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PRIVATE STRATEGIES, PUBLIC POLICIES & FOOD SYSTEM PERFORMANCE

LABOR MARKET DYNAMICS
IN THE U.S. FOOD SECTOR

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WP-3 September 1987

WORKING PAPER SERIES

A Joint USDA Land Grant University Research Project

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Research supported by the College of Agriculture and Life Sciences, Cornell University. A revised version of this paper is forthcoming in the American Journal of Agricultural Economics, 1988.

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Research assistance by Dirk Dijkerman and helpful comments on an earlier draft by William Tomek are gratefully acknowledged.

Labor Market Dynamics in the U.S. Food Sector

The 1970's brought significant changes to the U.S. food and agricultural system. In agricultural production, rapid increases in energy, commodity, and farmland prices and a sizable expansion of export demand proved particularly important. The food industry experienced several of these same changes along with inflation-induced increases in wages, a decline in labor productivity, and considerable structural change. Many of these developments were subsequently moderated (or reversed) in the early 1980's. While production sector adjustments to these trends have been the focus of considerable agricultural economics research, much less attention has been generally devoted to the impacts of these developments in food manufacturing and distribution. Polopulus, for example, has severely criticized researchers' lack of attention to a series of inflation, productivity and labor market-related issues influencing the food processing and marketing system, in part due to the size of that system, measured by employment or value-added, relative to production agriculture. Especially important in food system economics is the role of labor costs which comprise about 35 percent of consumer food expenditures - the single largest food cost component - and which are closely related to factors affecting food prices.

This article addresses several issues related to the role of labor markets in the U.S. food industry. The analysis begins by developing an aggregative markup-pricing model of food price determination based on the findings of recent research (Heien; Lamm and Westcott). A simultaneous equation approach to food industry labor market behavior is developed which incorporates the markup-pricing model and permits the simultaneous explanation of behavior in wages, employment, labor productivity, and other variables at both manufacturing and retail levels of the food system. Model results for the 1960-82 period confirm the high interdependence of food industry labor market variables over this period. Through dynamic simulation, the impacts of exogenous shocks in energy and agricultural commodity prices are then examined and insights developed regarding the dynamic interrelationships among labor market variables, macroeconomic variables and price behavior in the U.S. food sector.

Markup Pricing Models and Food Price Behavior

Much recent food sector research has focussed on food price behavior and price transmission processes. Gardner developed a static equilibrium model of price and marketing margin behavior to derive the effects of marketing input and farm product supply shifts on the farm-retail price spread. Heien added a wholesale sector to Gardner's framework and developed a dynamic model of food price determination based on the markup pricing rule that "changes in retail food prices are caused by changes in prices at lower levels in the marketing chain" (p. 16). Empirical testing of the causal directionality of wholesale-retail price linkages and the estimation of retail price equations for a number of commodities largely confirmed the markup pricing hypothesis. Much of the remaining research in this area has provided additional empirical support for the conclusions that changes in input costs (for raw and manufactured foods, labor, energy, etc.) generally explain a relatively high proportion of the variation in retail food prices, and that price transmission lags from the farm and wholesale levels to the retail level are fairly short (Popkin; Council on Wage and Price Stability; Hall, et al.; Lamm and Westcott).

Despite the general confirmation of the markup pricing approach, the nature and extent of the causal linkages between input costs and retail food prices remain unresolved. Heien, and Lamm and Westcott demonstrated one-way causality from wholesale to retail food prices and farm to retail prices, respectively, for most of the food groups tested. Lamm and Westcott further asserted (but did not test) that "the causal path between resource prices and output prices is assumed to be unidirectional - resource prices determine output prices" (p. 188). While possible in the short run, some resource costs may, in the longer run, be endogenously determined by other food sector and general macroeconomic variables.

