-7.9%	0.443	12.570	13.010
Biotech						
10/10	$61,621	4.1%	3.7%	0.162	0.014	0.176
10/25	$55,274	4.3%	3.3%	0.191	0.053	0.244
10/50	$41,558	4.6%	2.2%	0.238	0.145	0.383
25/10	$53,970	4.3%	3.3%	0.195	0.046	0.241
25/25	$45,925	4.5%	2.6%	0.224	0.094	0.318
25/50	$31,620	4.8%	1.0%	0.269	0.275	0.544
50/10	$37,845	4.5%	1.8%	0.250	0.131	0.381
50/25	$29,345	4.8%	0.6%	0.278	0.252	0.530
50/50	$16,942	5.3%	-10.8%	0.328	0.821	1.149

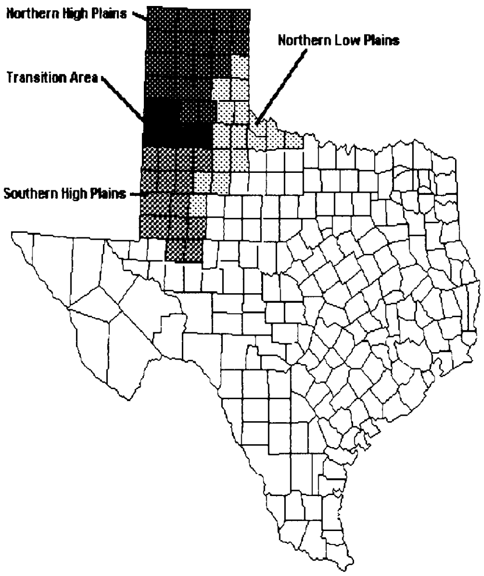

Figure 1. Texas High Plains Region and Sub-regions.