The Stochastic Effects of a Ban on Toxaphene Use on Cotton

By Reuben N. Weisz, Ronald R. Miller, and William Quinby*

A ban on toxaphene use in control of the cotton budworm bollworm would increase the average price of cotton as well as its price instability It would decrease the level and increase the variability of cotton yield and production Such a ban would also decrease the experted value but not the variance of exports A Monte Carlo economic simulation model was used to evaluate stochastic impacts of pesticide regulation This methodology should be applicable also in future technology impact policy analyses

Keywords

Pesticide
Policy
Technology assessment
Simulation
Risk

Decisionmakers are considering explicitly the concept of risk whenever they behave as if they know the probability distribution of the consequences of the decision they have made Policymakers, asking for the opportunity to play "Jimmy the Greek" in recent years, have asked research analysts to evaluate the full range of outcomes associated with a policy decision and to determine the probability associated with each level of outcome (*18*) [1]

Analysts of pesticide policy, however, have evaluated changes in levels of costs and yields but have failed to recognize the aggregate stochastic impacts of pesticide regulations (see *17*, for example) Because the dominant rationale for using pesticides may be to minimize risk, policymakers should evaluate the farm level and aggregate impacts of pesticide policies on risk Numerous microeconomic studies have stressed the importance of incorporating information on risk into the analysis of technological changes for a firm (see *9*, for example)

We present a methodology that can be used to incorporate risk implications into evaluations of pesticide policies, and we use this approach to evaluate a ban on the use of toxaphene for the budworm-bollworm on cotton This general approach should be applicable to other impact assessment studies [2]

GENERAL METHODOLOGY

The National Agricultural Policy Simulator, POLYSIM, was the economic model used, particularly its cotton yield and acreage equations The model can be made stochastic, which allows the decisionmaker to evaluate the statistical characteristics associated with the consequences of alternative policies

Overview of POLYSIM

Ray and Moriak provide an overview of the deterministic version

> The POLYSIM model was constructed differently from most simulation models to attain the desired policy analysis capability The model makes full use of the forecasted data as a reference baseline POLYSIM simulates the effects of policy specifications that differ from those assumed in the baseline while holding all other supply and demand shifters the same The model thus focuses on the interaction of supply and demand responses that result from specified changes in policy variables (*8*)

The model contains the following commodities feed grains, wheat, soybeans, cotton, cattle and calves, hogs, sheep and lambs, chicken, turkeys, eggs, and milk

POLYSIM was developed at Oklahoma State University by Richardson and Ray through cooperative agreements with the National Economics Division (then the

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[1] Italicized numbers in parentheses refer to items in References at the end of this article

[2] The sole purpose of this article is to present a methodology for technology impact policy analyses Our main point is to show a useful method of evaluating the outcome of policy action That alternative is a range of outcomes with the probability of occurrence of each outcome attached The base line numbers presented are not intended, nor should they be construed, to represent a forecast of future cotton prices

Because the dominant rationale for using pesticides may be to minimize risk, policymakers should evaluate the farm level and aggregate impacts of pesticide policies on risk

Commodity Economics Division), ESCS Documentation appears in several technical bulletins (*14, 15, 13*) ESCS economists have modified the model The ESCS baseline used here is available (*18*)

Simulation Procedure

The user begins a simulation by changing one or more of the variables contained in the model's baseline For example, a pesticide policy analysis could be conducted by changing the base values of one or more of the following variables

- Crop variables—
  Exogenous change in yield per harvested acre,
  Exogenous change in variance of yield per harvested acre, and
  Exogenous change in variable production expense per harvested acre
- Livestock variables—
  Exogenous change in production, and
  Exogenous change in nonfeed variable production cost

The actual values of the variables are computed outside the model by the analyst and are inputed into POLYSIM

The simulation procedure begins by shocking the model with the relevant changes in the cotton acreage and yield equations We obtain simulated cotton statistics (tables 2-6) for 5 years, which we compare with the baseline statistics The model may be viewed as an automated accounting routine that traces the initial effects on production through subsequent effects on price, use, and farm income, for each of the 11 commodity groups and for agriculture in the aggregate

