Effects of an Export Subsidy on the U.S. Cotton Industry

Patricia A. Duffy

Michael K. Wohlgenant

James W. Richardson

Patricia A. Duffy is Assistant Professor of Agricultural Economics in the Department of Agricultural Economics and Rural Sociology at Auburn University. Michael K. Wohlgenant is Professor of Economics in the Department of Economics and Business at North Carolina State University. James W. Richardson is Professor of Agricultural Economics in the Department of Agricultural Economics at Texas A&M University.

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Abstract

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Abstract

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Throughout the 1980's, volatile export markets have been a cause for concern for U.S. cotton producers. U.S. cotton exports dropped dramatically during the 1985-86 period as world prices reached record lows. In consequence, the direct costs of the domestic target price program for cotton were high causing a renewed interest in export expansion programs as a way to increase the domestic price.

This study presents quantitative estimates of the probable effects of an export subsidy on the domestic cotton industry. More specifically, the objective of this study is to provide estimates of the expected change in domestic price, consumer and producer surplus, and direct government costs of a subsidy program. To quantify the effects, a linear elasticity model is used. This study differs from most previous analyses in including explicit representation of the domestic farm programs currently in place. This study also differs from most previous work in incorporating some stochastic elements in the analysis.

Comparative Statics of an Export Subsidy

The expected changes in the cotton industry due to an export subsidy can be described by a series of equations in log differential form obtained from total differentiation of the set of equations describing initial industry equilibrium. Initial equilibrium can be described by:

(1) $Q_d = f(P_d)$

(2) $Q_x = g(P_d - S)$

(3) $Q_s = h(P_p)$

(4) $Q = Q_s = Q_d + Q_x$

where Q_d is domestic mill use, Q_x is total exports, Q_s is quantity supplied, S is the export subsidy in cents per pound, P_d is the domestic cotton price and P_p is the "supply-inducing" price to which producers respond. This "supply-inducing" price incorporates both market and government policy information

(Shumway, Lee and Helmberger, Bailey and Womack). More specifically following Shumway and Bailey and Womack,

P_p can be described as:

(5) $P_p = P_d$ if $P_d > P_s$

(6) $P_p = P_s$ if $P_d < P_s$

where P_s is the "effective government support price" defined by Houck et al. Under the 1981 and 1985 farm bills, the effective support price is simply the announced target price times one minus the acreage reduction percentage requirement.

Total differentiation of (1) through (4) yields:

(7) $d\ln Q_d = N_d \, d\ln P_d$

(8) $d\ln Q_x = N_x(d\ln P_d - a)$ with $a = dS/P_d$

(9a) $d\ln Q_s = E \, d\ln P_d$ if $P_d > P_s$

(9b) $d\ln Q_s = 0$ if $P_d(1 + d\ln P_d) < P_s$

(9c) $d\ln Q = E \, (d\ln P_d - R)$ if $P_d < P_s < P_d(1 + d\ln P_d)$

where (10) $R = (P_s - P_d)/P_d$

(11) $d\ln Q_s = K_d d\ln Q_d + K_x d\ln Q_x$

where N_d is the own-price elasticity of domestic demand, N_x is the price elasticity of foreign demand for U.S. cotton, E is the price elasticity of supply of U.S. cotton, K_d is the quantity share of domestic consumption, and K_x is the quantity share of exports.

Equations (9a) - (9c) represents supply response under three conditions. If the initial domestic price is above the effective support price, (9a) there will be a full supply response to changes in equilibrium price brought about by the export subsidy. If the post-subsidy domestic price ($P_d + P_d * d\ln P_d$) remains below the effective support price, there will be no change in supply (9b). Finally, the initial price may be below the effective support price but the post-subsidy price may become higher than the effective support price. In this case, supply responds to the difference between the new price and the effective support price (9c).

