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On the Power of Macroeconomic Linkages to Explain Events in U.S. Agriculture

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The significance for agriculture of macroeconomic events in the 1980s depends upon what elements in the macroeconomy are most strongly linked to agriculture and how these linkages function. It is idle to say, for example, that inflation poses particularly serious problems for agriculture in the 1980s unless we have evidence that inflation generally causes particularly serious problems for agriculture. This paper concentrates on the past literature and current state of evidence on such questions. The final section considers the possibility of scientifically defensible forecasts for the 1980s. It is short.

Theories of "Sectoral Macroeconomics"

Many economists have emphasized the importance of not treating the farm sector as a partial-equilibrium island, and a few have worked diligently at building the needed analytical and empirical bridges. Notable early examples are Kirk, Schultz, Hathaway, and Firch (1964), all of whom linked agricultural instability to business cycles. The period in which Hathaway and Firch wrote was the high-water mark of the "Keynesian" approach to these issues, which emphasized the uses of macroeconomic policy. Following the recent disintegration of the theory of macroeconomic policy, the theme of macroeconomic instability returns. Some prominent hypotheses are: "Instability in farm income has its origins chiefly in business fluctuations" (Schultz, p. 214). "Agricultural prices and income are not extremely sensitive to [macroeconomic] changes" (Lamm, p. 30). "National inflation exerts a real price effect on the farming industry, reducing the parity ra-

tio" (Tweeten and Griffen, p. 10). There is also the denial of the preceding hypothesis (Schluter and Lee); "inflation dampens productivity growth" (Ruttan, p. 896); and the denial of this hypothesis (Johnson). Schuh (1974) saw the exchange rate as an important determinant of real farm prices. Other hypotheses are that "inflation has contributed to a greater degree of inequality among regions and types of farms" (Robinson, p. 904); "the major long-run effect of inflation is perhaps in the way it affects the prices of fixed assets, primarily land for agricultural purposes" (Penn, p. 892); and that inflation "leads farmers to expand their operations more aggressively" (Schertz and Harrington, p. 64).

The derivation of these hypotheses tends to be theoretically ad hoc, as well it might be since standard macroeconomic theory provides little guidance. The empirical evidence adduced has been sparse and contradictory. There is a general hypothesis that instability in aggregate demand causes instability in relative commodity prices, which is supported by recent research (Vining and Elwertowski, Parks). Consequently, we expect real farm prices and incomes to be more variable when the general price level is more variable, as Firch (1977) indeed found. But the effect of macroeconomic disturbances on the level of real farm prices and incomes remains an open question.

Systematic connections between macroeconomic aggregates and sectoral variables may occur along the following lines: if an unanticipated exogenous event occurs (such as accelerated growth in the money supply), there will be a sequence of price and interest rate adjustments throughout the economy that will affect some sectors earlier than others. If these transmission mechanisms are stable—perhaps functions of capital intensities, industry structure, prevalence of long-term con-

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tracts, or other specific characteristics of the industry—then we expect a particular time path of adjustment in agriculture (and each other sector) in response to such shocks. Thus, farm prices will rise faster than nonfarm prices if the transmission mechanism works in certain ways, e.g., if prices in competitive auction markets adjust more quickly than prices in imperfectly competitive markets.

The roles of long-term contracts and differential changes in anticipations can be incorporated in a general discussion of price elasticity of supply and income elasticity of demand as determinants of macroeconomic influence on a particular sector. The ideas go back at least to Cairnes, who associated price transmission with sector-specific demand impacts and short- and long-run supply elasticities (see Bordo). The predictions of this approach are not as straightforward as they may appear at first glance. For example, one might expect farm prices to increase rapidly in response to an unanticipated increase in aggregate demand because intended crop output is costly to change during the period when crops are growing. On the other hand, shocks can be buffered by changes in stocks or international trade. Moreover, many nonagricultural goods are subject to relatively fixed capacity constraints in the short run, and long-term contracts with prespecified nominal prices appear more prevalent in nonagricultural industries. In short, while we expect sector-specific price effects of some kind, it is a matter of empirical investigation to discover what these effects are.

