

The Impacts of U.S. Cotton Programs on the West and Central African Countries Cotton Export Earnings

Mohamadou L. Fadiga, Samarendu Mohanty, and Suwen Pan¹

*Paper prepared for presentation at the American Agricultural Economics Association
Annual Meeting, Denver, Colorado, August 1-4, 2004*

¹ Respectively, Research Associate, Associate Professor, and Research Scientist in the Department of Agricultural and Applied Economics at Texas Tech University, Lubbock, Texas Box 42132, Lubbock, Texas 79409
Email contact person: Mohamadou.fadiga@ttu.edu

The Impacts of U.S. Cotton Programs on the West and Central African Countries Cotton Export Earnings

Abstract

This study uses a stochastic simulation approach based on a partial equilibrium structural econometric model of the world fiber market to examine the effects of a removal of U.S. cotton programs on the world market. The effects on world cotton prices and African export earnings were analyzed. The results suggest that on average an elimination of U.S. cotton programs would lead to a marginal increase in the world cotton prices thus resulting in minimal gain for cotton exporting countries in Africa.

Key Words: Stochastic simulation, partial equilibrium model, United States, Africa, cotton subsidies, export earnings.

JEL Classification: Q11, Q17

Introduction

Cotton plays an important role in the economy of the West and Central African (WCA) countries. The economic significance of cotton in the WCA countries can be measured by its contribution to the GDP and by its sizable share of total export earnings. For countries such as Togo, Chad, Burkina Faso, Mali, and Benin, cotton contributes between 5 and 10 percent of total GDP and between 20 and 43 percent of total export share (ICAC). As the main cash crop in most of these countries, cotton plays a central role in government strategies to alleviate rural poverty. An estimated 10 to 15 million people in the WCA countries depend on cotton for their livelihood (Fortucci). The high dependence on cotton explains the vulnerability of these countries to downturns in cotton prices. A recent study by Minot and Daniels (2002) found that fall in price led to significant decreases in rural per capita income and to higher incidences of poverty in rural areas.

In the last decade Sub-Saharan Africa's total production and exports of cotton have substantially increased passing from 0.94 and 0.55 million metric tons to 1.2 and 0.96 million metric tons for the 1992/93 and the 2002/03 marketing year, respectively (USDA, 2003). With nearly 85% of Africa's total cotton production, WCA region is the world third largest exporter of cotton fiber after the United States and Uzbekistan. The recent increase in cotton production in WCA countries may be attributed to a more liberalized agriculture. In the last two decades, these countries had implemented structural adjustment policies to reform their economy as recommended by the International Monetary Fund and the World Bank.

Although the pace and scope of the reforms varied from country to country, their primary objectives with respect to agriculture were to limit government intervention, to dismantle the bankrupt and inefficient state marketing boards, to promote private entrepreneurs in trading

and distribution of agricultural products and inputs, and to eliminate all forms of subsidy to the different sectors, including the cotton sector (Lele). These policies were conducted within a larger framework of macroeconomic reforms that involve, among others, currency devaluation and balance of payment adjustments to help correct sources distortions such as overvalued exchange rates that have traditionally hindered the competitiveness of African agriculture in the world market. These policies also sought to eliminate or at least to relax government control on farm prices. Government intervention in the marketing sector to set producer prices was identified as a major impediment to agricultural growth in Africa and was described as an implicit tax on producers to support domestic industries. Despite the economic reforms that took place, producer price in the WCA countries remained on average at about 53 percent of world price between the 1997/98 and 2000/01 period (Badiane, Ghura, Goreux, and Masson).

The elimination of major sources of distortions at the domestic level and the increased production levels that follow have not resulted in higher export revenues from cotton. In fact, export earnings from cotton have considerably declined. Watkins and Sul estimated that Sub-Saharan African countries have cumulatively lost 334 million of U.S. dollars in exports earnings due to subsidies to cotton producers in the United States. Total government assistance to U.S. cotton producers have consistently increased over the years. Between 1996/97 and 2001/02 marketing years, total assistance passed from 0.9 to 3.6 billion dollars, while world prices plummeted from 79 to 42 cents a pound (Baffes). As a percentage of A-index, total assistance received by U.S., Spanish and Greek farmers reached record highs in 2000/01 of 75, 187, and 253 percent of the A-index, respectively (Baffes). This paper is focused on the United States because of its position as the world largest cotton exporter.

While it is undisputed that a combination of factors, including a sluggish world economy, high yields, and polyester prices played a significant role in the downfall in world cotton prices, the WCA countries were critical to the subsidies as the main reasons for their export earning losses. Although a removal of the subsidies for cotton would benefit WCA countries in the short run, whether the effects on these economies would be sustained over time remain to be seen, especially if the analysis accounts for the effects on other major producers such as Australia, Brazil, and Argentina.

