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ECONOMICS AND MARKETING

Simulation Analysis of U.S. Cotton Production with ERS Costs and Returns Data

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ABSTRACT

Costs and returns data from the USDA are applied for evaluating the U.S. cotton industry. A sector model simulates economics of U.S. cotton production. Net returns for cotton production are projected as $68,658 in 2008 on the U.S. average of 299 hectares (740 acres). After deducting opportunity costs for land, projected income from cotton farming is $29,682. Without government payments, farm income would be -$16,602. Commodity programs maintain net returns within a constant range as market conditions lead to differing levels of income support. Government payments decrease as market revenues increase, and net returns are greatest when market circumstances lead to the minimum need for income support.

INTRODUCTION

Producer revenue from U.S. cotton production is a combination of both market returns and payments from government programs. Neither revenue source is predictable due to variability in market prices and yields. The efficacy of government programs in maintaining a viable cotton industry depends on the coordination of market revenue and commodity payments for income support. A goal of income support programs is to provide a floor in circumstances of low prices while allowing for increasing farmer income as market prices increase.

Effects of government programs in providing a safety net for agricultural producers should be evaluated under the entire range of likely prices and yields. Simulation analysis with stochastic variables and baseline costs of production provide results for comparing levels of farm net returns as market conditions change. A representative farm approach to simulation analysis is applied by the Agricultural and Food Policy Center (AFPC) at Texas A&M University. The methodology develops baseline costs and yields for representative crop and livestock farms in the U.S. Representative farm data are derived from a panel of producers that represent distinct production areas in major producing states. Costs data reported during periodic interviews with panel members are updated annually with input price projections from the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri. Simulation results are evaluated as the probability a farm having a negative ending cash balance and the probability of a farm losing real net worth in a production year (Richardson et al, 2007).

Aggregate data are applied to simulation analysis in a world fiber model developed by the Cotton Economics Research Institute (CERI) at Texas Tech University. The model includes cotton, as well as wool and man-made fibers. There are 24 countries in the model accounting for the major cotton importers and exporters. The U.S. component of the world model includes regional acreages and yields with cotton production divided into four regions: Delta, Southeast, West, and Southwest (Pan et al, 2004). Previous research involving policy proposals with the CERI world fiber model has investigated both U.S. and world outcomes. Elimination of U.S. cotton programs would result in an initial world cotton price increase of 2%. Initial price increases would subsequently be eliminated due to an increased supply response from other cotton producing countries (Pan et al, 2006). Application of the world model includes evaluation of U.S. policy proposed in 2007 by the U.S. Department of Agricultural (USDA). Impacts on the U.S. cotton sector due to legislation proposed for the next farm bill include increased market revenues and decreased government support. Net farm income decreases as higher market returns do not compensate for diminished price supports (Pan et al, 2007).

The Agricultural Policy Analysis Center at The University of Tennessee utilizes a simulation model of the U.S. agricultural sector. Policy Analysis System (POLYSYS) estimates crop supply for 305 Agricultural Statistics Districts (ASDs) as defined by

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the National Agricultural Statistics Service (NASS). Livestock supply and demand, crop demand, and agricultural income are estimated on a national basis. Simulated model outcomes may be reported at a level of ASD, region, state, or nationally. Data incorporated in the model are from FAPRI, USDA, and the Congressional Budget Office (Tiller, Ray, and Ugarte, 1999).

Simulation analysis has previously applied farm level data, as well as aggregate data, for analyzing sectors of the U.S. agricultural economy. The objective of this research is to develop a model representing production on a cotton farm with aggregate data at the national level. Stochastic analysis provides inferences about cotton production caused by relevant variables and correlations among the variables. Implementation of this modeling procedure will add another tool to existing simulation models for evaluating economic circumstances in the U.S. cotton industry.

Conceptual framework. A simulation model for U.S. cotton production is specified as:

$$NR = R + G - VC - FC, \qquad [1]$$

where NR is net returns, R is market receipts, G is government payments received, VC is variable costs, and FC is fixed costs. NR is stochastic as variable yields and market prices cause variability in R and G. VC are baseline costs with direct harvesting costs, custom operations, and marketing costs varying with yield.