The null hypothesis in this situation does not incorporate a “wrong” sign for any variable (hence two-tailed statistical tests are appropriate). Alternative null hypotheses are that all sectors respond to macroeconomic shocks at about the same rate; or that the differential responses are random, so that a sector that gains in one inflationary episode is just as likely to lose in the next. Unfortunately, independent inflationary episodes are scarce. While the years 1960–76, for example, contain sixty-eight quarters, they may contain only four or five underlying inflationary shocks, and hence give only a few degrees of freedom in studying sectoral redistribution. This is probably why Tweeten and Griffen can obtain “statistically significant” results that the parity ratio falls under inflation, while Schluter and Lee find the opposite results for a more recent (but shorter) time period.

While the fewness of inflationary episodes

suggests the use of a lengthy time series of data, this increases the likelihood that structural change has occurred during the period being considered. So we are presented with the following dilemma in empirical work: a short time series is unlikely to provide generalizable results about macroeconomic effects because there will be too few significant macroeconomic events; but in a long period the structure of agriculture may have changed so much that there are no generalizable results.

Some macroeconomic hypotheses involve factor-market linkages, e.g., there is “an increasingly close link between the rural sector and the general economy by means of factor markets” (Gardner, p. 22). One of the few sectoral models to emphasize these linkages is Lamm. The ideas derive from Walrasian general equilibrium rather than Keynesian models, involving sectoral linkages more closely related to standard supply and demand models. In particular, we expect labor returns in the farm sector to be strongly influenced by nonfarm labor returns, and the rate of return to investment in agriculture to be closely linked to rates of return in the general economy.

Data on Agriculture in Recessions and Inflation

Table 1 shows in calendar-year aggregates what happened in U.S. agriculture during recessionary and inflationary periods. A year is defined as recessionary if real GNP fell from the preceding year (except 1947 and 1949). To define an inflationary period, I considered two criteria. The first is the set of years when the year-over-year CPI increased 4% or more. The second is the set of years in which the actual rate of inflation exceeded the anticipated rate of inflation, i.e., when unanticipated inflation occurred. This criterion derives from the “rational expectations” view that people adapt to anticipations such that only unanticipated changes in the inflation rate have real effects. For example, because of experience in the early 1970s, an inflation rate of perhaps 6% was generally anticipated for 1977, so that interest rates, rental rates on capital, and so forth reflected this expectation; and had the inflation rate turned out to be 6%, all prices would have adjusted without dislocations of real economic activity. What makes

Table 1. Economic Indicators of the Farm Sector in Recession and Inflation

Year	Real Farm Prices ^a	Real Net Farm Income	Real GNP	Real Farm Land Price	Real Farm Wage Rate	Real Nonfarm Wage Rate
----- (% annual change) -----						
Regressions ^b						
1974-75	+14.4	-29.1	-1.8	+7.6	+1.1	-1.3
1970	-4.0	-7.0	-1.4	-2.3	+1.5	-0.9
1958	+3.6	+11.7	-1.4	+3.6	+2.9	+1.9
1954	-3.6	-5.2	-0.5	-4.3	-2.2	+1.8
1949	-14.2	-36.9	+0.6	+3.2	-1.0	+4.6
1938	-24.0	-35.1	-3.9	+1.9	+1.9	+1.9
1930-32	-21.3	-35.0	-12.3	-2.0	-13.8	-0.6
1927	-1.7	-2.2	-1.8	-1.1	+1.9	+1.9
1924	-0.2	-4.6	-0.2	-3.0	+4.6	+3.5
1921	-30.3	-46.1	-9.3	+2.3	-1.1	+3.4
1914	-1.3	+9.4	-3.9	-1.3	-1.3	-1.3
Average	-11.3	-24.2	-4.9	+0.6	-5.2	+0.8
Inflation years ^b	+2.8	+0.9	+3.5	+1.3	+3.4	+2.2
Unanticipated inflation ^b	+3.1	+4.0	+3.4	+1.1	+2.4	+2.4
All years, 1910-79	-1.1	-2.6	+2.9	+0.8	+1.3	+2.1

^a "Real" means deflated by the consumer price index. Sources of data: U.S. Department of Agriculture, U.S. Department of Commerce, and U.S. Council of Economic Advisers.

^b For definition of "recession," "inflation years," and "unanticipated inflation," see text.

