WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

PAPERS OF THE

1989 ANNUAL MEETING

WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

COEUR D'ALENE, IDAHO

JULY 9-12, 1989

SESSION 2

The Dynamics of Farm and Non-Farm Price Transmissions: The Case of Cotton

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Policymakers need to know the nature and characteristics of price transmission mechanisms between the economy's farm, industrial and consumer levels. We focus on how a drop in the spot price of cotton pulsates through the industrial fabric and apparel sectors of the economy. More specifically, this study emphasizes the farm/nonfarm price transmission mechanism among four prices: the spot cotton price near the farmgate (PF), the price paid for cotton as an industrial input (PI), the consumer price of cotton fabric (PC), and the retail price of cotton and noncotton apparel (PA).

Farmgate cotton prices declined an average monthly 7.0 percent during June-August, 1988 (ERS or U.S. Department of Agriculture, Economic Research Service). This study focuses on the following questions about the dynamic aspects of the PF-PI-PC-PA price transmission mechanism: (1) what are the reaction times necessary for industrial cotton, cotton fabric, and apparel prices to respond to a spot price shock?, (2) what are the directions, durations, and general patterns of impulse responses to a spot price decline?, and (3) what differences are there in response patterns of PI, PC, and PA to a decline in spot price?

These dynamic aspects about the PF-PI-PC-PA transmission mechanism are often ignored, or at best, inadequately addressed by more theoretically-based and structural price models. While informative about which economic variables are related, static theory frequently says little about the dynamics of an economic relationship or how such a relationship responds between pre- and post-shock states. Vector autoregression or VAR econometrics addresses such dynamics. VAR econometrics is a data-oriented and atheoretical method which uses theory loosely to suggest which variables are interrelated, and then imposes as few a priori theoretical restrictions as possible to permit empirical regularities about the above-cited dynamics present in the data to reveal themselves.

We first estimate a four-variable VAR model of PF, PI, PC, and PA. Second, we shock the VAR model with a decline in the spot price near the farmgate, and examine the impulse responses in the three nonfarm prices. In so doing, we demonstrate how, and for how long, a drop in cotton's spot price near the farmgate is expected to influence industrial and consumer cotton prices, as well as the price of apparel generally. Third, we obtain and analyze decompositions of forecast error variance for the model's four variables.

These analyses provide insight into the nature of the interrelationships among the four modeled prices. Such analyses reveal past data's empirical regularities and how the time-ordered series have moved through time. These past trends suggest how history would have these variables move through future time in the wake of a spot price shock.

A summary of the VAR econometric method is not provided here; this has been done before repeatedly. Those interested in such a summary within the context of agricultural issues should consult Babula and Bessler (1988) and

Orden.

Estimated VAR Model of Cotton-Related Price Transmissions

We demonstrate how a farmgate shock, which registers as a drop in the spot price of cotton (interchangably, farmgate cotton price), pulsates through the cotton-related sectors of the nonfarm economy. This study estimates the monthly VAR model in equations 1 through 4 below.

$$(1) \quad PF_t = a_{f,0} + a_{f,T}*TRD + a_{f,1}*PF_{t-1} + \ldots + a_{f,12}*PF_{t-12} + $$
$$+ a_{f,13}*PI_{t-1} + \ldots + a_{f,24}*PI_{t-12} +$$
$$+ a_{f,25}*PC_{t-1} + \ldots + a_{f,36}*PC_{t-12} +$$
$$+ a_{f,37}*PA_{t-1} + \ldots + a_{f,48}*PA_{t-12} + f_t$$

$$(2) \quad PI_t = a_{i,0} + a_{i,T}*TRD + a_{i,1}*PF_{t-1} + \ldots + a_{i,12}*PF_{t-12} + $$
$$+ a_{i,13}*PI_{t-1} + \ldots + a_{i,24}*PI_{t-12} +$$
$$+ a_{i,25}*PC_{t-1} + \ldots + a_{i,36}*PC_{t-12} +$$
$$+ a_{i,37}*PA_{t-1} + \ldots + a_{i,48}*PA_{t-12} + i_t$$