Consider, for example, Heien's empirical model for various product subsectors:

$$R_t = \beta_0 + \beta_1 W_t + ... + \beta_k W_{t-k} + \beta_l ULC_t + \beta_m UR_t$$

where retail food prices (R_t) are determined by wholesale food prices (W_t), unit labor costs in food retailing (ULC_t) and the unemployment rate (UR_t). Wholesale prices, here treated as exogenous, have been estimated by Popkin in a stage-of-processing model to be endogenously determined by wholesale prices for raw food products and intermediate food manufacturing materials, wage rates in nondurable manufacturing, and the (inverse of the) unemployment rate. The exogenous treatment of unit labor costs (or nominal wage levels) can also be questioned. Results from macroeconomic and labor economics research have commonly shown wage variation to be a function of such variables as lagged changes in the consumer price index (in which food price changes play a prominent part), the unemployment rate, and changes in the minimum wage (see Nichols or Rice, for example). In the food industry specifically, Lee has demonstrated not only causality running from labor costs to food prices but also the existence of feedback effects between unit labor costs and retail food prices, likely as a result of cost-of-living adjustments (COLA's) in wage contracts in turn induced, at least in part, by food price increases.

The major implication of these findings is that opening up markup pricing models to allow for the simultaneous determination of retail and wholesale prices and wages, among other variables, may further explain the dynamics of food price determination, particularly as labor markets are involved. This approach retains markup pricing rules for retail and wholesale food prices while endogenizing some important resource costs previously treated as exogenous and permitting the explanation of other important labor market variables (employment, productivity, etc.).

Food Retail Labor Markets

This model of food industry labor markets contains both manufacturing and retail food sectors. At the retail level, a quarterly markup pricing equation for food is expressed as:

$$\text{(1)}\quad \dot{CPIF}_t = \dot{CPIF}_t(\dot{PPIF}_{t-i}, \dot{WAGER}_{t-i}, \dot{PPIE}_{t-i}, Q_s) \qquad (i=0,...,n) \quad (t=1,...,T)$$

where CPIF is the CPI for food at the retail level, PPIF and PPIE are the Producer Price Index values for food and energy and fuel, respectively, at the wholesale level, WAGER is the average hourly wage in food retailing, and the Q_s denote quarterly seasonal dummies. These input costs are believed to significantly affect food price behavior (Popkin; Lamm and Westcott). Because markup pricing models generally posit that <u>changes</u> in input costs lead to <u>changes</u> in food prices, all variables are represented in quarterly percentage change form.

The impact of energy prices (PPIE) on food prices likely is exogenous given the historically dominant role of OPEC pricing policy. However, retail wage levels (WAGER) and producer food prices (PPIF) are endogenous in a more fully specified markup pricing model. Accordingly, assume that nominal wages in food retailing as specified as follows,

$$\text{(2)}\quad \dot{WAGER}_t = \dot{WAGER}_t(\dot{CPIA}_{t-i}, \dot{UMP}_{t-i}, Q_s) \qquad (i=1,...,n) \quad (t=1,...,T)$$

where CPIA is the value of the CPI for all items and UMP is the civilian unemployment rate. This specification closely resembles wage behavior equations for other economic sectors and the macroeconomy (Black and Kelejian; Eckstein and Girola; Nichols; Rice; etc.). The inclusion of CPIA in equation (2) is based on the expectation that wage changes follow changes in the CPI as workers attempt to "catch up" for past inflation, either explicitly through COLA adjustments or implicitly through wage demands.[1] The inclusion of the unemployment rate (UMP) in the wage equation with an expected negative sign is based on the assumption of a Phillips curve effect relating wage changes to rigidity in the overall labor market.[2] UMP is assumed to be exogenous with respect to the food sector.[3]

Turning to employment in food retailing, labor demand (LABRD) can be explained by:

(3) $LABRD_t = LABRD_t\ (RETSALES_{t-i}, Q_s)$ (i=1,...,n) (t=1,...,T)

where retail food sales ($RETSALES_t$) are given by:

(4) $RETSALES_t = (PRODR_t)(CPIF)$

The simple linear relationship between labor demand and total sales in food retailing is based on previous research which has demonstrated the existence of extremely limited labor substitutability (fixed proportions technology) in food retailing (Nooteboom). This finding is based on Dutch data and confirmed by data from U.S., U.K., and Canadian retail operations. It is based on results from queuing theory and the existence of unavoidable threshold labor costs in retailing. A positive expected relationship between LABRD and RETSALES in equation (3) is consistent with the observed phenomenon of steadily increasing employment in food retailing, despite declining labor productivity and increasing real wages.