This study examines the effects of a removal of U.S. farm subsidies on the WCA countries exports earnings using a stochastic simulation approach to account for the underlying uncertainties that characterize commodity markets. This approach is particularly attractive because of the dependence of policy impact evaluation on baseline analysis (Westoff *et al.*). The procedure therefore provides a unique framework to gauge the effects of alternative policies, to quantify the uncertainties as the results of policy shocks, and generate confidence bands for the response variables. This study does not evaluate the effects of full trade liberalization; it only focuses on the U.S. subsidies for cotton producers, which are the basis of WCA countries complaint to the World Trade Organization (WTO).

Conceptual Analysis

The history of the U.S. commodity programs has considerably changed in the last two decades. However, two major shifts are noteworthy: in 1985 with the introduction of the deficiency payment and in 1996 with its replacement by decoupled payments. Under the *Farm Security and Rural Investment Act*, which is the current *Farm Bill*, the U.S. government uses six major mechanisms to support cotton producers. These include direct payments (DP), counter-cyclical

payment (CCP), marketing loss assistance, loan deficiency payment (LDP), step-2 payment, emergency payments, and insurance.

A graphical representation of the effects of the U.S. cotton programs on the world market is shown in Figure 1. Panel (a) presents the domestic cotton supply and demand in the United States. The U.S. cotton programs include a marketing loan program, direct payment, counter cyclical payments using target price and marketing certificates through step 2 payments. For all these programs, the loan rate announced under the marketing loan program is directly linked to the current production level and acts as a minimum guaranteed price for the farmers. Thus farmers do not respond to market price if it is below the loan rate causing the supply curve to be vertical at the loan rate level (P_L). However, loan rate does not act as a floor for the market by allowing the market price to fall to the level (P_w) to clear the market. The net effects of these programs are to expand cotton exports from free market exports of OQ to OQ^1 .

In panel (c), the rest of the world excess demand is shown separately for China and rest-of-the-world minus China. The Chinese market is separated from the rest-of-the-world to point to the importance of Chinese trade policies on the world market. As part of WTO commitments, China has established a tariff-rate-quota for cotton imports. In quota import levels have been set to rise from 740,000 metric ton in 2002 to 890,000 metric ton in 2004 with a tariff of one percent. The out-of-quota tariff which was 76 percent in 2002 is scheduled to drop to 67 percent in 2003, 58 percent in 2004, 49 percent in 2005, and 40 percent in 2006, 780,000 in 2003, 820,000 metric ton in 2003, 860,000 metric ton in 2004, and 890,000 metric ton in 2004 increasing since 2002. The presence of a TRQ makes the Chinese import demand discontinuous at the quota level. The vertical line segment BC on Chinese excess demand represents the level of the TRQ, below and beyond which there is a demand response by Chinese importers.

Panel (b) displays the world market equilibrium with excess supply derived from the United States and excess demand from the rest-of-the-world. The United States faces a kinked rest-of-the world excess demand function due to the presence of TRQ in China and the rest-of-the-world faces a kinked U.S. excess supply function because of marketing loan program in the United States.

With the removal of the U.S. cotton subsidy programs, the decreased U.S. exports from OQ_1 to LM raise the world prices from P_w to P_{w1} . Cotton supply response in the United States returns to the original supply function rather than the kinked supply function induced by policy payments. This results in upward shift of the origination of the excess supply function from S to K in panel (b). The analysis theoretically shows that WCA countries will benefit from higher world prices and increased export share to capture part of U.S. export share loss that emanates from the elimination of U.S. farm programs. The extent to which the removal of these policies impact WCA export earnings depends on several factors including supply and demand elasticities in the world fiber market.

Stochastic Simulation Model

This study focuses on the impacts of the elimination of cotton subsidy programs in the United States on the WCA export earnings. The study applies a partial equilibrium world fiber model developed by Pan, Fadiga, Mohanty and Ethridge. The model includes the world's twenty-four major cotton importers and exporters: (1) Asia (China, India, Pakistan, Taiwan, South Korea, Japan and Other Asia); (2) Africa (Egypt and Other Africa); (3) North America (Mexico, United States, and Canada); (4) Latin America (Brazil, Argentina, and Other Latin America); (5) Oceania (Australia); (6) Middle East (Turkey and Other Middle East); (6) Former Soviet Union

(Uzbekistan, Russia, and Other FSU); (7) Europe (European Union, Central and Eastern Europe, and Other Western Europe). The dataset used in this study are compiled from various sources, which include Food and Agricultural Policy Institute (FAPRI) for the historical and predicted macro variables (real GDP, exchange rate, population, and GDP deflator), USDA Foreign Agriculture Service, Production, and Supply & Distribution (PSD) for cotton production, consumption, ending stocks, and import and export data, and FAO World Fiber Consumption Survey and Fiber Organon for the fiber mill consumption and man-made fiber data.

Model Structure

The interdependence of production, consumption, and price linkages and the increasing importance of synthetic and cellulosic in cotton in price formation require a model that is flexible enough to accommodate the changes taking place in the global fiber market. This is particularly important as the cotton mill demand is determined by the relative prices of cotton with respect to man-made-fibers, especially polyester (Meyer). This relationship underscores the importance of the man-made-fiber supply, use, and prices for a complete model of world cotton market. Thus, the structure of the cotton model includes a supply side, demand side, and price linkage equations for cotton and man-made fiber.