Role of Elasticities

Direct and cross-commodity supply and demand elasticities determine the magnitude and direction of endogenous variables' deviations from the baseline values The elasticities used were derived by Ray and Richardson from many sources—subjective judgments of commodity specialists, a survey of the literature, and direct estimation based on recent data

Although each commodity in the model has a unique set of parameters assigned to it, a large degree of similarity exists among the mathematical functions assigned to each commodity We now describe the cotton yield equations we modified for use in our study (figs 1 and 2)

Yield Equation

Simulated cotton yield in a given year, *t*, is calculated by adjusting the baseline yield in response to the following (fig 1)

1 The change between simulated cotton price and baseline price in the previous year,
2 The change between the current simulated prices paid index and the index implied by the baseline,
3 The change between simulated cotton harvested acreage and baseline acreage,
4 A long-term adjustment coefficient which allows current adjustment in yield to reflect the behavioral, capital, and investment inertia of past decisions,
5 A shift, due to a change in pesticide or other policy, of the level of the production function, the exogenous change in yield in the simulated year *t*, and
6 A shift, due to a change in the variance of yield

In the Ray and Richardson version, the analyst could select only one of the following yield options, and assume other things were equal for the other determinants of yield

Option A Deterministic, price-responsive yield equation (contains items 1 through 4, above),

Option B Strictly exogenous yields (considers item "5", only), and

Option C Strictly stochastic yields (considers item "6", only)

Option A contained no provision for incorporating a shift in the production function (item "5") or a change in the variance of yield (item "6") which may result from a change in technology Therefore, the deterministic, price-responsive, yield equation is inadequate for pesticide regulation impact analysis

However, the alternative of using a predetermined yield, Option B, is inappropriate, too Whenever a prespecified yield is inserted into the model it overrides the feedback loops between price and yield As the existence of the feedback effects is the main

Figure 1—Stochastic Cotton Yield Equation

$$
\begin{aligned}
&\text{Simulated cotton lint yield in pounds per harvested acre}_t = \text{Baseline cotton lint yield in pounds per harvested acre}_t \cdot \Big[1.0 + \Big(\text{Elasticity of cotton yield wrt cotton price} \cdot \text{\% change in cotton price from baseline}_{t-1} \Big) \\
&\quad + \Big(\text{Elasticity of cotton yield wrt change in prices paid for inputs} \cdot \text{\% change in prices paid index from the value implicit in the baseline data}_t \Big) - \Big[\text{Marginal effect of a change in cotton harvested acreage upon cotton yield/acre} \cdot \\
&\quad \Big(\text{Simulated cotton harvested acreage}_t - \text{baseline cotton harvested acreage}_t \Big) \Big] \Big] + \Delta YLD/HA_t + \Big(1.0 - \text{longrun adjustment factor} \Big) \\
&\quad \cdot \Big(\text{simulated cotton yield}_{t-1} - \Delta YLD/HA_{t-1} - \text{baseline yield}_{t-1} \Big) \\
&\quad + \Big(\text{Normally distributed deviation from the baseline yield per harvested acre} \Big)
\end{aligned}
$$

Note $\cdot$ = multiplied by
wrt = with respect to

reason for using POLYSIM, a strictly exogenous yield was not appropriate

Option C, the strictly stochastic yield equation, also is inappropriate, because the dependency of yield on items "1" through "5" is ignored These factors are all relevant for pesticide policy analyses

In our methodology, all six factors have a simultaneous impact on yield For example, in the first year simulated, t, the exogenous changes in the expected value and the variance of yield will result in a simulated yield different from the baseline yield This yield differential results in the simulated year t production, and, hence, prices that differ from the baseline values In the subsequent year, $t + 1$, the simulated yield is modified by the exogenous variables as well as the difference between the simulated and baseline values of the price variable for the preceding year The change in simulated cotton yield in year $(t + 1)$ with respect to (abbreviated as wrt) a percentage change in cotton price in year t is computed by multiplying the percentage change between simulated and base figures of cotton price by the elasticity of cotton yield to obtain its own price Other endogenous variables for cotton and other commodities in year $(t + 1)$ are affected through direct and cross elasticities with the price of cotton In this manner, POLYSIM traces out the effects within and between time periods and the feedbacks among endogenous variables