$$(3) \quad PC_t = a_{c,0} + a_{c,T}*TRD + a_{c,1}*PF_{t-1} + \ldots + a_{c,12}*PF_{t-12} + $$
$$+ a_{c,13}*PI_{t-1} + \ldots + a_{c,24}*PI_{t-12} +$$
$$+ a_{c,25}*PC_{t-1} + \ldots + a_{c,36}*PC_{t-12} +$$
$$+ a_{c,37}*PA_{t-1} + \ldots + a_{c,48}*PA_{t-12} + c_t$$

$$(4) \quad PA_t = a_{a,0} + a_{a,T}*TRD + a_{a,1}*PF_{t-1} + \ldots + a_{a,12}*PF_{t-12} + $$
$$+ a_{a,13}*PI_{t-1} + \ldots + a_{a,24}*PI_{t-12} +$$
$$+ a_{a,25}*PC_{t-1} + \ldots + a_{a,36}*PC_{t-12} +$$
$$+ a_{a,37}*PA_{t-1} + \ldots + a_{a,48}*PA_{t-12} + a_t$$

The PF, PI, PC, and PA are defined above. All a-coefficients are regression coefficients; the f, i, c, a subscripts on the a-coefficients refer to the PF, PI, PC, and PA, variables, respectively. TRD is a time trend. The $a_{f,0}$, $a_{i,0}$, $a_{c,0}$, $a_{a,0}$ refer to the intercepts on the PF, PI, PC, and PA, equations, respectively. The f_t, i_t, c_t, and a_t are the stochastic errors or innovations for the PF, PI, PC, and PA relations, respectively. We accounted for seasonal influences by estimating with a series of dummy variables.

Monthly Bureau of Labor Statistics (BLS) data serve as PF, PI, PC, and PA proxies. The estimation period is 1978:2 through 1987:7. Farmgate cotton price or PF is represented by the "spot price," that is, the producer price index (PPI), farm products (detail), raw cotton, grade 41, staple 34, spot market average. The industrial cotton price (PI) is proxied by the PPI, products and apparel, grey fabrics, cotton broadwovens. The price of finished cotton fabrics (PC) is reflected by the PPI, textile products and apparel, finished fabrics, cotton broadwovens. This PC proxy may be viewed not only as a consumer price of cotton fabric, but perhaps also as the price of an important input for apparel generally. Finished cotton fabrics are both, purchased directly by retail-level consumers, and utilized in apparel manufacture. Finally, the consumer price index, all urban consumers, apparel commodities less footwear, is the proxy for retail apparel price (PA).

Doan and Litterman's package, Regression Analysis of Time Series (RATS), generated all VAR econometric results. The Tiao-Box likelihood ratio test results (not reported here) suggest a 12-order lag.

Influences of a Decline in Farmgate Cotton Price

We demonstrate the reaction times of, directions and durations of, and general interrelationships among cotton's spot price, industrial cotton price, finished cotton fabric price and general apparel price. We did this through (i) analysis of impulse responses of PI, PC, and PA from a once-only seven percent (one standard error) drop in farmgate cotton price, and (ii) analysis of the decompositions of the forecast error variance or FEV of the VAR model's four prices.

The impulse response function simulates, over time, the effects of a one-time shock in one of the system's series on itself and on other series in the system. This is done by converting the VAR model into its moving average representation. The parameters of the MA representation are complex and nonlinear combinations of the AR coefficients of relations 1 through 4.

Note that PF, PI, PC, and PA may have contemporaneously correlated innovations. Failure to correct for contemporaneously correlated current errors in the VAR relations will produce an impulse response function which is not representative of historical patterns. We implement a Choleski decomposition in order to orthogonalize the current innovation matrix, such that the variance/covariance matrix of the transformed current innovations is identity. Basically, the Choleski orthogonalization "fixes" the problem of contemporaneous correlation which distorts the impulse responses.

The Choleski decomposition requires a sometimes arbitrary imposition of a Wold Causal ordering or chain among the current values of the dependent variables. We choose the ordering of PF to PI to PC to PA for two reasons. First, intuition suggests that farm prices more directly affect the PI and PC prices than the retail price of cotton and noncotton apparel. Second, we simulate the effects of a farm price decrease on industrial cotton and cotton fabric prices, and in turn, on retail apparel price. Thus the ordering is suggested by the question investigated.