Domestic supply of cotton is the sum of production, imports, and beginning stocks. Production is further decomposed into areas and yields. Under this specification, area allocation is a function of expected net returns or prices of cotton and competing crops. In the case of the United States, expected net returns are preferred to farm prices because they account for the effects of supply-side distortions, which are the sources of the controversy fueling the debate over the effects of U.S. farm policies on the world cotton market. Meanwhile, yields are

specified as a function of rainfall, expected prices, and a time trend. The uncertainty in the fiber markets is, for the most part, driven by the stochastic nature of yields and is the basis of the simulation experiments. It is important to note that U.S., China, and India have four producing regions to account for the heterogeneity between producing regions within each country. The partial equilibrium model allows each of these regions to be simulated separately, with separate cropping patterns and yield equations. Area (A), yield (Y), and production (QP) are specified as follows:

$$(1) \quad A_{c,t}^i = f(NR_{c,t-1}^i, NR_{o,t-1}^i, T) + \varepsilon_{c,t}^i,$$

$$(2) \quad Y_{c,t}^i = f(P_{c,t-1}^i, RF_{c,t-1}^i, T) + \mu_{c,t}^i,$$

$$(3) \quad QP_{c,t}^i = A_{c,t}^i \cdot Y_{c,t}^i,$$

Where NR represents net return of cotton and competing crops, RF is the rainfall, T is the time trend, P is price, and the subscripts c and o refer to cotton and competing crops, respectively.

The demand sector comprises ending stocks (ES), mill-use (QS) and exports (X). Domestic cotton consumption (mill-use) is modeled in two stages: total domestic fiber consumption (D) and cotton share of fiber mill use. Per capita consumptions of apparel, floor coverings, home textiles, and others textiles are predicted separately, continuing the prediction of total fiber domestic mill-use. The weighted fiber price (cotton, wool and polyester) and per capita GDP determines the fiber consumption, and the price ratio of cotton and other fibers is used to determine the share of cotton and man-made fiber. The domestic demand components are specified as follows:

$$(4) \quad D_{f,t}^i = f(P_{f,t}^i, GDP_t^i) + \eta_{f,t}^i,$$

$$(5) \quad QD_{c,t}^i = f(P_{c,t}^i / P_{s,t}^i) + \delta_{c,t}^i$$

$$(6) \quad ES_{c,t}^i = f(ES_{c,t-1}^i, QP_{c,t}^i, P_{c,t}^i) + \kappa_{c,t}^i$$

the subscript f is total fiber, while i , c and t remain as previously defined. The domestic market equilibrium (equation 7 below) is obtained by combining equations (1) to (3) on one side and (4) to (6) on the other. Solving this equilibrium yields the domestic price of cotton.

$$(7) \quad ES_{c,t}^i + QD_{c,t}^i + X_{c,t}^i = ES_{c,t-1}^i + QP_{c,t}^i + I_{c,t}^i,$$

where I represents imports. At the world level, total exports equal total imports. Thus, the world market equilibrium condition is expressed as

$$(8) \quad \sum_i X_{c,t}^i = \sum_i I_{c,t}^i.$$

Solving for equation (8) yields the world cotton price (A-index). Similarly, man-made-fiber represented by polyester is modeled using capacity and utilization. In the model, capacity is specified as a function of lagged oil prices, lagged wage index, and lagged of cellulosic or synthetic prices. Meanwhile, the demand of man-made-fibers is the sum of exported man-made fiber and man-made-fiber mill consumption. Equilibrium at the domestic level yields domestic price of man-made-fiber, while world price of polyester is endogenous to the model and is derived as in the case of cotton.

In this analysis, the stochastic levels are initially simulated under the continuation of the policies currently in place in the United States. Then the simulations are conducted under a new policy regime that assumes a removal of the policies. The effects of this new policy regime on the stochastic levels are evaluated by comparing the level of endogenous variables before and after implementing the new policy. The model allows the rest-of-the-world to react to price signals that follow the removal of the policies and subsequently evaluate their impacts on the different sectors each year for the next ten years. The extent to which one sector reacts to

changes originating from another is conditioned by the magnitude of the elasticity estimates, which are calculated based on historical data. In the case of Africa, income and price elasticities of cotton mill use are estimated at 0.55 and -0.74, respectively, while cross-price elasticity with respect to polyester was estimated at 0.24 and acreage price elasticity was evaluated at 0.0106. Pan, Fadiga, Mohanty, and Ethridge provide a detailed description of the elasticities of the remaining countries and regions.

Simulation Procedure

The stochastic simulation approach in this study is based on Monte Carlo simulations of the stochastic components of twenty-seven regional and country yields (equation 2). The simulation experiments are conducted using a multivariate empirical distribution of the stochastic error components derived from the historical yield data. The multivariate empirical distribution circumvents difficulties that arise with small samples, especially the assumption of a specific error term distribution, while dealing with autocorrelation and heterokedasticity problems that are characteristic to yields (Richardson, Klose, and Gray, 2000).