1977 an inflationary year is that the inflation rate accelerated to 9%.

To estimate anticipated inflation, I fit an ARIMA model to natural logs of the CPI. The anticipated rate of inflation is the forecasted value for each year from the differenced CPI time series. The ARIMA (1,1,1) model over the 1910-79 period is

$$I_t = 0.314 I_{t-1} - 0.554 e_{t-1} + e_t, \\ (0.158) \quad (0.138)$$

where I_t (= change in log CPI) is the rate of inflation in year t , and e_t is the forecast error. The numbers in parentheses are standard errors of the coefficients. The forecast for I_t is made as soon as I_{t-1} and e_{t-1} are observed. This specification fits better than a simple first-order autoregressive or moving-average process (i.e., adaptive expectations), or a random walk as used in Parks (p. 90). But higher-order AR or MA lags do not significantly reduce forecast errors, and the autocorrelations of the residuals from the fitted model are not significant.

Given the ARIMA forecast as the anticipated rate of inflation, years of unanticipated inflation are defined as those in which the actual rate exceeds the predicted rate by one standard error (3%) and in which the rate of inflation was positive (to exclude decelerations of deflation in 1922 and 1934). These years are 1916-20, 1941-42, 1946-47, 1951,

1971, 1973-74, 1977-79. The years in which the CPI rose more than 4.0% are the same except that 1943, 1948, 1969-70, and 1975-76 are added. Note that 1970, 1974, and 1975 are years of simultaneous recession and inflation under one or both criteria of inflation. And of course there are many years, forty-six out of seventy in the 1910-79 period (although only one in the 1970s), in which neither inflation nor recession is observed.

The performance of agriculture during recessions is variable, as the table 1 data indicate, but on average the farm sector fares poorly during these episodes. Farm income tends to fall substantially more sharply than overall GNP, as do farm prices relative to the general price level and farm wage rates relative to nonfarm wage rates. Thus, it appears that agriculture has an even greater stake than other sectors in avoiding recessions, although the differential effects are less pronounced since 1950. (The substantial farm income decline in 1974 is misleading, being measured relative to the extraordinary year of 1973. 1974-75 was still well above 1970-72 in real farm income.)

The effects of inflation are roughly similar under both criteria for inflation. For the nonfarm variables and for farm wage rates and land prices, the inflationary periods do not differ appreciably from the seventy-year mean rates of growth. However, real farm product

prices and real farm income grow faster in the inflationary years, particularly in years of unanticipated inflation.

Econometrics of Macroeconomic Linkages

Two serious deficiencies of the table 1 data are that they provide no indication of the statistical significance of the observed differences, and they leave out everything else that happened during recessions and inflation besides these macroeconomic events. In an attempt to remedy these deficiencies, this section develops regression models for these data. Table 2 shows results for real farm prices. Regression 1 indicates effects of about the same magnitude as the averages reported in table 1, but the effect of inflation is not statistically significant. This is the same result found by Grennes and Lapp.

Regressions 2-7 include other variables that may be influencing farm prices. The variables

added in regressions 2 and 3 pertain to long-term forces underlying U.S. farm prices, while regressions 4 and 5 add variables on output changes and exports, which may be more important in determining short-term price fluctuations. Output changes clearly influence price changes but also are clearly endogenous variables. However, it seems likely that output changes are caused primarily by weather, or similarly exogenous forces, rather than being production responses to contemporaneous price changes. Lagged output is included along with current output because the calendar-year basis of the price index results in two crop years being relevant to the observed price change.

Exports also involve obvious problems of mutual determination with prices, but analysis of the time series did not detect causality going from prices to exports. For recent years, it is possible to include an additional export-related variable, the exchange rate of the dol-

Table 2. Regression Coefficients Explaining Percentage Changes in Farm Prices Received, 1910-78