Government payments. Income support is available to cotton farmers in the form of direct payments (DP), countercyclical payments (CCP), and marketing assistance loan programs. Descriptions of each payment and methods for calculation as established by the 2002 Farm Act are provided by Westcott, Young, and Price (2002). DP is fixed for each production year and does not vary with prices or yields. There is a DP limit of $40,000 per person for each crop year. CCP rates vary with the national commodity price and are applied to the constant program yield and acreage levels for each farm, not varying with realized production year yields. The CCP limit is $65,000 per person for each crop year. The Farm Service Agency (FSA) administers commodity loan programs with marketing loan provisions. An alternative provision in programs for marketing assistance loans is a loan deficiency payment (LDP). Instead of putting commodities in storage for later loan repayment, a farmer may choose to receive benefits directly when marketing the commodity. Marketing loan gains from crops under loan are equivalent to gains from the LDP alternative. All quantities marketed are eligible for the LDP and total receipts vary with stochastic prices and yields. Marketing loan gains are limited to $75,000 per person for each crop year. Each payment limit is applied with a three-entity rule in which an individual can receive a full payment directly and up to a half payment from two additional entities. This effectively doubles payment limits for each program type.

MATERIALS AND METHODS

Data for simulation are the U.S. cotton costs and returns from the Economic Research Service of USDA. Costs and returns data are historical accounts based on the actual costs incurred by producers. Data are reported for all participants in the production process and can be regarded as "sector accounts" that represent all resources used in the production sector. Data include only costs incurred in the production of a crop and exclude costs for marketing and storage. The theoretical basis and accounting methods used for estimating costs and returns data conform to standards recommended by the American Agricultural Economics Association (USDA-ERS, 2007).

Published costs data for this research are U.S. average per acre forecasts for the 2008 production year (USDA-ERS, 2007). Costs for ginning and purchased irrigation water are estimated by applying FAPRI price increases (Richardson et al, 2007) to ERS 2006 costs. All ERS costs data are reported as fixed on a per acre basis. However, harvesting costs, ginning costs, expenses for custom operations, and marketing costs vary with yield. Methodology for this analysis separates aggregated ERS costs reported as fuel, lube, and electricity into 1) fuel and lube and 2) electricity. Fuel and lube are further separated into preharvesting and harvesting costs. Harvesting costs, ginning costs, as well as custom operations, are converted to a yield basis for simulation. Information for separating fuel and lube costs, electricity costs, as well as allocating harvesting costs is from enterprise budgets published by U.S. land grant universities. Expenses typically paid by producers for marketing and warehousing are not included in ERS costs data. Adding marketing and warehousing costs of $0.0688 kg^{-1} ($0.0312 lb^{-1}) represents an increase to ERS variable costs (Shurley and Ziehl, 2007). Average production unit size is 299 hectares (740 acres) for ERS cotton costs and returns data. Variable costs and fixed overhead costs for 2008 which are based on U.S. average acre costs applied to the average production unit are displayed in Table 1.

Table 1. Projected 2008 production costs for a 299 hectare U.S. cotton farm.

	Dollars
Seed	**52,429**
Custom Operations	**19,610**
Ginning	**84,580**
Fuel, Lube, and Electricity	**32,550**
Fertilizer	**41,100**
Chemicals	**50,601**
Repairs	**16,978**
Purchased Water	**1,069**
Operating Interest	**6,423**
Marketing, Warehousing	**17,818**
Variable Costs	***323,157***
Hired Labor	**12,166**
Capital Recovery	**58,808**
Taxes and Insurance	**6,653**
General Farm Overhead	**13,749**
Overhead Costs	***91,375***

Expected 2008 cotton price received reported in Table 2 is \$1.389 kg^{-1} (\$0.6302 lb^{-1}) as projected by FAPRI (Richardson et al, 2007). Value of cotton seed sold of \$150 metric ton^{-1} (\$136 ton^{-1}) is estimated by applying FAPRI seed price increases (Richardson et al, 2007) to ERS 2006 price (USDA-ERS, 2007). Yields reported with ERS costs and returns data are on a per planted acre basis. Expected 2008 yield of 883 kg ha^{-1} (788 lbs $acre^{-1}$) is the average for 2003-2007 adjusted for the average annual trend derived from the moving 5 year average for 2002-2007 (USDA-NASS, 2007). Base U.S. yields for calculating DP and CCP are 677 kg ha^{-1} (604 lbs $acre^{-1}$) for DP and 715 kg ha^{-1} (638 lbs $acre^{-1}$) for CCP. Planted U.S. acreage has exceeded base program acreage in each year during 2002-2007. This analysis assumes that all average production unit acreage includes base program acreage for calculating DP and CCP (USDA-FSA, 2003). Expected 2008 adjusted world price (AWP) of \$1.305 kg^{-1} (\$0.592 lb^{-1}) for calculating LDP is estimated as the 2002-2006 average difference between AWP and the U.S. price (USDA-FAS, 2007; USDA-NASS, 2007).