The stochastic nature of yields is governed by the residuals $\mu_{c,t}^i$ in equation (2). These residuals are collected from the estimation of the partial equilibrium model, then normalized, and converted into deviates about their respective means. The deviates are then sorted to generate a correlation matrix for the sorted residuals, a matrix of correlated uniform standard deviates, and the probabilities of the sorted deviates (Richardson, Schumann, and Feldman, 2002). These three elements represent the parameters of the multivariate empirical distribution and serve as the basis for the simulation experiments. It is important to note that only yields from different geographic regions within a specific country are assumed to be correlated to each other. For instance, in the

case of the U.S., yields in the West, South, Southeast, and Southwest regions are correlated; however, yields in, say, China are not correlated with yields in India regardless of the producing region.

The simulations are conducted over a ten-year horizon using SIMETAR© to draw 500 alternatives stochastic output ranges. The 500 alternative stochastic ranges were then applied to projected mean yields for all twenty seven countries and regions for the period 2004/05 to 2013/14. Since the yield equations are linked to the remaining endogenous variables via the partial equilibrium model, each alternative set of yields corresponds to a set of endogenous variables. Thus substituting the 500 yields into the partial equilibrium model enables to solve for 500 alternative response variables for a ten-year time horizon.

The next step is to conduct similar experiments after removing the U.S. subsidies to generate a new set of 500 alternative solutions. These results are compared to those generated under the original scenario to evaluate the stochastic and deterministic effects of policy changes on each endogenous variable. For the purpose of this study, only the effects on A-index, polyester prices, African production and exports revenues are presented.

Results

The results of the simulation indicate that under the continuation of the current policies in the U.S., the average base value of the A-index amounts to 63.96 cents a pound, while the stochastic mean is estimated at 60.70 cents a pound (table 1). Under this scenario, the stochastic averages are consistently below the deterministic baseline values. The results also suggest that on average, there is 80 percent chance that the A-index falls between 41.72 and 76.58 cents a pound.

A removal of cotton subsidies in the U.S. leads to a moderate increase in world price (A-index). As table 2 indicates, the average world cotton price amounts to 64.68 cents a year over

the next ten years compared to 63.96 cents if the current policies are left unchanged. Similar to the base scenario, these averages are lower under the stochastic framework with an average difference of 4.98 percent. However, there is 80 percent chance that they fall between 42.03 and 77.53.

In sum, the deterministic baseline increases by 0.28 cent in 2004/05 and 1.29 cent in 2005/06, about 0.45 and 2.14 percent, respectively. The stochastic average follows a similar path and is expected to increase by 1.38 cents a pound (its highest change) in 2004/05 compared to the base scenario. The stochastic simulation also shows that most of the increase in the A-index takes place in the second (2.05 percent) and third years (1.90 percent) following the elimination of the subsidy programs in the United States. The effects of removal of U.S. farm policies on the A-index will be reduced starting the year 2006/07 projected changes in the A-index would range between 0.31 and 1.17 cents per pound.

The analysis also shows that the international price of polyester is expected to barely change as a result of U.S. policy changes. Polyester prices changes are minimal compared to cotton prices affecting the price relationship between the two fibers in favor of polyester. As a result, mill demand for polyester increases at the detriment of cotton and may be the reason for a limited change on export earnings.

The removal of the cotton program in the U.S. has limited effects on Africa's cotton supply response. On average, Africa's total production is expected to increase by just 1,250 metric tons a year under the deterministic baseline and by 1,510 metric tons following a stochastic analysis. The changes in total production take place in 2005/06, three years after the removal of the policies. The results also suggest that 80 percent of the time, total production increases after removal of the subsidies falls between 1,200 and 1,810 metric tons. The fact that

production is barely affected may be expected because, as Levin noted, arable lands are becoming increasingly scarce and yields have not increased since the late 1980s and are expected to stagnate for the foreseeable future due to high dependence of cotton production on rainfall and low rate of technological adoption, especially the use Bt cotton.

A removal of the U.S. cotton subsidies induces exports earning effects. Similar to the A-index, the simulated Africa's average export earnings over the ten years assuming continuation of current policies amounts to 1.93 billion dollars using the deterministic baseline (table 3), while the stochastic average over the next ten years amounts to 1.80 billion dollars. Moreover, the results suggest that for 80 percent of the time, the total African export earnings would fall between 1.32 and 2.39 billion dollars.

The discontinuation of current policies would lead to an increase in Africa's average export earnings to 1.96 and 1.83 billion dollars under the deterministic baseline and stochastic framework, respectively (table 4). Moreover, the average export earnings for the next ten years fall between 1.33 and 2.44 billion dollars under the new scenario. The policy changes also lead to higher cotton exports for Africa. The combination of the price and quantity effects that result from the policy discontinuation would lead to a slight growth of Africa export earnings. If the current policies in the U.S. are discontinued, Africa export earnings would register additional gains amounting to 45.158 million dollars in 2005/06 under the deterministic baseline and 48.775 million dollars under the stochastic analysis thereafter, the additional gains follow a slow and steady decline averaging about 26 million dollars a year for the next ten years.