The VAR's three nonfarm prices (PI, PC, PA) are much less volatile than movements in farmgate cotton price (Babula and Bessler 1988). Cotton price at the farmgate is nearer the random effects of climate than nonfarm prices. Being further away from the annual agricultural production timetable for cotton than farm price, the nonfarm fabric and apparel prices reflect less of the annual movements than cotton production. Our deseasonalized nonfarm prices therefore reflect a distribution process of fabric and clothing to the economy throughout the year which is "steadier" than the harvest-oriented distribution of raw cotton to the economy immediately from the farmgate. One therefore expects farmgate market shocks to have more pronounced impacts on farmgate cotton price than on industrial cotton, consumer cotton, and apparel prices (Babula and Bessler 1988).

Figure 1 summarizes the impulse responses in PI, PC, and PA from the initiating farm price decline. Figure 1 provides approximate percent changes in the nonlogged price indices. The broken line represents changes or impulse responses in industrial cotton price. The solid (nonbold) line constitutes the plot of cotton fabric price impulses. Responses in retail apparel price constitute the solid bold line.

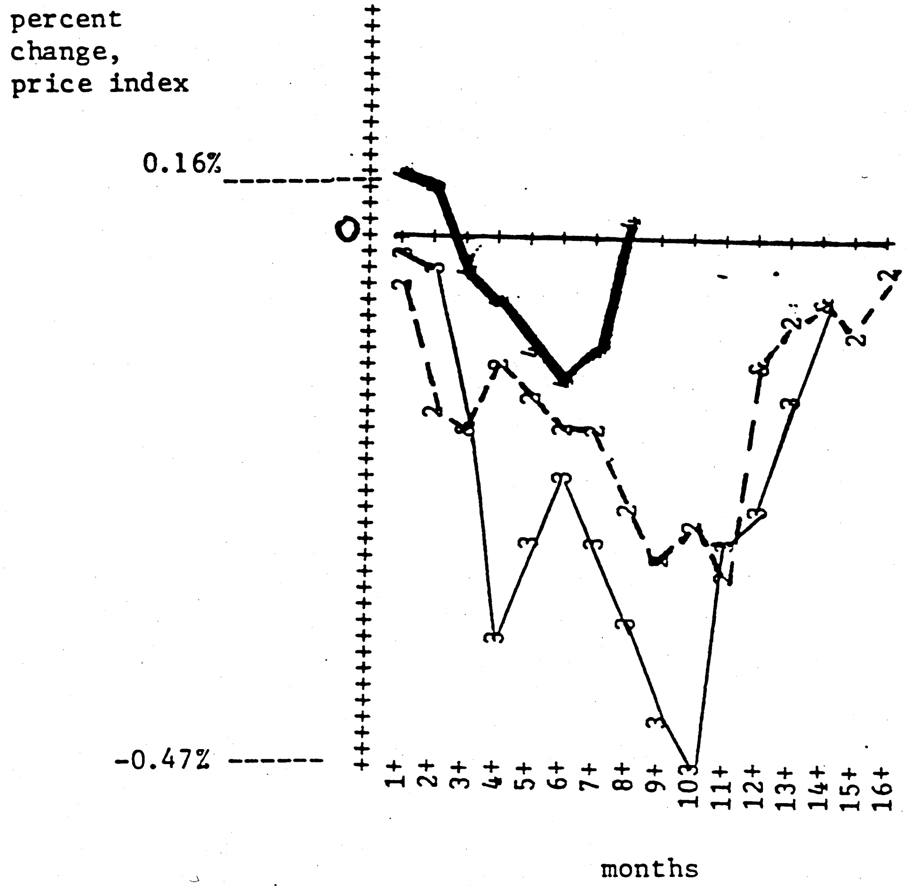
The seven percent decline in farmgate cotton price generates declines in industrial cotton prices. The PI-decreases gradually gain in strength and reach a trough at 11 months. At their trough of -0.30 percent, industrial cotton price declines are less than a twentieth of the initiating one standard error decline in farm cotton price. Industrial cotton price declines continue for 16 months before reaching zero.