Substituting (7) - (9) into (11) and solving for $d\ln P_d$ yields:

(12a) $$d\ln P_d = \frac{-K_x N_x a + ER}{E - (K_d N_d + K_x N_x)}$$

with $R = (P_s - P_d)/P_d$ if $P_s > P_d$ and $R = 0$ if $P_d > P_s$ The percent change in price has an upper bound of

(12b) $$d\ln Pd^U = \frac{K_x N_x \ a}{(k_d N_d + K_x N_x)}$$

when $d\ln Q_s$ is zero.

Measures of the changes in producer and consumer surplus are derived using the trapezoidal rule based on linear demand and supply curves. Welfare gains to producers are:

(13) $P_d/P_d^o + (1/2)\ E\ (\ P_d{}^2/P_d^o)$

Welfare losses to consumers are:

(14) $-K_d\{P_d/P_d^o + (1/2)N_d(\ P_d{}^2/P_d^o)\}$

Where welfare changes are measured from the initial point P_d^o, Q_s^o.

When domestic price is below the target price, total direct government costs for both the export subsidy and deficiency payments can be expressed as:

(15) $GC = (TP - P_d)Q_s + S^*Q_x$

where TP is the target price. The percent change in government cost from an initial subsidy of zero is accordingly:

(16) $d\ln GC = d\ln Q_s - P_d\ d\ln P_d/(TP - P_d) + (S/(TP-PD))\ d\ln Q_x K_x + (S/(TP-P_d))\ K_x$

Because of the form of (16), the lower the initial price, the greater the savings (or less the additional cost) from the export subsidy.

Domestic Supply and Demand Estimates

For the analysis, estimates of the own-price elasticity of supply, demand, and export demand are required. Supply elasticity was estimated using annual time-series data for U.S. cotton production for the period 1959-1983. Effective support prices for cotton and a competing enterprise were developed following Houck et al. and the supply inducing price was the higher of a one period lagged market price or the effective support price. The estimated supply response equation is reported in table 1. The estimated own-price elasticity was .86. This is higher than most previous estimates (Shumway, Gardner, Duffy et al.) and a lower value of 0.3 in line with previous estimates was therefore used for sensitivity analysis. The lower value seems more plausible in light of recent changes in the farm program which reduce flexibility in the crop mix.

The price elasticity of domestic demand was assumed to be -0.3 (Wohlgenant). This elasticity was close to the estimate of -0.24 obtained by Monke and Taylor for world consumption demand.

Export Demand

The elasticity of export demand was estimated in an Armington framework. Armington expressed the demand for a commodity exported from country j to country i as:

$$(17) \quad MS_{ij} = b_{ij}^{\sigma} (P_j/P^*)^{-\sigma}$$

where MS_{ij} is the market share of country j in country i, P_j is the price of the commodity from country j, P^* is the world average price of the commodity, and is the elasticity of substituion between the commodity from country j and the same commodity from other exporters. Taking the logarithm of (17) leads to an equation linear in parameters and therefore easy to estimate. Market share equations for major importers of U.S. cotton were estimated and are reported in table 2.

From 17, an analysis of changes leads to:

$$(18) \quad d\ln X_{ij} = N_y d\ln Y + \{-\sigma(1-S_{ij}) + N_t S_{ij}\} d\ln P_j + \sum_{k\neq j} \{S_{ik}\sigma + S_{ik}N_t\} d\ln P_k$$

where X_{ij} is the demand for country j's commodity, N_y is the income elasticity of demand, Y is income, S_{ij} is the country j's share of sales of the commodity, N_t is the total elasticity of demand for the commodity, and the P_k are the prices of the commodity from competing countries.

The first bracketed term of (18)is the direct own-price elasticity of export demand. This term has been all that has been considered in most analyses (Armington; Grennes, Johnson, and Thursby). Ignoring the second term, however, is equivalent to assuming that the rest of the world has an infinite elasticity of supply for the commodity, an assumption that is probably quite unrealistic.

From (18), the total elasticity (Buse) of export demand for U.S. cotton is.