These findings are in sharp contrast with the findings by similar studies with respect to the effects of subsidy programs on the cotton A-index and Africa's export earning losses. The previous studies follow a deterministic simulation approach, thus their findings can only be

compared to the deterministic means or to some extent to the stochastic averages derived here. Studies conducted by FAPRI estimated that the elimination of the subsidies would lead to an appreciation of the cotton A-index by 11.8 percent and Africa's export earnings would increase by 12.6 percent. Similarly, the ICAC estimated the changes on the A-index at 15 percent, while Africa would gain 230 millions dollars in additional export earnings. A recent study by Tokarick concluded that the A-index would appreciate by 2.8 percent, while Africa's export earnings would increase by 175 million dollars if the subsidies on cotton were removed. Baffes found that an elimination of all forms of distortions including trade distortions would increase the A-index by 11 percent, while Watkins and Jung-Ui estimated the financial losses suffered by the WCA countries at 330 million dollars. The difference in the results arises from the nature of the policy reforms being analyzed. The effects on A-index and export earnings are higher under a policy that considers a full liberalization compared to one that is limited to reforms of farm programs in the United States. In instances where the policies being analyzed are the same, the difference generally stems from differences in the elasticities used in the partial equilibrium analysis.

It is important to note that the stochastic simulation approach enables to capture the probabilistic nature of the effects of policy changes. Thus, with respect to changes in the A-index (Table 5), the results indicate that there is 80-percent chance that the changes in the A-index fall between 0.52 and 0.90 cents for 2004/05 and between 0.95 and 1.83 cents per pound for the year 2005/06. Likewise there is 80 percent chance that the African export earning would fall between 17.85 and 32.22 million dollars for the 2004/05 year and between 31.87 and 66.59 million dollars for the 2005/06 year. Further details on the cumulative distribution of the effects of a removal of U.S. farm programs on Africa export earnings are presented in table 6.

Concluding Remarks

The conceptual analysis shows that a removal of farm subsidies in the U.S. would will lead to higher international cotton prices and export earnings for cotton exporters such as WCA countries. These findings have been verified empirically using a stochastic analysis. However, the empirical results indicate that world price appreciates on average by an average annual rate of 1.13 percent a year for the next ten years, while production has increased minimally because of physical and technological constraints. For these reasons, Africa's export earnings increase minimally compared to what earlier studies have suggested. The effects of these policy changes are most noticeable within the first two years following the policy changes; however, most of the impacts will die down in the later years as the results of supply and demand adjustments in the world market.

References

- Badiane, O., D. Ghura, L. Goreux, and P. Masson. "Cotton Sector Strategies in West and Central Africa." Working Paper 2867, World Bank, 2002.
- Baffes, J. "Cotton: Market Setting, Trade, and Issues." World Bank Policy Research Working Paper 3218. The World Bank, Washington DC, February 2004.
- Beghin, J. C., B. El Osta., J. R. Cherlow, and S. Mohanty. "The Cost of the U.S. Sugar Program Revisited." *Contemporary Economic Policy*, 21(1), 2003:106-116.
- FAPRI. "The Doha of the World Trade Organization: Appraising Further Liberalization of Agricultural Markets." Food and Agricultural Policy Research Institute Working paper 02-WP-317, November 2002.
- FAS. "China, People Republic of Cotton and Products Annual, 2002." June 16, 2002. Available at <http://www.fas.usda.gov/itp/china/accession.html>.
- Fortucci, P. "The Contribution of Cotton to Economy and Food Security in Developing Countries." FAO, 2002.
- ICAC. "Impacts of Government Measures on African Cotton Producers." International Cotton Advisory Committee, October 2003.
- Lele, U. J. "Managing Agricultural Development in Africa." *Agricultural Development in the Third World*. C. K. Eicher and J. M. Staatz, eds., pp 531-539. Baltimore and London: The John Hopkins University Press, 1990.
- Levin, A. "Francophone West Africa Cotton Update." Beltwide Cotton Research Conference, San Antonio Texas, January 2000.
- Minot N. and L. Daniels. "Impact of Global Cotton Markets on Rural Poverty in Benin." *Mimeo*, International Food Policy Institute, Washington, D.D., 2002.
- Pan, S., M. Fadiga, S. Mohanty, and D. Ethridge. "Structural Models of the U.S. and Rest-of-the-World Natural Fiber Markets." Working Paper CER 04-03, Department of Agricultural and Applied Economics, Texas Tech University, May 2004.
- Richardson J.W., S. L. Klose, and A. W. Gray. "An Applied Procedure for Estimating and Simulating Multivariate Empirical Probability Distributions in Farm-Level Risk Assessment and Policy Analysis. Management." *Journal of Agricultural and Applied Economics*, 32 (August 2000): 299-315.
- Richardson J. W., K. Schumann, and P. Feldman. *Simetar: Simulation for Excel to Analyze Risk*. Agriculture and Food Policy Center, College Station, Texas, July 2002.