Table 2. Expected prices and yields for a U.S. cotton farm in 2008.

	Unit	Value
US Price	**dollars/kg**	**1.389**
AWP	**dollars/kg**	**1.307**
Seed Sold	**dollars/metric ton**	**150**
Expected Yield	**kg/ha**	**883**
DP Base Yield	**kg/ha**	**677**
CCP Base Yield	**kg/ha**	**715**

Cotton prices and yields have historical relationships that can be accounted for with stochastic analysis. CCP varies with price while LDP varies with price and yield. Thus, total revenue, as well as baseline expenses for harvest, custom operations, marketing, and warehousing, are variable. Generation of random prices and yields leads to net returns that account for the stochastic relationships existing in cotton production. An alternative to typical normality assumptions in simulating stochastic commodity prices and yields is application of a multivariate empirical (MVE) distribution. The MVE distribution accounts for interrelationships occurring in the data and avoids enforcing a specific distribution on the variables. Simulating commodity prices and yields with an MVE distribution includes a correlation matrix that generates correlated stochastic variables (Richardson, Klose, and Gray, 2001). Simulation with MVE results in simulated random variables that are bounded by historical minimums and maximums of the original data. In contrast, simulation with normal distributions can result in simulated random variables that are outside of historical bounds. This simulation of U.S. cotton production applies the MVE function of Simetar (Richardson, Schumann, and Feldman, 2006). Simetar generates random variables with means of price and yield in Table 2 and covariance structures determined by 1997-2006 historical prices and yields (USDA-NASS, 2007).

RESULTS

Cotton prices and yields have a Pearson's correlation coefficient of -0.19 with a student's-t value of 4.34, indicating a statistically significant negative correlation. Financial results for the average of 500 iterations are presented in Table 3. Total market revenue of $436,906 consists of $367,992 from lint and $68,914 from selling cotton seed. Government payments total $46,284 and are 10% of farm revenue from all sources. Deducting costs in Table 2 results in average net returns of $68,658. Costs and returns data indicate land opportunity costs of $130.09 ha^{-1} ($52.67 ac^{-1}). Accounting for land opportunity costs of $38,976 results in farm income of $29,682. Without government payments, income from cotton farming would decrease to -$16,602. Farm income represents 64% of government payments received by the average farm.

Table 3. Simulated revenues, net return, land cost, and farm income for a 299 hectare cotton farm in 2008: average of 500 iterations.

	Dollars
Lint Revenue	**367,992**
Seed Revenue	**68,914**
Government Payments	**46,284**
Net Returns	**68,658**
Land Opportunity Cost	**38,976**
Farm Income	**29,682**

Stochastic simulation provides the basis for graphical analysis of the relationships among variables. Figure 1 is a scatter plot of price and LDP. Increasing prices lead to decreasing LDP until it diminishes to $0 as price approaches $1.232 kg^{-1} ($0.559 lb^{-1}). The point of $0 LDP is the sum of the loan rate at $1.146 kg^{-1} ($0.520 lb^{-1}) and the difference between the expected U.S. price and the AWP in Table 2.

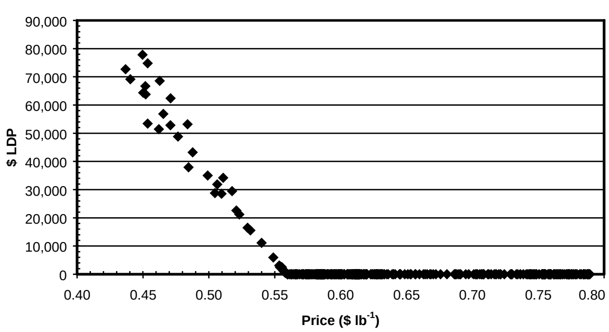

Figure 1. Simulated loan deficiency payment to a 299 hectare U.S. cotton farm at various cotton prices.