Independent Variables ^a	Regressions						
	(1)	(2)	(3)	(4)	(5) ^b	(6) ^b	(7)
Recession (dummy)	-.12 (4.2) ^c	-.11 (3.5)	-.11 (3.4)	-.10 (3.6)	-.004 (0.1)	GNP 1.28 (2.3)	1.28 (8.0)
Inflation 4+ % (dummy)	.04 (1.6)	.03 (1.0)		.03 (1.1)	.002 (0.1)	CPI 1.47 (1.5)	.47 (1.6)
Unanticipated inflation			.03 (0.9)				
Productivity		-3.5 (0.9)	-3.8 (1.0)	-3.2 (1.0)	.71 (0.2)	8.5 (1.5)	-.50 (0.2)
Nonfarm wage		.49 (1.4)	.47 (1.3)	.45 (1.3)	-1.1 (0.6)	-2.6 (1.8)	-.52 (1.8)
Government programs (dummy)		.06 (1.1)	.07 (1.4)	.06 (1.3)			-.01 (0.2)
Exchange rate					-.39 (1.6)	-.42 (2.1)	
Exports				0.5 (1.1)			.03 (0.9)
Output				-.12 (0.5)	.20 (0.4)	.66 (1.6)	-.44 (2.5)
Lagged output				-.70 (3.3)	.32 (0.6)	.57 (1.3)	-.74 (4.8)
R ²	.23	.31	.31	.43	.22	.44	.70
Durbin-Watson	2.18	1.61	1.60	1.46	2.06	2.20	1.57

^a All continuous variables are percentage changes, so coefficients are elasticities. Definitions and sources of variables: recession and inflation dummies defined in text; productivity is USDA's index of total factor productivity, smoothed using a fitted fifth-degree polynomial (no trend in 1910s, gradually rising in 1920s and 1930s, accelerating in 1950s and 1960s, decelerating in 1960s and 1970s); nonfarm wage is Department of Commerce hourly wage rate in U.S. manufacturing; government program dummy is 0 through 1932 and 1 thereafter; exchange rate is the Federal Reserve Board's trade-weighted dollar; exports are U.S. Department of Commerce estimates of the value of agricultural products exported; output is USDA agricultural output index, 1967 = 100. All dollar variables except the exchange rate are deflated by the CPI.

^b Regressions containing the exchange rate cover 1956-78 only.

^c "t"-statistics.

lar for foreign currencies. An interesting literature has grown up around Schuh's hypothesis that an overvalued dollar was a prime cause of agriculture's problems in the pre-1972 period. Of the variables that have been suggested for use in testing this hypothesis, the most attractive is a trade-weighted dollar, an index of exchange rates of major currencies weighted by the share of trade accounted for by each country. Such a variable is included in regression 5. Since it is only available after 1956, this regression covers a much shorter time period than regressions 1-4.

The results are quite different for the shorter time period. Output, productivity, and non-farm wages all become insignificant.¹ The most significant variable is the exchange rate, whose coefficient indicates that a 1% fall in the value of the dollar generates a 0.4% increase in

real farm prices. Most important for the present discussion, there is no longer any significant effect of being in either a recession or an inflationary period. This bears out what the table 1 data indicate for recessions—that they no longer are as important to the farm sector as they once were. This is consistent with the findings of Lamm. Regressions 6 and 7 include real GNP and the CPI as continuous variables instead of dummies for particular episodes. The results are basically similar, but the *t*-ratios and *R*² generally improve.

Table 3 contains regressions explaining real farm income, wage rates, land prices, and prices paid by farmers. The recession coefficients tell the same story as the raw data of table 1—the significant effects are to reduce the real farm wage rate by about 5% and real farm income 23%–24%. The effects of inflation are insignificant on all the real variables (also true for years of unanticipated inflation, although to save space these regression results are not shown). This conflicts with Tweeten, who found inflation to increase real prices paid by farmers.

Regressions 9 and 13 show results for the

Table 3. Regression Coefficients Explaining Annual Percentage Changes in Farm-Sector Variables