Tokarick, S. "Measuring the Impact of Distortions in Agricultural Trade in partial and General Equilibrium." IMF Working Paper WP/03/110, International Monetary Fund, May 2003.

USDA. 2003. Economic Research Service. Available online at <http://www.ers.usda.gov>

Watkins, K. and Jung-ui Sul. Cultivating Poverty: The Impact of U.S. Cotton Subsidies on Africa. Oxfam Briefing Paper, 20, 2002:1-36.

Westoff, P., J. Fabiosa, J. Beghin, and W. Meyers. "Challenges in Modeling the Effects of Trade Agreements on the Agricultural Sector." CARD Working Paper 04-WP 358, Center for Agricultural and Rural Development, Iowa state University, April 2004.

Table 1. Simulated A-Index under the Current U.S. Farm Programs (Cents per Pound)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	61.20	60.30	60.51	61.33	62.77	63.97	65.27	66.72	68.28	69.29	63.96
Stochastic Average	58.38	56.67	57.13	58.32	59.76	60.83	62.36	63.40	64.73	65.41	60.70
Difference	-4.62%	-6.01%	-5.59%	-4.90%	-4.81%	-4.91%	-4.46%	-4.97%	-5.21%	-5.59%	-5.11%
Standard deviation	8.31	10.21	11.19	11.92	12.69	13.42	14.02	15.16	15.76	17.16	12.98
Percentiles											
5%	46.90	40.05	38.04	38.21	38.25	38.30	38.15	37.79	37.57	37.07	39.03
10%	47.70	42.14	40.66	40.05	40.76	41.08	42.34	41.09	41.36	40.01	41.72
20%	49.78	46.38	46.41	45.98	46.92	47.27	48.48	48.70	48.40	46.75	47.51
30%	51.75	50.90	50.48	51.87	53.53	52.31	54.41	54.49	54.27	55.64	52.96
40%	55.56	54.37	54.78	56.44	57.87	58.96	59.24	60.03	61.41	62.01	58.07
50%	59.03	57.94	58.47	59.53	61.73	62.09	63.65	65.50	67.18	67.59	62.27
60%	60.90	60.28	61.54	63.07	64.34	66.23	67.41	69.16	71.89	71.88	65.67
70%	62.90	62.85	63.84	66.23	67.08	68.86	71.54	73.45	75.79	76.72	68.93
80%	65.92	65.65	66.76	68.75	70.76	72.69	75.11	77.16	79.94	80.86	72.36
90%	69.39	68.76	71.30	72.38	75.50	77.29	79.27	81.97	83.24	86.73	76.58
95%	72.38	71.65	74.10	75.72	79.08	81.88	83.96	85.28	86.87	90.73	80.17

Notes: Deterministic baseline indicates the simulated A-index (world price) over the next ten years under current farm program in the US without accounting for uncertainty. Stochastic average (standard deviation) indicates the averages (standard deviation) of the simulated A-index derived from the 500 draws of stochastic A-index level under current farm programs in the United States. Union. Difference is simply the deviation of the stochastic average with respect to the deterministic baseline. Percentiles indicate the confidence bands for simulated A-index derived from 500 draws of stochastic A-index level under the current farm programs in the United States.

Table 2. Simulated A-Index under a Discontinuation of Current U.S. Farm Programs (Cents per Pound)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	61.48	61.59	61.50	62.08	63.46	64.61	65.93	67.35	68.92	69.89	64.68
Stochastic Average	58.72	57.83	58.21	59.04	60.40	61.63	62.98	63.91	65.52	66.38	61.46
Difference	-4.49%	-6.10%	-5.35%	-4.90%	-4.83%	-4.62%	-4.46%	-5.11%	-4.93%	-5.02%	-4.98%
Standard deviation	8.68	10.27	11.88	11.83	13.06	13.63	14.52	15.06	16.36	17.22	13.25
Percentiles											
5%	46.68	40.83	38.29	38.37	39.44	37.21	38.64	38.80	38.50	36.89	39.36
10%	48.34	42.53	40.03	41.14	42.25	41.71	40.82	41.89	41.04	40.54	42.03
20%	50.44	48.05	45.90	47.15	46.67	48.91	47.64	48.57	47.96	48.21	47.95
30%	52.01	51.50	51.80	52.92	51.20	53.66	54.67	54.69	56.64	56.58	53.57
40%	54.45	55.86	55.87	57.48	58.35	59.68	60.49	60.98	62.83	63.94	58.99
50%	58.61	59.46	59.26	60.84	62.07	63.21	65.08	65.98	67.38	68.15	63.00
60%	61.18	62.03	62.92	63.41	65.52	66.82	69.21	70.11	72.20	72.99	66.64
70%	63.74	64.56	65.93	65.79	69.53	69.87	72.38	72.86	75.98	77.96	69.86
80%	66.54	66.86	68.79	68.90	72.66	73.54	75.13	77.48	79.15	81.85	73.09
90%	70.29	69.69	72.85	73.71	75.85	77.98	79.82	82.50	85.36	87.20	77.53
95%	73.21	72.82	75.75	76.32	79.77	82.30	84.21	86.08	90.45	90.88	81.18

Notes: Deterministic baseline indicates the simulated A-index (world price) over the next ten years after discontinuing the current U.S. farm programs without accounting for uncertainty. Stochastic average (standard deviation) indicates the averages (standard deviation) of the simulated A-index derived from the 500 draws of stochastic A-index level after removing the farm programs. Difference is simply the deviation of the stochastic average with respect to the deterministic baseline. Percentiles indicate the confidence bands for simulated A-index derived from 500 draws of stochastic A-index level after the removal of farm programs.