A sectoral labor supply function for food retailing could also be estimated if the empirical evidence suggested no excess labor supply and wage levels in food retailing below levels in comparable industries. In this case, relative wages in food retailing would have to increase to attract labor from competing industries. The evidence does not support this possibility, however. Though a relatively low wage industry, food retailing is also a relatively low skill industry which absorbs a growing proportion of part-time workers who have limited employment alternatives. Nonetheless, average wages in food retailing ($7.21 per hour in 1982) remain considerably higher than average wages in all retail trade ($5.48 per hour in 1982). Thus, employment in food retailing appears largely determined by retail firms' labor demands (equation

(3)), and labor supply can be considered perfectly elastic at an exogenously determined above-equilibrium wage level. Under these conditions (Deaton and Muellbauer, p. 289) labor supply in food retailing ($LABRS_t$) is simply equal to sectoral labor demand. The real (inflation-adjusted) wage in food retailing is also given simply by:

(5) $RELWGR_t = (WAGER_t)/(CPIA_t)$

Equations (2) and (5) include CPIA as an endogenous variable. It is assumed for simplicity that the overall CPI is a function of food and non-food components,

(6) $\dot{CPIA}_t = \dot{CPIA}_t\ (\dot{CPIF}_t, \dot{CPIMF}_t)$

where CPIMF denotes the quarterly value of the non-food CPI, which is assumed (initially) to be exogenous. Equation (6) permits a feedback linkage from food prices to the general price level; the latter in turn plays a primary role in food sector wage determination via equation (2). Note that equation (6) is not an exact identity because individual CPI series are in index form.

The overall demand for food at the retail level is the product of per capita demand ($PCDEMR_t$) and population (POP_t) at time t:

(7) $DEMR_t = (PCDEMR_t)(POP_t)$

Population is exogenous, while per capita retail food demand is specified as follows:

(8) $PCDEMR_t = PCDEMR_t\ (RLPRFR_t, RLINCD_t, DUM73, Q_s) \quad (t=1,...,T)$

where RLPRFR is the real price of food at retail and RLINCD is real personal disposable income, with expected negatively and positively signed coefficients, respectively. By definition,

(9) $RLPRFR_t = (CPIF_t)/(CPIA_t)$

(10) $RLINCD_t = (INCD_t)/(CPIA_t)$

where INCD is aggregate U.S. personal disposable income. Variable DUM73 (=0 in 1960-72; =1 thereafter) is a quarterly dummy variable which allows for a negative shift in consumer food demand beginning in 1973, the first year in a period of rapidly rising commodity prices and fluctuating per capita food demand.

Finally, the aggregate supply of food (PRODR) equals demand ($DEMR_t$) in food retailing through a simple equality. Two other variables in the food retail sector can also be explained by two more identities. Unit labor costs (ULCR) are defined by the product of average wage levels times labor demand divided by units produced:

$$(11)\quad ULCR_t = \frac{(WAGER_t)(LABRD_t)}{(PRODR_t)}$$

Unit labor cost (considered exogenous) has been used as an alternative measure of labor costs in retail price equations (Heien); here, it is explained endogenously. Similarly, labor productivity in food retailing is defined by:

$$(12)\quad PDYR_t = (PRODR_t)/(LABRD_t)$$

and thus is explainable from the retail sector equations specified above.

The close linkages of these labor market variables means that their behavior can be expressed by relatively few behavioral equations. In retail sector equations (1)-(12), the only endogenous variable which is thus far not explained is the producer price of food (PPIF) which is determined in the food manufacturing sector model.