The marginal effect of a change in cotton harvested acreage upon the yield per harvested acre was obtained from Evans and Bell and incorporated into the POLYSIM yield equation (*6*) They showed a negative relationship between yield and harvested acreage because increases in cotton acreage involve bringing marginal land into production Similarly, decreases in cotton acreage result in higher average yields because marginal land moves out of cotton production

Acreage Equation

The cotton harvested acreage equation also is driven by initial policy shocks and subsequent price feedbacks (fig 2) The simulated cotton acreage is a function of

1 Prices of cotton and competing crops,
2 Production costs,
3 Expected yields, and
4 A long-term adjustment coefficient

Net returns from cotton relative to those from competing crops influence acreage decisions A negative relationship exists between acreage and AVOC, the sum of the average variable and opportunity costs of growing cotton (*6*) Evans and Bell calculate AVOC as a function of the prices, costs, and yields of competing crops, as well as the variable cost and yield per harvested

Figure 2—Cotton Harvested Acreage Equation

$$
\begin{aligned}
&\text{Simulated cotton harvested acreage million acres}_t = \text{Baseline cotton harvested acreage million acres}_t \cdot \Big[1\ 0 + \Big(\text{Elasticity of cotton acreage wrt cotton price} \cdot \text{\% change in cotton price from baseline}_{t-1}\Big) \\
&+ \Big(\text{Elasticity of cotton acreage wrt corn price} \cdot \text{\% change in corn price from baseline}_{t-1}\Big) + \Big(\text{Elasticity of cotton acreage wrt soybean price} \cdot \text{\% change in soybean price from baseline}_{t-1}\Big) \\
&+ \Big(\text{Elasticity of cotton acreage wrt wheat price} \cdot \text{\% change in wheat price from baseline}_{t-1}\Big) + \Big(\text{Elasticity of cotton acreage wrt Prices Paid Index} \cdot \text{\% change in Prices Paid Index from baseline}_{t-1}\Big)\Big] \\
&- \Big[\text{marginal effect (in million acres/dollars per pound) of a change in cotton variable cost per pound upon cotton harvested acreage} \cdot \Delta VPE/HA_t - \text{Expected yield per acre}_t\Big] \\
&+ \Big(1\ 0\ \text{longrun adjustment factor}\Big) \cdot \Big(\text{calculated cotton acreage}_{t-1} - \text{baseline cotton acreage}_{t-1}\Big)
\end{aligned}
$$

Where $\Delta VPE/HA_t$ = Exogenous change in cotton variable production expense per harvested acre (Dollars/acre),

$$
\text{Expected yield per acre}_t = \left(\frac{YLD_{t-1} + YLD_{t-2} + YLD_{t-3}}{3}\right) + \Delta YLD/HA_t - \left(\frac{\Delta LD/HA_{t-1} + \Delta YLD/HA_{t-2} + \Delta YLD/HA_{t-3}}{3}\right),
$$

YLD_t = simulated yield per harvested acre (Pounds/acre), in year t

and where $\Delta YLD/HA_t$ = exogenous change in yield in year t

Note $\cdot$ = multiplied by
wrt = with respect to

acre of cotton This relationship has been incorporated into the POLYSIM cotton acreage equation, so that the cotton acreage response curve (response to cotton price) can shift to the left as AVOC increases because of a pesticide ban

Procedure for Making POLYSIM Stochastic

The procedure for making POLYSIM stochastic has been described by Ray and Richardson (*13*)

> A deterministic model can be made stochastic by drawing values for selected variables The impact of the drawn values on the model endogenous variables are estimated with the simulator By repeating the process a large number of times and recording the values of the output variables, experimental probability distributions are developed for the endogenous variables in the model