Table 3. Simulated African Cotton Export Earnings under the Current US Farm Programs (Billion U.S. Dollars)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	1.75	1.72	1.74	1.77	1.84	1.90	1.96	2.04	2.12	2.18	1.93
Stochastic Average	1.66	1.60	1.61	1.66	1.72	1.77	1.85	1.91	1.98	2.02	1.80
Difference	-5.37%	-7.28%	-7.10%	-6.44%	-6.34%	-6.48%	-6.01%	-6.44%	-6.77%	-7.15%	-7.09%
Standard deviation	0.28	0.35	0.39	0.41	0.45	0.48	0.50	0.55	0.59	0.65	0.48
Percentiles											
5%	1.27	1.04	0.97	0.96	0.95	0.98	0.99	0.99	0.99	0.99	1.01
10%	1.30	1.10	1.05	1.02	1.04	1.09	1.14	1.10	1.12	1.08	1.10
20%	1.37	1.25	1.25	1.24	1.29	1.31	1.36	1.37	1.39	1.35	1.32
30%	1.43	1.40	1.39	1.44	1.50	1.47	1.55	1.57	1.60	1.63	1.51
40%	1.56	1.51	1.52	1.60	1.65	1.68	1.73	1.78	1.84	1.89	1.71
50%	1.67	1.63	1.64	1.69	1.78	1.82	1.88	1.96	2.05	2.10	1.86
60%	1.74	1.73	1.75	1.82	1.88	1.95	2.00	2.12	2.23	2.25	1.99
70%	1.81	1.80	1.84	1.93	1.97	2.07	2.17	2.29	2.38	2.44	2.11
80%	1.91	1.90	1.95	2.02	2.09	2.19	2.29	2.42	2.51	2.62	2.23
90%	2.03	2.02	2.13	2.16	2.27	2.36	2.45	2.57	2.71	2.83	2.39
95%	2.14	2.14	2.21	2.27	2.42	2.52	2.63	2.71	2.82	3.01	2.53

Notes: Deterministic baseline indicates the simulated total export earnings over the next ten years under the continuation of the current policies in the U.S. without accounting for uncertainty. Stochastic average (standard deviation) indicates the averages (standard deviation) of the simulated export earnings derived from the 500 draws of stochastic export values under the current farm programs. Difference is simply the deviation of the stochastic average with respect to the deterministic baseline. Percentiles indicate the confidence bands for simulated export earnings derived from 500 draws of stochastic export values assuming a continuation of current farm programs.

Table 4. African Cotton Export Earnings after Removing US Farm Programs (Billion U.S. Dollars)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	1.76	1.77	1.77	1.80	1.87	1.93	1.99	2.07	2.15	2.21	1.96
Stochastic Average	1.67	1.64	1.65	1.69	1.75	1.81	1.88	1.93	2.01	2.06	1.83
Difference	-5.20%	-7.40%	-6.79%	-6.48%	-6.41%	-6.15%	-5.91%	-6.71%	-6.45%	-6.53%	-6.90%
Standard deviation	0.30	0.35	0.41	0.41	0.46	0.48	0.52	0.55	0.61	0.64	0.49
Percentiles											
5%	1.26	1.06	0.97	0.97	1.01	0.95	1.00	1.01	1.03	0.97	1.02
10%	1.32	1.11	1.04	1.06	1.12	1.08	1.09	1.14	1.11	1.11	1.11
20%	1.39	1.30	1.24	1.28	1.26	1.36	1.33	1.37	1.39	1.40	1.33
30%	1.44	1.42	1.42	1.46	1.42	1.54	1.58	1.61	1.67	1.70	1.54
40%	1.52	1.58	1.58	1.60	1.65	1.71	1.75	1.79	1.91	1.96	1.73
50%	1.66	1.69	1.69	1.75	1.81	1.87	1.94	2.01	2.07	2.13	1.90
60%	1.75	1.79	1.80	1.83	1.92	1.98	2.10	2.14	2.25	2.32	2.02
70%	1.84	1.86	1.91	1.94	2.04	2.12	2.22	2.27	2.40	2.48	2.15
80%	1.93	1.94	2.00	2.05	2.18	2.22	2.32	2.43	2.52	2.64	2.26
90%	2.06	2.04	2.17	2.19	2.31	2.40	2.48	2.61	2.76	2.83	2.44
95%	2.17	2.16	2.27	2.30	2.42	2.52	2.64	2.71	2.90	3.03	2.57

Notes: Deterministic baseline indicates the simulated total export earnings over the next ten years without accounting for uncertainty. Stochastic average (standard deviation) indicates the averages (standard deviation) of the simulated export earnings derived from the 500 draws of stochastic export values after removing the U.S. farm programs. Difference is simply the deviation of the stochastic average with respect to the deterministic baseline. Percentiles indicate the confidence bands for simulated export earnings derived from 500 draws of stochastic export values after the removal of farm programs.