<u>Food Manufacturing Labor Markets</u>

An analogous set of equations can be specified to explain price and labor market behavior at the manufacturing or producer level of the food industry. A markup equation for producer food prices is specified as follows:

$$(13)\quad \dot{PPIF}_t = \dot{PPIF}_t\,(\dot{PRF}_{t-i}, \dot{WAGEM}_{t-i}, Q_s) \qquad (i=0,\ldots,n) \quad (t=1,\ldots,T)$$

where PRF denotes the index of prices received by farmers and WAGEM denotes the hourly wage rate in food manufacturing. Expenditures for these two cost categories generally account for 80% or more of firm expenditures at the manufacturing level (Lutton).

Farm prices can be considered exogenous in equation (13), following the results of Lamm and Westcott who concluded that "causality is unidirectional from farm to retail prices for all foods considered in the study" (p. 190). Although equation (13) explains producer rather than retail price behavior, Lamm and Westcott's results are applied to farm to producer price causality as well, consistent with Heien's demonstration of wholesale to retail price causality for most food groups in the short run.

Unlike farm input prices, however, wages at the manufacturing level may be endogenous, leading to the following wage equation:

$$(14) \quad \dot{WAGEM}_t = \dot{WAGEM}_t\,(\dot{CPIA}_{t-i}, \dot{UMP}_{t-i}, \dot{LABMD}_{t-i}, Q_s) \quad (i=0,..., n) \quad (t=1,..., T)$$

where LABMD denotes labor input in food manufacturing. Variables CPIA and UMP are included based on the same reasoning outlined above for the retail wage equation, while food manufacturing employment (LABMD) has a negative expected sign.

A conventional labor demand equation for food manufacturing is given by:

$$(15) \quad LABMD_t = LABMD_t\,(RELWGM_{t-i}, UMP_{t-i}, Q_s) \quad (i=0,...,n) \quad (t=1,...,T)$$

where labor demand is inversely related to both changes in the real wage,

$$(16) \quad RELWGM_t = (WAGEM_t)/CPIA_t$$

and the flexibility of the overall labor market, as measured by the unemployment rate (UMP). Again, due to relatively high wage levels in food manufacturing - an average hourly wage of $7.89 compared to $7.68 in the private non-farm business sector in 1982 - a perfectly elastic labor supply (LABRS) is assumed at a demand - determined wage level, and is given by the equality of LABRD and LABRS.

Finally, the total demand for food at the producer level (DEMM) is the product of per capita demand (PCDEMM) times population:

(17) $DEMM_t = (PCDEMM_t)(POP_t)$

where per capita demand is a function of real own price and income variables, and a demand shifter, DUM73:

(18) $PCDEMM_t = PCDEMM_t\ (RLPRFR_t, RLINCD_t, DUM73, Q_s) \quad (t=1,...,T)$

Product market equilibrium again requires that supply (PRODM) equals demand (DEMM) at the manufacturing level, and unit labor cost (ULCM) and labor productivity (PDYM) variables in food manufacturing are represented by:

(19) $ULCM_t = \dfrac{(WAGEM_t)(LABMD_t)}{(PRODM_t)}$

(20) $PDYM_t = (PRODM_t)/(LABMD_t)$

Together, equations (1)-(20) plus identities describe a simultaneous system of 24 equations and 24 endogenous price and labor market variables.[4] Because of the close interrelationships and the number of identities contained in the system, relatively few behavioral equations are needed to solve the model and thus explain macro food system behavior.

Data and Estimation

The simultaneous equation system was estimated using quarterly data for the period 1960-1982. A quarterly (versus an annual) model is estimated here because of the central role of the price transmission equations in the model and the focus on time paths of changes in system variables in response to exogenous shocks. All price, output, and labor market data were obtained from public sources: employment and wage data from BLS Employment and Earnings; output data from the Federal Reserve Board's Industrial Production and Department of Agriculture data; price data from the

Department of Labor's Consumer Price Index and Producer Price Index series; and remaining data from USDA Agricultural Statistics and other Commerce Department and BLS sources. Variable definitions are summarized in table 1.