In the original version of the model, the yield and export demand equations are bypassed when the model is run stochastically In our version of the model, we add a normally distributed deviation from the baseline to the yield and export equations

Several probability distributions for yields and exports are available to the analyst who wishes to use POLYSIM in the stochastic mode We assumed that the yields and exports of each of the model's four crops are distributed as a correlated multivariate Table 1 shows the default variance-covariance matrix for this option This matrix, calculated by Richardson and Ray from detrended data for 1960-74 for average national values of crop yields and exports, is used to develop a stochastic baseline

EMPIRICAL ANALYSIS

At the time of our study, USDA and Environmental Protection Agency researchers were developing partial budget and yield estimates of the impacts of this pesticide ban Preliminary data developed for the Federal/State Assessment Team on Toxaphene (*17*) give the following average U S results In response to a ban, average U S cotton yield per harvested acre would

Table 1—Default variance-covariance matrices for feed grain, wheat, soybean and cotton yields and exports[1]

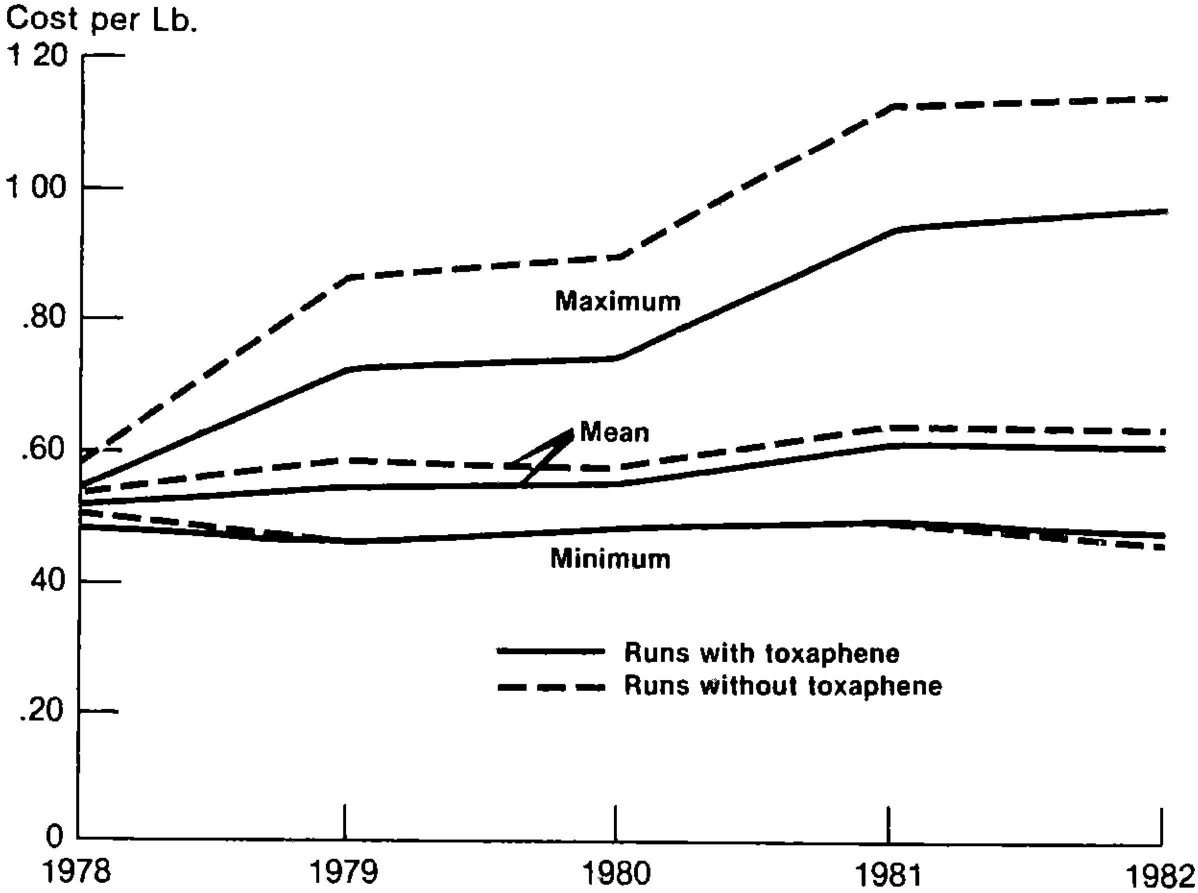
Commodity	Variance covariance for crop yields				Variance-covariance for crop exports			
	Feed grains	Wheat	Soy-beans	Cotton	Feed grains	Wheat	Soy-beans	Cotton
	Tons/ acre	*Bushels/ acre*	*Bushels/ acre*	*Pounds/ acre*	*Million tons*	*Million bushels*	*Million bushels*	*Million net bales*
Yields								
Feed grains	0 028	0 068	0 079	-0 304	0 588	8 760	2 890	0 051
Wheat		1 470	498	353	2 396	32 471	24 467	064
Soybeans			878	-2 275	1 876	37 421	19 512	124
Cotton				102 567	-8 926	207 665	-79 504	4 921
Exports								
Feed grains					23 365	529 668	82 816	2 100
Wheat						21,386 810	578 938	77 710
Soybeans							1,831 926	11 613
Cotton								953