(19) $N_x = \{-\sigma(1-S_{us}) + N_t S_{us}\} + \sum_{k \neq j} \{S_{ik}\sigma + S_{ik}N_t\} d\ln P_k / d\ln P_{us}$

To get at the change in competing price with respect to U.S. price the following system of equations is used:

(20) $d\ln q_1 = e_{11}\, d\ln P_1 + e_{12}\, d\ln P_2$

(21) $d\ln q_2 = e_{21}\, d\ln P_1 + e_{22}\, d\ln P_2$

(22) $d\ln q_2^S = E_s d\ln P_2$

where q_1 is the export demand for U.S. cotton, q_2 is the export demand for the competing cotton, q_2^S is the export supply of competing cotton, e_{11} and e_{22} are direct own-price elasticities of demand for q_1 and q_2 respectively and e_{12} and e_{21} are the direct cross-price elasticities. E_s is the elasticity of export supply for the competing cotton. From (21) and (22), it is possible to solve for $d\ln P_2/d\ln P_1$.

(23) $d\ln P_2/d\ln p_1 = e_{21}/(E_s - e_{22})$.

Estimates of e_{11}, e_{12}, e_{21}, and e_{22} can be obtained from the Armington model. One of the Armington assumptions is that the elasticity of substitution ( ) is constant and equal across exporting regions. Hence, the estimates of sigma reported in table 2 can be used to calculate the direct own and cross price elasticities of demand for competing cottons. Estimates of the total demand elasticity for cotton in each importing region are needed, however. Babula and Monke and Taylor have estimated this parameter. Babula obtained estimates ranging from -0.15 to -0.25 for the different regions and Monke and Taylor estimated a pooled elasticity of -0.24 for "price responsive" countries. In this study, the Monke and Taylor estimate of -0.24 was used to calculate the direct own and cross price export demand elasticities.

An estimate of E_s can be obtained using an excess supply specification (Floyd).

(24) $E_s = \sum_i e_{si} (Q_{xi}/Q_{si}) - N_{di} (Q_{xi}/Q_{di})$

where e_s is the domestic supply elasticity. Using e_s of .38 and N_d of .24 (Monke and Taylor) for the major price-responsive competing exporters and domestic elasticities of zero for the U.S.S.R. yields an excess supply elasticity for U.S. competitors in the cotton market of 1.11. (The competing price responsive exporters are Syria, Australia, Turkey, Israel, India, and the cotton producing countries of South America, Central America, and Africa.) This in turn leads to an estimate of $d\ln P_1/d\ln P_2$ of 0.64. Using a total demand elasticity of -0.24 (Monke and Taylor), the trade weighted export elasticity for the United States is calculated as -1.65.

Simulation Results

The relationships described in (7) - (16) were simulated for both a 5¢ and 10¢ a pound subsidy under two alternative assumptions concerning the domestic supply elasticity. In the first case, the elasticity of supply is assumed equal to the estimated elasticity of 0.86. In the second case, the elasticity of supply is assumed to equal 0.30, a figure more consistent with previous studies.

Because the relationship of market price to target price is extremely important in determining both the level of supply response and the changes in costs associated with introducing the export subsidy, a stochastic specification for begining market price was used. Price was assumed to be normally distributed with a mean of 58 and a standard deviation of 10. The initial shares, K_d and K_x, were each assumed to be 1/2 (based on sales in recent years). The simulation was run fifty times using different observations from this price distribution. Target price was assumed to be 79¢ and the acreage reduction was 25% (1987 law) leading to an effective support price of 60¢. Under current law, the marketing loan does not lead to CCC stock accumulation regardless of the market price. Government stock accumulation is therefore always zero.

Results from simulation of current policy are reported in Table 3. In the event that the beginning market price drawn from the distribution is greater than the target price, equation (16) is not valid as the percent change in costs would be infinity. Percent change in costs was therefore not calculated in this case and the average is underestimated somewhat. (2 out of 50 or 4% of the beginning market prices were above the target price.)