The mechanics of the CCP payment rate, PR_{cc}, are given by:

$$PR_{cc} = \max\{0, TP - PR_{direct} - \max(P, LR)\}, \quad [2]$$

where TP = target price of $1.596 kg^{-1} ($0.724 lb^{-1}), PR_{direct} = DP rate of $0.147 kg^{-1} ($0.0667 lb^{-1}), P = national market price, and LR = the U.S. loan rate of $1.146 kg^{-1} ($0.520 lb^{-1}). Maximum PR_{cc} of $0.302 kg^{-1} ($0.137 lb^{-1}) occurs when $P = LR$. As P increases at levels above LR, PR_{cc} decreases and becomes 0 when $P = TP - PR_{direct}$ or $1.448 kg^{-1} ($0.657 lb^{-1}). Figure 2 shows that CCP is constant at a level of $55,000 when price is less than or equal to $1.146 kg^{-1} ($0.520 lb^{-1}). CCP decreases as price increases between $1.146 kg^{-1} ($0.520 lb^{-1}) and $1.448 kg^{-1} ($0.657 lb^{-1}). At prices greater than or equal to $1.448 kg^{-1} ($0.657 lb^{-1}) CCP equals $0.

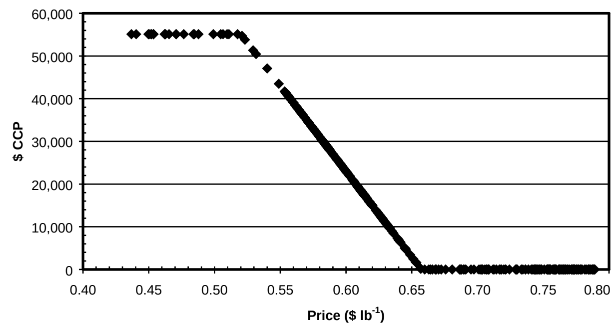

Figure 2. Simulated counter cyclical payment to a 299 hectare U.S. cotton farm at various cotton prices.

Figure 3 shows the relationship between price and all government income support (DP, CCP, and LDP). At prices below $1.232 kg^{-1} ($0.559 lb^{-1}) government payments include receipts from each of the three program types. At prices above this point, government payments consist only of CCP and DP. Government payments reach the lowest level equal only to constant DP of $25,300 at prices greater than or equal to $1.448 kg^{-1} ($0.657 lb^{-1}).

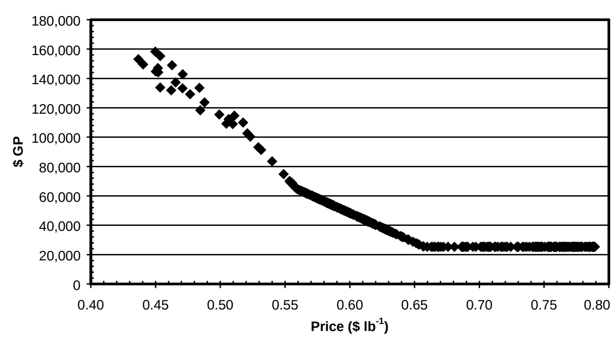

Figure 3. Simulated total of all government payments to a 299 hectare U.S. cotton farm at various cotton prices.

Figure 4 is a scatter plot of price and net returns. Net returns have no discernable trend with prices less than $1.146 kg^{-1} ($0.520 lb^{-1}). With prices between $1.146 kg^{-1} ($0.520 lb^{-1}) and $1.235 kg^{-1} ($0.560

lb^{-1}) net returns decline slightly as price increases. Price increases occurring above \$1.235 kg^{-1} (\$0.560 lb^{-1}) lead to increased net returns.

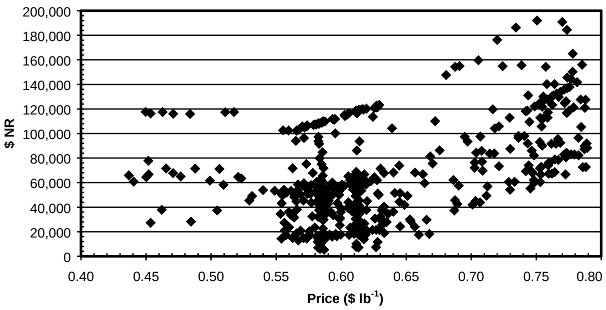

Figure 4. Simulated net returns including all government payments for a 299 hectare U.S. cotton farm at various cotton prices.

Figure 5 and Figure 6 indicate safety net features of cotton income support programs. Figure 5 shows decreasing government payments as market revenues increase. Market revenues reach their greatest levels when government payments are lowest. Figure 6 indicates that at low levels of government payments above the minimum of DP only, increases in government payments maintain net returns within a constant range. Higher levels of government payments above \$60,000 increase the floor of net returns, but maximum net returns do not increase. Net returns are greatest when market circumstances lead to the minimum need for income support. Thus, Figure 5 and Figure 6 show substitutability between market revenues and government payments while commodity programs support net returns.