Because the equation system is nonlinear in variables and contemporaneously correlated error terms across equations were expected a priori, a nonlinear (SAS) three stage least squares (N3SLS) estimation procedure using a modified Gauss-Newton iterative solution method was used in estimating regression coefficients. The presence of nonlinearities in the system of equations made solving for the reduced form highly impractical (Labys). As a result, only the structural equation coefficient estimates are presented below. Following estimation, the equation system was simulated using dynamic nonlinear simulation procedures to validate the model over the sample period and to examine the effects on key endogenous variables of various exogenous shocks. Three such scenarios are reported here. Because of the limited usefulness of traditional linear stability tests for nonlinear models, the procedure suggested by Pindyck and Rubinfeld (p. 345-6) for testing the stability of nonlinear models was followed. This involved dynamic simulation of the model under a variety of assumptions regarding the time paths of the exogenous variables and the length of the sample period. The model converged and proved stable under all conditions tested.

Empirical Results and Model Validation

The results of estimation of the structural equations are presented in table 1. Durbin-Watson (DW) statistics and, where relevant, estimated non-zero autocorrelation coefficients ($\hat{p}$) resulting from the initial round of equation estimation are presented for each equation. Except for equations (13) and (14), all equations were corrected for findings of autocorrelation prior to N3SLS system estimation.[5] Estimated root-mean-squared errors (RMSE) are also presented.

In all cases, the estimated coefficients have the expected signs and generally have acceptable levels of statistical significance. In the retail sector equations, several results deserve specific mention. Retail food prices (equation (1)) are determined by producer food price and fuel and energy price changes at lag lengths of two quarters and one quarter, respectively, confirming previous results indicating relatively short transmission lags in retail food pricing. Wage changes in food retailing are influenced by CPI changes as far back as three quarters. The positive and highly significant linear relationship between retail labor demand and retail sales found by Nooteboom closely characterizes U.S. food retailing as well in equation (3). Per capita retail food demand, as expected, is negatively related to real food price changes, positively related to real income, and exhibits a negative shift beginning in 1973.

In the food manufacturing sector, the price transmission process for producer food prices is somewhat shorter than in food retailing, confirming Popkin's results. Only changes in current quarter farm output prices and current and one-quarter lagged wage levels are significant determinants of producer price changes. The manufacturing wage equation is, however, similar to that in food retailing, with CPI changes lagged up to three quarters causing changes in wage levels. The expected negative relationship between wage changes and manufacturing employment in fact occurs in food manufacturing. The manufacturing labor demand and product demand equations also yield the expected signs and relationships.

The model was validated over the 1960-82 period using both static and dynamic simulation. Static simulation results yielded estimated root-mean squared percentage errors (RMSPE's) uniformly less than 2.0% for all endogenous variables. Dynamic simulation, as expected, yielded somewhat higher RMSPE's, although only two exceeded 5.0%, and the highest (for retail unit labor costs) was only 6.0%. The model clearly has satisfactory explanatory ability over the sample period.

Simulations and Dynamic Multipliers

Over the 1960-1982 sample period, and particularly during the 1970's, two important exogenous shocks were the sharp increases experienced in agricultural commodity prices and fuel and energy prices. For example, the USDA quarterly index of prices received by U.S. farmers increased by more than 5% on 14 occasions over the 1960-1982 period; five of these times, the quarterly increases exceeded 10%. Over the same period, the quarterly PPI measuring fuel and energy prices increased over 5% on 12 occasions, eight of which exceeded 10%.

Based on these past events, the results of three dynamic simulations are reported here: (1) a one-time 10% rise in quarterly farm prices (PRF); (2) a one-time 10 percent increase in quarterly energy prices (PPIE); and (3) sustained 10% rises in both farm and energy prices over one year (four quarters). Impact, interim and total multipliers resulting from these shocks are reported in tables 2-4. The multipliers are calculated at the mid-point of the sample period, 1971.