Independent Variables ^a	Dependent Variables ^b					
	Real Net Farm Income		Real Prices Paid by Farmers	Real Farm Wage Rate	Real Farmland Price	
	(8)	(9)	(10)	(11)	(12)	(13)
Recession	-.23 (4.0) ^c	-.14 (1.2)	-.03 (1.8)	-.05 (2.2)	.01 (0.9)	.003 (0.1)
Inflation (4%)	-.002 (.04)	.06 (0.7)	.004 (0.3)	.01 (0.5)	-.01 (0.4)	-.04 (1.5)
Productivity	-2.6 (0.4)	26.6 (2.3)	-1.87 (0.9)	-1.14 (0.5)	-2.49 (1.4)	-7.8 (2.5)
Nonfarm wage	.71 (1.0)	-2.8 (0.5)	.29 (1.3)	.70 (2.7)	-.14 (0.9)	-.12 (0.1)
Gov't. programs	.05 (0.5)		.04 (1.3)	.05 (1.6)	.08 (3.6)	
Exchange rate		-4.3 (6.0)				.34 (1.8)
Exports	.08 (0.8)		.07 (2.4)	.07 (2.0)	.04 (1.6)	
Output	1.02 (2.2)	1.09 (0.8)	.02 (0.2)	.39 (2.3)		
Lagged output	-1.35 (3.2)	.63 (0.4)	-.35 (2.6)	-.00 (0.0)		
<i>R</i> ²	.50	.76	.32	.41	.34	.31
D-W	1.67	2.36	1.32	1.88	1.75	1.89

^a Same as in table 2.

^b Net farm income is the USDA's estimated total net income from farming. Prices paid is the USDA index for production items. The farm wage rate is the USDA index, as is the farm real estate price. All are deflated by the CPI.

^c "*t*"-statistics.

1956–78 period. The recession effects are weaker in this period. Note that the exchange-rate variable is highly significant, as it was in the output-price regression. However, in the land-price regression, the exchange rate has a positive sign, which means that depreciation of the dollar is associated with lower land prices, an unexpected result. Note also that the land price is the only dependent variable in the table 3 regressions for which the government-program dummy has a significantly positive effect. The hypotheses that inflation increases the real prices of fixed assets and the rate of growth of farm size (Penn; Schertz and Harrington) lack evidential support. While the raw data of table 1 show real estate prices rising 1% to 2% faster in inflationary years, regressions 12 and 13 show no effects of inflation on real land prices.

Alternative econometric specifications to those of this paper include the following: one could model less aggregated commodities, as in Chen; one could imbed the farm sector in a fuller model of the rest of the economy, as in Cromarty, Fox, Shei and Thompson, or Lamm; or the specification of the foreign market influences on the U.S. farm sector could be more complete, as in Grennes and Lapp. A detailed model of the agricultural sector, fully integrated with a model of the general economy, would permit study of macroeconomic effects on agriculture simultaneously with the effects of agriculture on the rest of the economy. An assumption of my regressions is that a fully specified model is not necessary to identify macroeconomic effects upon agriculture. Because agriculture is a small part of the general economy, the dominance of causality from the general economy to agriculture seems plausible, but fuller models are necessary to test the assumption.

A few small-scale simultaneous models have been developed, notably Lamm, Shei and Thompson, and Chambers and Just. I have found the results in these papers suggestive but inconclusive in establishing the nature of sectoral linkages. Chambers and Just find that "a sustained 10 percent reduction in domestic credit would eventually evoke more than a 17 percent change in the level of wheat price, a 7 percent change in corn price and an 11 percent change in soybean price" (p. 17). This is a quite implausible result, and it is not clear that the differences are statistically significant. Shei and Thompson conclude that Soviet grain purchases had a substantial effect

on the general price level in 1973, while over a longer time period Lamm concludes that "changes in the rest of the economy have large effects on agriculture, while the converse is not ordinarily the case" (p. 32). Overall, the evidence adduced in these papers is far from settling the issues.

Firch (1977) considers subperiods of data that are suggestive of structural change over time in macroeconomic influences on agriculture. He finds, for example, that inflation was a more prominent agent of instability in 1920–39 than in 1946–75. The weakness of his approach is the lack of tests of significance for time-varying effects.

Evidence on instability is obtainable by a modification of regression 7 above in which the log changes of price, the inflation rate, and other variables are squared. This transformation generates a component of the log variance of price and other variables, so that a zero coefficient on an independent variable means that it contributes negligibly to variation in the dependent variable. A significantly positive coefficient on variability confirms the hypothesis of Parks that instability in the general price level generates instability in real sectoral variables. For the 1910–78 period, regression 7 as transformed yields a statistically significant effect of price-level variability increasing the variability of real farm prices. The shorter period 1956–78 as respecified shows a smaller instability effect, but a null hypothesis of no structural change in the regression coefficient over time cannot be rejected. The overall result is to confirm for agriculture the Parks and Vining-Elwertowski results that macroeconomic instability has real sectoral effects. But it remains the case that there is no predictable direction in which real farm prices are affected by general inflation.