[1] These matrices were obtained by calculating the variances and covariances from detrended data for average national values of crop yields and exports 1960 74 (*13*, p 125)

A ban could raise cotton prices by 3 1 cents per pound for an average yield year and push prices up 15-20 cents per pound in a poor yield year Thus, cotton could cost over $1 per pound at 1978 price levels, if toxaphene is banned

Figure 3

Stochastic Cotton Prices



decrease by 16 5 pounds of lint Standard deviation of yield would increase 2 7 pounds per acre, and variable cost per acre would go up $2 86 Because we have "massaged" preliminary data, our results are not official, yet they are reasonable estimates

To perform this analysis, we chose a Monte Carlo simulation approach rather than a pure, point estimate method as the probability of achieving a given point is zero Our approach presents ranges of estimates and the corresponding probabilities of their occurrence

A Monte Carlo simulation generated the random deviations in the yield and export equations A single 5-year simulation run would illustrate only one of the infinite possible combinations To evaluate the relative frequency of possible outcomes, we ran two sets of simulations in each of which a 5-year (1978-82) Monte Carlo sequence of events was simulated 300 times

The first set simulated a stochastic baseline, one with no user input changes but which includes by default the effect of the random shocks on baseline yields and exports This set, the base, represents a stochastic view of the economy in the absence of a ban

Before the 300 iterations of the second run, without toxaphene, were performed, the levels and variance of cotton yield and the variable expense per harvested acre were modified by the partial budget and yield results presented earlier This is referred to as the simulated run

Graphic Display of Results

Figure 3 summarizes the base and simulated cotton prices for each of the 5 years The figure shows the maximum (top line), mean (middle line), and minimum (bottom line) observation recorded in each time period with (solid line) and without (dotted line) toxaphene

The proposed policy's cost and yield shocks reduced output The negative impact on production resulted in a wider range of cotton prices without toxaphene than with it The annual maximum, mean, and minimum values without toxaphene are higher than the corresponding values with it A ban could raise cotton prices by 3 1 cents per pound for an average yield year and push prices up 15 20 cents per pound in a poor yield year Thus, cotton could cost over $1 per pound at 1978 price levels, if toxaphene is banned

Hypothesis Testing

Numerical results for selected variables are illustrated in tables 2 through 5 In each case we test the hypothesis that no significant difference occurs in the results of the POLYSIM runs with and without toxaphene