Cumulative distribution functions (CDF) for net returns including government payments and net returns with only market receipts are presented in Figure 7 for an 80% confidence interval. The CDF indicates the probability that net returns are less than or equal to a point on the horizontal axis. All points of the CDF with government payments are to the right of the CDF with only market receipts, indicating government payments increase net returns at all probability levels. All CDF points with government payments are to the right of \$0, and no probability levels intersect negative net returns. In contrast, the CDF with only market receipts intersects \$0 at a 36% probability level. Thus, 36% of all simulated net returns without government payments are negative. Government payments serve as a safety net for cotton producers and reduce the likelihood of financial hardships that would extend to industries that are associated with cotton production.

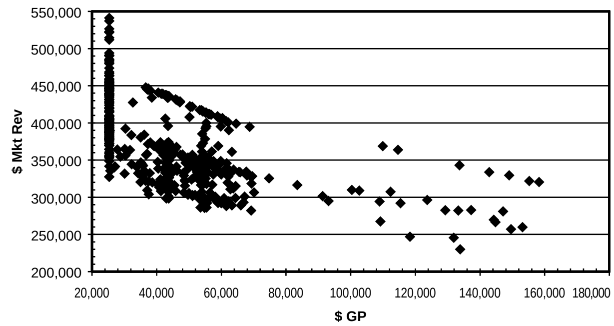

Figure 5. Relationship of market revenue to government payments for a simulated 299 hectare U.S. cotton farm.

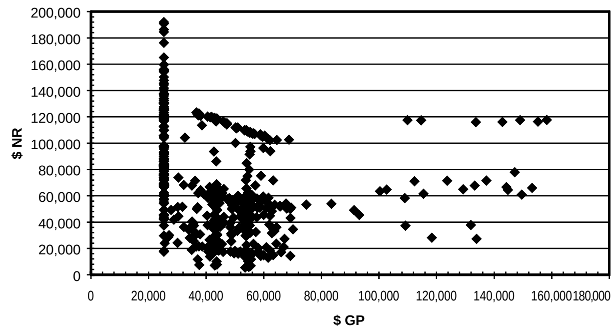

Figure 6. Relationship of net returns to government payments for a simulated 299 hectare U.S. cotton farm.

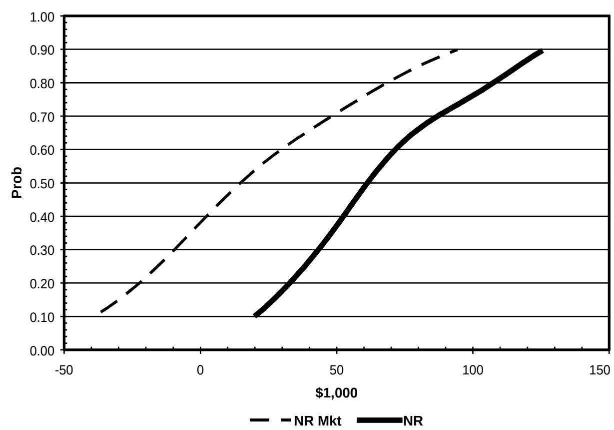

Figure 7. Cumulative distribution functions of simulated net returns with and without government payments for a 299 hectare U.S. cotton farm in 2008.

SUMMARY AND CONCLUSIONS

Simulation analysis with ERS costs and returns data is a tool for conducting sector analysis of U.S. cotton production. Costs and returns data are historical accounts based on the actual costs incurred by producers. Average production unit size is 299 hectares (740 acres) with annual production costs of \$414,532. Net returns are \$68,658, and deducting land opportunity costs results in farm income of \$29,682. Farm income represents 64% of the

$46,284 in government payments received. Farm income would be -$16,602 without government payments.

Graphical analysis with simulation results shows the component responses of government payments as market price changes. Results show the safety net features of cotton income support programs. Government payments decrease as market revenues increase, and market revenues reach their greatest levels when government payments are lowest. Commodity programs maintain net returns within a constant range as market conditions lead to differing levels of income support. Net returns are greatest when market circumstances lead to the minimum need for income support. Government payments reduce the probability of negative net returns in the cotton production sector which would lead to financial hardships extending beyond cotton farms.

A cotton sector model provides general inferences for alternative market conditions and government policies. Aggregate data limits sector models in evaluating production risk at the farm level. This research demonstrates the importance of government programs in sustaining a viable cotton industry. Extended applications of this methodology should investigate the economic importance of the cotton production sector to the entire U.S. economy.

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