Farm Commodity Price Increase

The multipliers associated with a one-time 10% increase in farm commodity prices are shown in table 2. The 10% increase in farm prices leads to 4.4% and 2.9% total increases, respectively, in the PPI and CPI levels for food, and a 0.7% total rise in the overall CPI. These impacts are all distributed over four quarters. The values of these total multiplier effects are several times larger than those estimated by Lamm and Westcott, but their multipliers measured responses to changes in cattle, hog, and broiler farm-level prices only, and thus would be expected a priori to be smaller in magnitude.

The 10% increase in farm prices leads to roughly 0.4% cumulative increases in nominal wage levels in both food retailing and manufacturing. These impacts extend over seven and six quarters, respectively. Since farm prices lead to increases in both nominal wage levels and the CPI, the impact on real wage levels is uncertain, a priori. Table 2 indicates that the real wage effect is initially negative as the CPI rises faster than nominal wages, but the latter increases over time while the former diminishes. The real wage effects become positive for the retail and manufacturing sectors after three quarters and one quarter, respectively, although the total effects both remain negative in direction. The employment effects, however, are unidirectional. While the change in farm price has a negligible impact on employment in food manufacturing, the effects on employment in food retailing are modestly positive. These effects are expected given the positive responses of retail food prices, retail sales and retail labor demand to increased farm prices.

The increases in food prices at both producer and retail levels cause decreases in food demand (both per capita and total demand) at both levels of the food system. The total multipliers for retail and wholesale food demand are -.024 and -.154, respectively. These decreased levels of total food demand (and production), increased wages and slightly increasing employment result in definitive increases in unit labor costs in both food retailing and manufacturing. These impacts are estimated at 1.3% over six quarters at the retail level and 1.9% over six quarters in manufacturing. Similarly, the impacts of the farm price increase on labor productivity represent the net impact of the impacts on employment and food production (or demand); labor productivity at both manufacturing and retail levels falls as a result of the sharp food price increase. The observed declines in productivity growth in the food industry during the 1970's may thus reflect the persistent increases in farm commodity prices and their effects on food demand, employment and productivity levels. Finally the increase in farm level prices leads to an expected increase in real food prices, since the CPI for food increases faster than the overall CPI, and to a small decrease in real income levels.

Energy Price Increase

Table 3 reports the multipliers associated with a one-time 10% increase in fuel and energy prices for the food system. The exogenous shock in energy prices (variable PPIE) is also incorporated into the non-food CPI variable (CPIMF) through the following relationship, estimated by OLS over the period 1960-1982:

$$
\begin{array}{llllll}
(21) & \dot{CPIMF} = & .008 & + .033\,\dot{PPIE} & + .044\,\dot{PPIE}(-1) & + .047\,\dot{PPIE}(-2) \\
 & & (.002) & (.009) & (.012) & (.012)
\end{array}
$$

$$
\begin{array}{lll}
+ .037\,\dot{PPIE}(-3) & + .025\,\dot{PPIE}(-4) & + .027\,\dot{PPIE}(-5) \\
(.012) & (.012) & (.012)
\end{array}
$$

Thus, the impact of the energy price increase is evident not only in retail food prices directly (via equation (1)), but also through an increase in the CPI (via variable CPIMF in equations (6) and (21)).

The estimated multipliers in table 3 are relatively high compared to the multipliers estimated for increases in farm prices. Because fuel and energy prices comprise an important part of the overall CPI (8-9%) and because of their essential role in many sectors of the economy, energy prices are an important factor in determining economy-wide price levels. Given the CPI-wage-output price linkage, energy price-induced CPI and wage changes thus have a substantial impact on the prices of food (and other goods) at producer and retail levels through increases in the cost of labor inputs.

The importance of labor costs in food price determination is shown by the multipliers in table 3. A 10% quarterly increase in energy prices leads to more than a 16% rise in the overall CPI; this is a <u>cumulative</u> impact, extending over 11 quarters. This rise in the total CPI is largely responsible for 10.5% and 8.2% total changes in wages at the food retail and manufacturing levels, respectively. These wage changes along with the original direct impacts of the energy price increases lead to cumulative changes of 7.6% and 9.0% in food prices at retail and wholesale levels, respectively. Due to the significant lagged effects of energy price changes, much of the total multiplier effects resulting from those price changes occurs beyond the fifth quarter following the original shock. In the short run, the indirect economic relationships between energy prices, food prices and wages in the model lead to negative impacts on these wage variables; however, these effects are strongly outweighed by the long-term positive impacts of energy price changes on wages and food prices.