Comparison of Means

The reduction in average production from 11 09 to 10 86 million bales due to the pesticide ban pushes cotton prices an average of 3 1 cents per pound above the baseline (table 2) The higher level of cotton prices reduces the effect of the 16 5 pounds per acre exogenous change in yield per acre to -13 4, 81 percent of the initial value Higher prices reduce exports from 4 5 to 4 4 million bales The t' tests indicate that there is less than a one out of 1,000 probability that the differences

Table 2—Average 5 year mean for 1978-82

Item	Base line	Simulated	t' statistic	Level of significance
Cotton price (dollars per pound)	0 564	0 595	9 83	0 001
Cotton yield (pounds per acre)	481 252	467 876	-27 03	001
Cotton exports (million bales)	4 509	4 373	-3 64	001
Cotton acreage (million acres)	11 064	11 144	4 81	001
Cotton production (million bales)	11 091	10 861	-12 42	001
Soybean price (dollars per bushel)	5 331	5 347	40	N S

Note N S means not significant

in cotton prices, yields, exports, acreage, and production with and without toxaphene could have been obtained by chance alone [3] However, there is no significant difference between 5-year mean soybean prices Similar data on annual mean values appear in table 3

Table 3—Annual means

Item	Base line	Simu-lated	t' statistic	Level of significance
Cotton price (dollars per pound)				
1978	0 511	0 535	19 71	0 001
1979	543	585	7 47	001
1980	550	580	5 25	001
1981	609	641	3 92	001
1982	606	632	3 23	005
Cotton acreage (million acres)				
1978	10 80	10 70	(¹)	(¹)
1979	11 164	11 173	69	N S.
1980	11 136	11 304	4 27	001
1981	11 109	11 276	4 07	001
1982	11 112	11 269	3 03	005
Soybean price (dollars/bushel)				
1978	4 333	4 333	02	N S
1979	4 704	4 717	44	N S
1980	5 113	5 142	58	N S
1981	6 185	6 222	50	N S
1982	6 320	6 321	01	N S

Note N S means not significant

[1] The stochastic variation was initiated in 1978 Thus, acreage in 1978 was nonstochastic because it was based on 1977 yields

Comparison of Standard Deviations

Table 4 provides the 5-year standard deviations and table 5, the annual standard deviations of selected variables, with and without toxaphene An F-test is used to test the hypothesis that there is no significant difference in the results of simulation runs with and without toxaphene The hypothesis was not rejected for the 5-year standard deviations of cotton exports and soybean prices Nor was it rejected for the annual values of cotton exports and soybean prices However, F-tests for the other variables indicate that there is a significant difference between the baseline and simulated standard deviations In these cases, there is a less than a one out of 100 probability that these results could have been obtained by chance alone

Over the 5-year period, the increased variance on yield results in a significant (0 01 level) increase in the variability of the values of cotton price, acreage, and production The standard deviation of price increased from 7 5 to 9 4 cents a pound The standard deviation of harvested acreage increased from 390,000 to 510,000 acres The standard deviation of production increased from 440,000 bales to 570,000 bales

Table 4—Average 5-year standard deviation for 1978-82

Item	Base line	Simu lated	F statistic	Level of significance
Cotton price (dollars per pound)	0 075	0 094	1 57	0 01
Cotton yield (pounds per bushel)	12 226	14 763	1 46	01
Cotton exports (million bales)	1 008	1 039	1 06	N S
Cotton acreage (million acres)	393	512	1 69	01
Cotton production (million bales)	439	569	1 68	01
Soybean price (dollars/bushel)	1 094	1 110	1 03	N S

Note N S means not significant

[3] It cannot be assumed *a priori* that variances of the two means are identical The t' statistic of Cochran (*3*) is used As the number of observations for each sample is identical for our study, the Cochran approach here means simply to calculate $t' = t$ and adjust the degrees of freedom from $2(n-1)$ to $(n-1)$ Cochran's t' statistic is slightly more conservative than the solutions of (*1*, *2*, and *7*)

The input data for our stochastic POLYSIM simulation indicated a ban on toxaphene would decrease the level and increase the variability of yield and production