Over this 16 month period, we calculated a "price sensitivity parameter" of PI's changes to changes in PF -- hereafter PSP(PI/PF). This sensitivity parameter is the total change in industrial price over farm price changes during the 16 months. Such a parameter is elasticity-like insofar as it measures percent PI-change over percent change in PF. The PSP is not anelasticity because the sensitivity parameter spans more than one time period, while elasticities are defined for a point in time. This PSP of industrial cotton price to farm price, for the first 16 months in figure 2, is 0.135, a very inelastic level. So for each percent change in PF, the industrial cotton price moves in the same direction but by less than one fifth the PF changes' percent magnitude.

Results show similar patterns for consumer cotton price or PC. The seven percent drop in farm price generates PC declines which reach a trough at 10 months. At this trough, the decline in PC is only a 0.47 percent, less than a tenth of the initiating seven percent decrease in farm price. Consumer cotton prices drop for 14 months. The PSP of PC to PF-changes over this 14-month period is 0.155, a number close to the 0.135 for PSP(PC/PF). On average, each farm cotton price decline results in a far milder 0.155 percent decline (also less than a fifth of a percent) in cotton fabric price.

The impulse response patterns of PI and PF have a number of similarities. First, the industrial and consumer price declines peak in strength at approximately the same time (10-11 months). Second, the declines in price from the farm price shock of -7.0 percent are mild and reach a trough within an approximate range of only a third to a half of a percent. Third, the PSP's of both industrial price and cotton fabric price are very inelastic at 0.135 and 0.155, respectively, over initial post-shock response periods of 14 to 16 months. And third, the mild declines of the two series (PC, PI) have similar durations of 14-16 months.

The impulse responses in general apparel prices are also examined. The apparel price excludes footwear, but includes prices of such noncotton materials as polyester and wool, as well as cotton. Further, "apparel" goods have substantial services such as tailoring, fashion design, marketing, nonfabric accessories, etc. added to industrial cotton and finished fabrics. Because apparel price includes noncotton price influences, one expects a more muted response in retail apparel price to a farmgate shock than in industrial



= 4 = impulse responses, retail apparel price

= 3 = impulse responses, cotton fabric (finished) price

= 2 = impulse responses, industrial cotton price

Figure 1. Impulse Responses of Cotton-Related Prices to a 7.0 Percent Decline in Farm Price.

and consumer cotton price. Apparel price declines reach a trough at six months, and persist for seven months, before dying out at zero. Apparently, lower cotton price induces substitution away from noncotton fabrics and cuts short the apparel price decreases as demand for the PA's cotton component rises. The decreases in retail apparel price are mild, and bottom-out at about a tenth of a percent. The sensitivity parameter of PA to changes in farm cotton price, is, as expected, extremely inelastic at 0.02.

Analysis of Decompositions of Forecast Error Variance

Analysis of decompositions of forecast error variance (FEV) is another tool of VAR econometrics for discerning the relationships among the modeled system's time series. FEV is, at alternative forecast horizons or steps, attributed to shocks in each of the dynamic system's series, such that a measurement of relative "strength" of relationships emerges (Bessler 1984a, p. 111). Decompositions of FEV are in table 1. We calculated FEV decompositions for 36 months or "steps." With a stationary series, the standard errors increase out into time but level off towards a value (Sims 1980). Table 1 suggests that the modeled series are stationary. A variable's exogeneity is suggested when its FEV is largely attributed to its own variation. Likewise, a variable's high degree of endogeneity is suggested when small a proportion of its FEV is attributed to own variation. Table 1 suggests that farm cottonprice is largely exogenous because over half of its FEV is self-attributed at all reported horizons. Consumer or finished cotton fabric price is the second largest explanatory element of farm price. Up to 27.6 percent of the farm price's forecast error variance is explained by the price of finished cotton fabrics.