Implications for the 1980s

In 1969, Egbert derived the following policy implication from his sectoral model: "Some form of production controls will continue to be needed in agriculture to maintain prices and incomes, at least for the next decade" (p. 31). The most convincing explanations of what happened to make this and similar forecasts look ridiculous in the 1970s are macroeconomic linkages. Are we now equipped to speak with any better authority about the 1980s? It would be rash to suppose so. But

there may be better prospects for preinterpretation of the 1980s, that is, projection of the kinds of influences that it will be most important to watch for, and forecasts conditional on salient contingent events.

In the research to date I see three main channels of influence from the rest of the economy to agriculture. They are (a) "Walrasian" influences—the forces associated with the attainment of neoclassical general equilibrium between sectors, most notably equalization of rates of return in factor markets; (b) "Marshallian" influences—the effects of standard shifters of supply and demand curves, such as consumers' incomes or population; and (c) "Keynesian" influences—a catchall for the nonstandard hypotheses such as those of Schultz, Firsch, and Schuh.

The Walrasian view of agriculture's connection with the rest of the economy has not been as prominent in the recent literature as the Keynesian hypotheses. Nonetheless, this approach holds promise for preinterpretation of the 1980s. Schuh (1962) and many successor studies on farm labor indicate that the most important determinant of farm wage rates is nonfarm wage rates. More recent work, notably Melichar, Hughes, and Feldstein, is establishing the groundwork for similar conclusions in the capital markets. From this point of view, the most important determinants of the trend of farm factor returns in the 1980s will be factor returns in the general economy.

The Marshallian linkages dominate the early sectoral models of Cromarty, Fox, and Egbert, although they were developed in conjunction with Keynesian macromodels. The inflation rate, for example, does not enter into the determination of relative farm commodity prices, nor does the exchange rate or other nonstandard influences. This continues to be the case for large farm-sector models such as Chen's. Thus, preinterpretation of the 1980s using such models will not involve the issues which have been emphasized in this paper, except insofar as real GNP influences demand functions.

The main "Keynesian" variables that appear to possess explanatory power in the historical data are recessions and the exchange rate. But recessions are not important after 1950 (and GNP is not that nonstandard anyway). Moreover, on further consideration it is dubious whether one can expect future fluctuations in the foreign value of the dollar to play a major role in the real well-being of the farm

sector in the 1980s. The reason is that the effect, for example, of the exchange rate in regressions 5, 6, and 9, above, results from the switch from a fixed to a flexible exchange-rate system, which took place in two steps in 1971 and 1973. (This is revealed by the fact that an exchange-regime dummy that captures only the fixed versus floating contrast picks up virtually the whole exchange-rate effect, while the exchange rate itself, in the presence of the structural-shift dummy, becomes insignificant.) So one cannot use the exchange-rate coefficient to forecast effects of future exchange rate fluctuations under the floating-rate regime. There may well be real exchange-rate effects, but these will turn on deviations from purchasing-power parity in exchange rates, a topic on which future research should be given high priority, but on which there is not yet enough knowledge to base forecasts.

The "Keynesian" preinterpretations of the 1980s that I have to offer are thus negative: even if I knew the future course of U.S. business cycles, inflation, and foreign value of the dollar, I could not predict any particular consequences for agriculture (compared to other sectors). Of course, to predict nominal prices, we need to forecast the general price level, and for this we need a macromodel. But there is no evidence that the best macromodel for the purpose has anything agricultural in it. Thus, there is no reason to believe that agricultural economists can forecast better by expressing their models in nominal values (as most of the papers cited in the list of references do) and then incorporating determinants of the overall price level such as the money supply on the right-hand side. With further research this situation may change, but for forecasting the 1980s at our present state of knowledge, I believe it preferable to use the macroeconomists' models for the economy-wide variables and sectoral models with deflated prices for agricultural variables. In short, the classical dichotomy between real and nominal values prevails in practical forecasting of annual data.

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