When supply elasticity was assumed to be 0.86, the 5¢ subsidy resulted in an average domestic price increse of 6% and an average government cost decrease of less than 1%. In 56% of the runs government costs decreased. On average, 65% of the subsidy was passed through to the producers in terms of higher market price. For the 10¢ subsidy (E=0.86), price increased an average of 12% but government costs increased an average of 4%. The export subsidy decreased government expenditures in only 38% of the runs. Under the higher subsidy, substantially larger increases in domestic price frequently raised the domestic price above the effective support price of 60¢ resulting in increased domestic supply. This increased supply offset some of the savings in the deficiency payment program associated with higher prices.

When the elasticity of supply is assumed to be low (0.3), the export subsidy is more effective in raising domestic price and saving government expenditures. For both the 5 and 10¢ subsidy, the export subsidy saved government expenditures 96% of the time. In this case, the 10¢ subsidy resulted in the greatest average savings in government costs. With a low supply elasticity, even substantially higher prices do not result in large supply increases. Thus, the amount of supply response to higher domestic prices is a crucial factor in determining the total costs of the export subsidy program.

Simulation Results under a Traditional Loan Program

Although the current farm bill does not allow for the accumulation of CCC stocks, this provision has been a major component of most past farm bills. The simulation was accordingly also done under the assumption that a traditional loan program was in effect.

Incorporation of the traditional loan program is done in the following manner. If the initial price is below the loan rate, the iniital price is set equal to the loan rate and stocks are accumulated so that

(25) $Q_{ccc} = -(K_x N_x + K_d N_d)(P_d^o - LR)/P_d^o)$

Where Q_{ccc} is the quantity of CCC stocks, P_d^o is the price that would have prevailed in the absence of a loan rate, and LR is the loan rate.

With the export subsidy in place, the market price that would prevail ignoring the loan is calculated using (12). If this price is above the loan rate, no stocks are accumulated. If the domestic market price under the export subsidy is still below the loan rate, then the domestic market price is once again set to the loan rate and the new quantity of stocks accumulated is calculated using (25). Because of increased export sales with the subsidy, this quantity will be less than that which would have accumulated without the subsidy.

Results for the export subsidy under a traditional loan program (loan rate of 55¢) are reported in table 4. In calculating changes in government cost, the relatively small storage and interest costs of the loan program are ignored. Outlays for the commodity are not generally considered a direct cost of the program because, in theory, the commodity will be sold at some future date. In reality, however, expensive PIK programs have often beeen implemented to reduce unwanted stocks. Thus, the reduction in cost of the domestic programs resulting from an export subsidy is probably underestimated in this study.

With a traditional loan program in effect and a supply elasticity of 0.86, an export subsidy is unlikely to save government expenditures. With a low supply elasticity (0.3), however, the export subsidy reduces government cost of the program over 60% of the time. Stocks accumulation is slowed considerably under the export subsidy as well. Because the loan rate is below the effective support price, the assumed elasticity of supply response does not affect the changes in stock accumulation.

Conclusions

An export subsidy may be a method to reduce the costs of the cotton program when market prices are expected to be substantially below the target price. The cost effectiveness of the subsidy is greatly affected by the supply response, however. A supply control provision might be an important consideration in designing such a program.

When a traditional loan rate is in effect, the export subsidy is not as effective at reducing direct costs of the farm program. Stock accumulation is slowed considerably, however, reducing the likelihood of expensive PIK programs.

Although the effects of alternative domestic supply elasticities were tested, space did not permit a treatment of the effects of different export demand elasticities. As export demand becomes more elastic, the subsidy becomes an increasingly more effective method of raising the domestic price and hence lowering government costs. Hence, like the elasticity of domestic supply, the elasticity of export demand is crucial in determining the "success" of the subsidy.

A final consideration in designing an export subsidy is the possibility of retaliation. Although this study used "total" elasticity of export demand rather than simply the direct elasticity, the elasticity estimate was developed under the assumption that no specific retaliation to an export subsidy policy occurred. Retaliation by foreign competitors could make the program very costly.