Except in the shortrun horizons of six months or less, industrial cotton price is largely endogenous. Less than half of PI's forecast error variance is self-explained at all reported horizons of a year or more. Cotton fabric price contributes most to PI's explanation. Over 40 percent of PI's FEV is traced to finished fabric price at horizons exceeding 12 steps.

Consumer cotton price (PC) has a high degree of endogeneity because less than half of its FEV is self-explained after the shortrun six-month horizon. Farm price and industrial cotton prices have a substantial combined explanation of cotton fabric price, particularly at the longer run horizons.

Retail apparel price is highly endogenous to the system because no more than about a fifth of its FEV is self-explained at horizons exceeding 12 steps. At horizons beyond six steps, finished cotton fabric price is the largest explanatory factor in retail apparel price's FEV. Note that while PC accounts from about 39 to 46 percent of PA's FEV at most reported horizons, PA adds little to the explanation of PC's FEV. So cotton fabric price appears to explain retail apparel price's FEV to a greater degree than general apparel price explains the FEV of finished cotton fabric price.

Findings and Conclusions

A number of findings emerged from this time-series analysis into the dynamics of the farm-nonfarm price transmission mechanism for cotton-based products. First, a seven percent decline in farm cotton price generates rather mild decreases which fail to exceed -0.30 percent for industrial price; -0.47 percent for cotton fabric price; and -0.13 percent for retail apparel

Table 1. Proportions of forecast error variance k months ahead allocated to innovations in respective series.

Variable	Steps (k)	Std. Error	Percent PF	Percent PI	Percent PC	Percent PA
Farmgate price (PF)	1	.0845	99.53	0.43	0.02	0.03
	6	.1014	76.49	4.79	2.59	16.12
	12	.1151	64.79	7.28	11.11	16.82
	18	.1399	50.62	9.88	27.59	11.91
	24	.1498	52.25	11.01	26.01	10.73
	35	.1572	52.05	11.06	26.31	10.58
	36	.1576	51.89	11.23	26.25	10.64
Industrial price (PI)	1	.0055	8.97	87.41	0.00	3.62
	6	.0100	15.46	57.63	5.95	20.96
	12	.0187	13.33	41.95	25.29	19.43
	18	.0278	6.65	35.97	42.63	14.75
	24	.0372	10.80	31.40	48.91	8.89
	35	.0463	25.73	27.64	40.76	5.86
	36	.0467	26.69	27.36	40.17	5.78
Cotton fabric price (PC)	1	.0113	0.19	11.59	87.60	0.61
	6	.0190	9.94	24.09	54.16	11.81
	12	.0308	10.87	30.60	43.24	15.30
	18	.0421	7.02	32.79	46.79	13.40
	24	.0540	14.51	29.84	47.33	8.32
	35	.0642	28.33	25.92	39.81	5.94
	36	.0646	29.04	25.67	39.41	5.88
Retail apparel price (PA)	1	.0036	2.87	5.12	0.99	91.01
	6	.0050	19.04	10.48	4.85	65.63
	12	.0075	14.64	11.57	42.43	31.36
	18	.0100	11.47	22.17	46.37	19.99
	24	.0116	10.81	27.80	44.72	16.67
	35	.0140	21.69	25.86	38.96	13.50
	36	.0142	22.54	25.37	38.88	13.21

prices. Second, decreases reach a trough, that is their peak strengths, at 10-11 months at the industrial and finished fabric levels, and at six months for retail apparel level. Third, the price declines last for between a 14 and 16 months at the industrial and finished fabric levels, and for seven months at the retail apparel level. Fourth, the shorter effects on retail apparel price may arise from a substitution away from PA's noncotton elements and towards PA's important cotton price component. Fifth, price sensitivity parameters of PI, PC, and PA with respect to PF-changes are very inelastic, especially for retail apparel prices. Sixth, farm price is highly exogenous, while the industrial, finished fabric, and retail apparel prices are endogenous. Seventh, finished cotton fabric prices or PC seem to influence retail apparel prices or PA more than PA influences PC. And eighth, the largest factor of explanation of forecast error variance (at the longer run horizons) appears to be an own-error for farm price; finished fabric price for industrial price; own-error and errors of PI and PF for finished fabric price; and PC-errors for retail apparel price.

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