Other notable effects are also evident in table 3. Energy cost changes lead to the expected negative effects on real wage levels (since wages rise more slowly than the overall CPI), food demand (since food prices rise), real income and real food prices. Retail employment decreases, but manufacturing employment increases modestly in response to the energy price increase. This result appears to confirm the greater substitutability of labor and energy in food manufacturing compared to food retailing. Overall, labor productivity in both food retailing and manufacturing falls in response to the energy price shock, although this effect is largely a lagged one. Again, this last result is consistent with the arguments made by many economists that a major cause of the productivity slowdown of the 1970's was the unprecedented change in the costs of fuels and energy (e.g., Martial and Meltz).

Overall, the results demonstrate that the food sector is strongly affected by energy price shocks, such as those of the 1970's. Although many of these influences occur indirectly through changes in wage levels and other labor market variables, they were nonetheless important, in some cases more important to the food sector than increases in raw food prices.

Sustained Farm and Energy Price Increases

The two periods of unprecedented high inflation in the early and late 1970s were distinguished by simultaneous increases in farm and energy prices sustained over several quarters. From the fourth quarter of 1972 to the first quarter of 1974, for example, the index of prices received by farmers increased over 53%, with quarterly price increases averaging between 9% and 10%. Fuel and energy prices increased nearly 73% from the first quarter of 1973 to the second quarter of 1974, with quarterly increases averaging over 10%. A similar situation occurred over the 1978-79 period. The occurrence of these periods of sustained inflation suggests that particular insight into the behavior of the food system may be gained under these circumstances.

The results from simulating the effects of 10% increases in both farm and energy prices over four successive quarters are reported in table 4. The estimated multipliers are largely similar in sign to those estimated above, but are much larger in magnitude. In addition, many of the effects of the sustained farm and energy price increases occur over a longer time than the impacts of the one-time price increases, and a higher proportion of the total effects generally occurs beyond the fourth quarter.

As expected, food prices (nominal and real) and the overall CPI rise significantly as a result of the sustained farm and energy price increases. The effects of the price increases are felt well beyond the initial four-quarter period, with impacts extending through 14 quarters. This result again confirms the importance of the wage-food price-inflation linkage in food system behavior, and likely explains, in large part, the continual increase since the 1970's of food marketing costs long after periods of increased raw food prices.

For the labor and other variables in the system, nominal wages and unit labor costs rise substantially in the long run while real income and food demand decline, as expected. Real wage levels in both retailing and manufacturing decline as well, since the increases in nominal wages are less than those of the CPI. Employment changes are modest at both wholesale and retail levels, with decreased real wage levels leading to a slight increase in labor demand in food manufacturing, and increased retail sales (despite lower food demand) leading to an increase in retail employment. These increases in employment combined with decreases in demand (and production) lead to productivity declines at both retail and manufacturing levels. Again, these results suggest the productivity declines of the 1970's in food retailing (and an alleged decline in the rate of growth of labor productivity of food manufacturing) may be partially due to the input price shocks on the food system.

Conclusions and Implications

The results of this study suggest several general conclusions about the effects of recent developments in the food system and appropriate modeling approaches. First, although traditional markup pricing models may be useful in explaining the short-run determination of food prices, these models are rather limited in scope. In particular, the limitations of the exogenous treatment of such inputs as producer food prices and wages are made apparent by this analysis, which gives explicit attention to the linkages between wages, food prices, general inflation and other important food system and macroeconomic variables. Incorporation of these linkages yields a more plausible explanation of economic interrelationships in the food system and a more accurate portrayal of the long run system-wide effects of exogenous shocks such as increases in farm and energy prices.