Table 1. U.S. Cotton Production (1959-1983)

$$LN(USPROD) = 6.344 + 0.863\ LN(CTPR) - 0.695\ LN(SGPR) - 0.434\ DP + 0.101\ LN(T)$$

$$(.666) \quad (.170) \qquad (.161) \qquad (.087) \qquad (.049)$$

R^2 = .79   D.W. = 2.06

USPROD is total U.S. production of cotton, CTPR is the supply inducing price of cotton, SGPR is the supply inducing price of sorghum, DP is the voluntary diversion payment defined following Ryan and Abel, and T is a trend variable (1959=1).

Table 2. Market Shares of U.S. Cotton in Foreign Markets (1959-1983)

	Europe	Japan	Other Asia	Canada	Centrally Planned
Constant	-0.509	-0.982	-0.522	-0.144	-3.199
	(0.540)	(0.265)	(0.191)	(0.217)	(0.929)
Price Ratio	-8.480	-3.118	-2.723	-5.168	-20.240
	(2.024)	(1.743)	(1.360)	(1.873)	(5.201)
MS_{t-1}	0.822	0.358	-0.045	0.384	0.330
	(0.188)	(0.127)	(0.160)	(0.141)	(0.126)
Trend	0.074	0.109	-0.090	0.018	0.594
	(0.755)	(0.084)	(0.070)	(0.084)	(0.300)
R^2	0.510	0.459	0.211	0.518	0.540

Equations estimated in log-linear form. Price Ratio is U.S. price divided by a trade-weighted average price. (The reported coffecient of the price ratio is - .) System estimated using Parks' Procedure to correct for both autocorrelation and simultaneous correlation across equations. Because the equations contain a lagged dependent variable, the Wallis procedure was first used to create instrumental variables. Equation for Centrally Planned countries uses one year lagged priced ratio. All others are current.

Table 3. Effects of An Export Subsidy under Current Farm Progam

	N_x=-1.65, E =0.86		N_x=-1.65, E=0.3	
	S=5¢/lb	S=10¢/lb	S=5¢/lb	S=10¢/lb
Mean Percentage Change in:				
Domestic Price	6.12	11.59	6.85	13.37
Domestic Mill Use	-1.84	-3.48	-2.05	-4.01
Exports	4.68	10.44	3.48	7.50
Government Costs	-0.21	3.72	-4.96	-7.54
Mean Change in Surplus as a % of Value of Production:				
Producer Surplus	6.31	12.29	6.92	13.66
Consumer Surplus	-6.09	-11.47	-6.81	-13.22
% of Times Subsidy Saves Government Outlays	56	38	96	96
Mean % of Subsidy Received by Producers as higher Price	65.45	61.82	75.00	73.17

Simulations based on beginning price N(58,10). Target Price = 79¢, Effective support price = 60¢. Average change in government cost calculated for trials in which beginning price was lower than target price. (96% of results).

Table 4. Effects of An Export Subsidy With Loan Program

	N_x=-1.65, E =0.86		N_x=-1.65, E=0.3	
	S=5¢/lb	S=10¢/lb	S=5¢/lb	S=10¢/lb
Mean Percentage Change in:				
Domestic Price	3.18	6.63	3.91	8.40
Domestic Mill Use	-0.95	-1.99	-1.17	-2.52
Exports	8.51	16.58	7.31	13.65
Government Costs	5.38	13.17	0.62	1.96
Mean Change in Surplus as a % of Value of Production:				
Producer Surplus	3.24	6.87	3.94	8.53
Consumer Surplus	-3.17	-6.58	-3.89	-8.33
% of Times Subsidy Saves Government Outlays	24	6	64	66
Mean Reduction in Stocks as % of Production	3.21	5.08	3.21	5.08
Mean % of Subsidy Received by Producers as higher Price	38.87	40.27	48.41	51.62

Simulations based on beginning price N(58,10). Target Price = 79¢, Effective support price = 60¢. Average change in government cost calculated for trials in which beginning price was lower than target price. (96% of results).

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