Table 5—Annual standard deviation

Item	Baseline	Simulated	F statistic	Level of significance
Cotton price (dollars per pound)				
1978	0 012	0 017	1 99	0 01
1979	058	078	1 80	01
1980	059	081	1 90	01
1981	085	110	1 68	01
1982	083	109	1 75	01
Cotton acreage (million acres)				
1978[1]				
1979	140	163	1 35	01
1980	375	490	1 71	01
1981	444	554	1 56	01
1982	573	694	1 47	01
1978	242	242	1 00	N S
1979	357	361	1 02	N S
1980	589	602	1 05	N S
1981	901	932	1 07	N S
1982	1 226	1 251	1 04	N S

Note N S means not significant

[1] The stochastic variation was initiated in 1978 Thus, acreage in 1978 was nonstochastic because it was based on 1977 yields

In Earlier Issues

A good textbook is the most reliable tool of a teacher It often becomes the blueprint for a course, and in many instances the success or failure of a teacher working under the pressures of a heavy teaching load is dependent on the thoroughness of organization and presentation in the text material

D B DeLoach
AER, Vol III, No 4,
Oct 1951, p 135

Future research should evaluate the impact on net farm income of changes in the variability of yields, costs and prices received

Comparison of Variances and Frequency Distributions

The major stochastic shock in this analysis is the change in the variance of cotton yield that is induced by the proposed pesticide regulation The variances of yield, then, deserve closer scrutiny As table 6 indicates, the variance without toxaphene is over twice the value of the historical variance and 146 percent of the value of the stochastic baseline

Table 7 illustrates the frequencies of alternative cotton prices These indicate that a toxaphene ban would shift the expected frequencies of cotton prices from lower to higher values and expand the range of likely values from 51 1 cents to 69 1 cents The mean and standard deviation both increase The chi-square statistic, 276, measures the difference between baseline and simulated frequencies This indicates that the probability that the price frequencies without toxaphene do not differ from those with it is close to zero

Table 6—Variances on cotton yield per harvested acre

Source	Variance		
	Pounds per acre squared	*Percent of detrended values*	*Percent of stochastic baseline*
From detrended data for average national values, 1960 74	[1] 102 567	100	
From stochastic baseline 1978-82	[1] 149 475	146	100
From stochastic without toxaphene run, 1978-82	217 946	212	146

[1] As described in the text, we used the POLYSIM default option for the probabilistic assumptions when constructing the stochastic baseline An analysis of historical crop yield data indicates the presence of heteroskedasticity Future 1978 82 variance of yield will likely differ from that observed in 1960-74 but why the actual difference occurred in our study remains unclear

Table 7—Frequencies of cotton prices for 1978-82

Price interval (cents per pound)	Frequency of occurrence	
	Baseline	Simulated
45 50	[1] 240	[1] 102
50-55	559	506
55 60	313	336
60-65	205	246
65 70	106	140
70 75	39	62
75 80	19	50
80-85	9	20
85 90	3	17
>90	[2] 7	[3] 21

[1] The minimum baseline and simulated value recorded was 46 0 cents per pound [2] The maximum baseline value recorded was 97 1 cents per pound [3] The maximum simulated value recorded was 115 1 cents per pound

Note Chi-square equals 276 Other nonparametric statistical tests could have been applied to the empirical results of this Monte Carlo experiment For example the Kolmogorov-Smirnov test also rejects the common distribution hypothesis Our examples only suggest the types of analysis that could be performed with such data

CONCLUSIONS

The input data for our stochastic POLYSIM simulation indicated a ban on toxaphene would decrease the level and increase the variability of yield and production The POLYSIM analysis indicates that a ban would also increase the average price of cotton as well as its price instability It would decrease the expected value but not the variability of exports Data on crops other than cotton would not be affected significantly

The farm income part of POLYSIM is weak so we did not examine this component in detail At the farm level, a pesticide ban will affect the variability of costs and yields Future research should evaluate the impact on net farm income of changes in the variability of yields, costs, and prices received