Table 5. Distribution of Changes in the A-index after Removing U.S. Farm Programs (Cents per Pound)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	0.28	1.29	0.99	0.76	0.69	0.64	0.65	0.63	0.64	0.60	0.65
Stochastic Average	0.73	1.38	0.91	0.75	0.71	0.67	0.63	0.60	0.56	0.53	0.70
Difference	162.42%	6.67%	-8.35%	-0.42%	2.43%	3.93%	-3.36%	-5.29%	-11.96%	-11.41%	7.33%
Standard deviation	0.14	0.34	0.34	0.30	0.32	0.28	0.32	0.30	0.32	0.31	0.27
Percentiles											
5%	0.50	0.84	0.42	0.31	0.27	0.26	0.21	0.17	0.13	0.12	0.31
10%	0.52	0.95	0.48	0.37	0.31	0.33	0.28	0.24	0.20	0.16	0.37
20%	0.58	1.07	0.58	0.48	0.42	0.41	0.36	0.34	0.28	0.26	0.46
30%	0.64	1.16	0.69	0.56	0.50	0.50	0.43	0.43	0.35	0.33	0.53
40%	0.69	1.28	0.78	0.64	0.58	0.57	0.49	0.50	0.43	0.40	0.60
50%	0.75	1.36	0.88	0.71	0.67	0.64	0.57	0.56	0.51	0.48	0.67
60%	0.79	1.47	1.00	0.82	0.78	0.70	0.64	0.64	0.60	0.54	0.75
70%	0.82	1.59	1.11	0.94	0.87	0.80	0.76	0.71	0.70	0.66	0.83
80%	0.85	1.70	1.22	1.04	0.98	0.91	0.89	0.84	0.83	0.77	0.93
90%	0.90	1.83	1.36	1.17	1.12	1.06	1.09	1.02	0.98	0.97	1.06
95%	0.94	1.91	1.48	1.28	1.26	1.18	1.19	1.15	1.20	1.14	1.18

Notes: Stochastic means indicates the averages of the simulated changes in A-index derived from difference between the 500 draws of stochastic A-index values after removing the U.S. farm programs and the 500 draws of stochastic A-index values with the programs remaining intact.

Table 6. Distribution of African Additional Export Earnings after Removing U.S. Farm Programs (Million U.S. Dollars)

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	Average
Deterministic Baseline	9.513	45.158	38.362	31.490	29.358	27.878	28.209	27.897	28.255	27.034	26.650
Stochastic Average	25.572	48.775	34.922	29.439	27.292	25.542	23.855	22.541	21.000	19.560	26.043
Difference	168.81%	8.01%	-8.97%	-6.52%	-7.04%	-8.38%	-15.43%	-19.20%	-25.68%	-27.64%	-2.28%
Standard deviation	5.435	13.469	13.450	12.048	12.458	11.548	12.816	12.549	13.163	12.991	10.902
Percentiles											
5%	17.067	27.793	15.291	11.884	10.391	9.873	7.970	5.867	4.360	3.366	11.076
10%	17.850	31.871	18.149	14.620	12.827	11.934	10.421	8.348	6.567	5.337	13.264
20%	19.714	36.564	22.327	18.369	15.823	15.285	12.975	11.511	9.330	8.568	16.222
30%	22.074	40.196	26.228	22.117	18.756	18.379	15.541	15.068	12.164	11.030	19.048
40%	24.133	44.340	29.548	24.615	22.293	21.612	18.375	17.861	15.072	13.771	21.782
50%	26.261	47.880	33.729	27.302	25.852	23.986	21.188	20.452	18.522	17.027	24.561
60%	27.797	52.276	37.665	31.868	29.455	26.393	24.499	23.644	21.973	20.142	27.608
70%	29.163	56.862	42.470	36.396	33.524	30.557	28.495	26.620	26.243	24.306	31.147
80%	30.307	61.680	46.753	40.547	37.663	34.903	33.805	31.592	31.254	29.219	35.064
90%	32.228	66.596	53.468	46.137	43.711	41.456	41.726	39.963	37.982	37.754	40.818
95%	34.223	70.302	57.747	50.062	49.949	45.739	47.252	45.131	47.167	45.606	45.560

Notes: Stochastic average indicates the averages of the simulated additional export earnings derived from difference between the 500 draws of stochastic export earnings after removing the U.S. farm programs and the 500 draws of stochastic export earnings with the programs remaining intact.