The stochastic method used in our policy analysis allows examination of a range of possible outcomes and assigns probabilities to alternative outcomes In past pesticide policy analyses with the deterministic version of POLYSIM, we have used commercial econometric models to evaluate the consumer price implications of POLYSIM's results A commercial econometric model could be used in conjunction with stochastic POLYSIM in future studies

REFERENCES

(1) Aspin, A A "Tables for Use in Comparisons Whose Accuracy Involves Two Variances, Separately Estimated " *Biometrika* 43 203, 1956

(2) Behrens, W V *Landwirtschaftliche Jahrbucher* 68 807, 1929

(3) Cochran, W G "Approximate Significance Levels of the Behrens Fisher Test " *Biometrics*, 20 191,1964

(4) Davison, Cecil W , and Milton H Ericksen "Alternative Economic Settings for Agriculture " In *Agricultural-Food Policy Review* Econ Res Serv , U S Dept Agr ERS AFPR-1, Jan 1977, pp 12 29

(5) Evans, Sam "Regional U S Cotton Acreage Response " In *Cotton and Wool Situation* Econ Res Serv , U S Dept Agr CWS-11, July 1977, pp 20-24

(6) Evans, Sam, and Tom Bell "How Cotton Acreage, Yield, and Production Respond to Price Changes " In *Agr Econ Res* Vol 30, No 2, Apr 1978

(7) Fisher, R A , and F Yates *Statistical Tables* 5th ed Oliver and Boyd, Edinburgh, 1957, tables VI, VI_1 , and VI_2

(8) Moriak, Theo F "Implications of Uncertainty in Yields and Exports " U S Dept Agr , unpubl Aug 1977

(9) Moscardi, Edgardo and Alain de Janvry "Attitudes Toward Risk Among Peasants An Economic Approach " In *Am J Agr Econ* Nov 1977, pp 710-716

(10) Ray, Daryll E , and Earl O Heady *Simulated Effects of Alternative Policy and Economic Environments on U S Agriculture* Ctr Agr and Rural Devlpt , Iowa State Univ CARD rpt 46T Mar 1974

(11) Ray, Daryll E , and Theo F Moriak "POLYSIM A National Agricultural Policy Simulator " In *Agr Econ Res* Vol 28, No 1, Jan 1976 pp 14-21

(12) Ray, Daryll E "U S National Agricultural Projection and Policy Models " Paper presented at U S -U S S R Agr Business Seminar, Nov 16-17, 1977, Harvard University Professional paper P 433, Okla Agr Expt Sta , 1977

(13) Ray, Daryll E , and James W Richardson *Detailed Description of POLYSIM* Okla State Univ , and U S Dept Agr , Tech Bull , T-151, Stillwater, Okla , Dec 1978

(14) Richardson, James W , and Daryll E Ray *User's Manual for UPDATE—An Auxiliary Program for POLYSIM* Agr Expt Sta , Okla State Univ , Res Rpt P-726 Nov 1975

(15) Richardson, James W , and Daryll E Ray *User's Manual for the National Agricultural Policy Simulator (POLYSIM) Agr Expt Sta , Okla State Univ , Res Rpt P-727 Nov 1975*

(16) Trickett, W H , B L Welch, and G S James "Further critical values for the two-means problem " *Biometrika* 36 290, 1949

(17) U S Department of Agriculture "Biological Estimates and Partial Budgets Related to the Use of Toxaphene and Its Alternatives " Draft of supplement to report, "Assessment of Toxaphene in Agriculture," Sept 9, 1977 Prepared by USDA State Assessment Team on Toxaphene in cooperation with Environmental Protection Agency Coordinated by Office of Environmental Quality Activities, U S Dept Agr 1977

(18) ———— Transcript of remarks by Secretary of Agriculture, Bob Bergland, at meeting with USDA staff sponsored by Org of Professional Employees of Dept Agr , Wash , D C , Feb 8, 1977

(19) ———— "November 1977 Baseline Intermediate Outlook Projections for Research Purposes " Econ , Statis , Coop Serv , Commod Econ Div working paper, Feb 1978