Second, the food price determination process shown here is more complex than is commonly assumed. Previous models have explained food price changes using only two sectors - retail and wholesale (Heien), or farm and manufacturing/distribution (Lamm and Westcott). This analysis demonstrates a clear path of sequential price changes among three sectors, from farm to producer and retail levels. In addition, the lag structure of the food price determination process appears longer and more complex than is generally thought. Lamm and Westcott, for example, concluded that the food sector was significantly different from nonfood sectors in that "input prices, changes in expectations, and demand shifts all impact almost immediately on retail food prices," while nonfood industries typically exhibit more complex lag patterns (p. 189). The present analysis suggests that, while some of these effects are indeed immediate, the lags may continue two or three years beyond the initial shock when the complete cycle of inflationary effects, wage determination processes and feedbacks into food prices is considered. Thus, the food system may resemble other economic sectors more than is commonly thought.

Third, the use of a model which is not limited to simple markup pricing equations leads to some important new insights into price determination processes and other characteristics of the food industry. Among other things, the results of this study have shown that: (1) wage changes are not only important direct determinants of food price changes, but also a principal avenue through which macroeconomic changes influence the food system; (2) energy price increases, largely through their effects on the nonfood CPI and in turn on wage changes and food prices, appear at least as important as changes in raw food prices in the long-run determination of food prices; and (3) the declining rate of growth in productivity in the food system is partially attributable to the large commodity price increases of the 1970's and their effects on food demand and supply, relative input costs and factor substitution. None of these conclusions are possible from a simple markup pricing model of food price behavior.

In general, the results of this study confirm the importance of labor market developments in the food industry, and of macroeconomic effects on the food system and food prices. While many observers have stressed the importance of the macroeconomy to agricultural production, this analysis carries the point further. An expanded markup pricing approach can incorporate relevant macroeconomic changes as a partial explanation of changes in the larger food system. The next logical step is to further disaggregate the model to allow for differential pricing structures and labor market effects in various food system subsectors.

Footnotes

1. Negotiated COLA adjustments are but one outcome of collective bargaining agreements in food retailing. For additional discussion concerning the role of unions in food retailing, see Lamm and Harp, Dunham, and Southard.

2. Empirical evidence concerning the Phillips Curve hypothesis relating wage changes to unemployment is ambiguous. The inclusion of explanatory variable UMP in food retail and manufacturing wage equations here is based on recent research using disaggregate data which strongly supports the role of unemployment in wage determination, especially in low and medium-wage occupations (Nichols).

3. Variables representing other possible determinants of retail wage behavior - specifically, unionization in food retailing and changes in the minimum wage - were included in earlier specifications of equation (2) but are omitted from the final specification following preliminary statistical analysis which did not find them to be statistically significant determinants of wage changes. A major problem in testing the impact of unionization on wage behavior, as noted by Vroman, is the lack of aggregated union wage data over a sufficiently long time series for analysis. The proxy variable ultimately used here was the proportion of unionized workers in food retailing, e.g., members of the United Food and Commercial Workers Union and its predecessor organizations, the Retail Clerks and Meatcutters Unions. Such a proxy variable has been successfully used to represent unionization in previous research (see Hunt, et. al., for example), and its lack of statistical significance here should not be interpreted as evidence of the lack of importance of unions in food retailing.

4. Identities needed to transform individual variables into their first-difference form (and vice versa) are not included in these 24 equations.

5. Correction for autocorrelation in a simultaneous system involves first deriving an estimate of $\hat{p}$ for each equation, then estimating the system using N3SLS while simultaneously imposing the autocorrelation corrections on all relevant equations (Kelejian and Oates, p. 276-79.)

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Table 1: Structural Equation Estimates

<u>Retail Sector Model</u>

$$(1)\quad \dot{CPIF} = \underset{(0.003)}{0.005} + \underset{(0.034)}{0.411}\,\dot{PPIFP} + \underset{(0.028)}{0.118}\,\dot{PPIFP}(-1) + \underset{(0.029)}{0.117}\,\dot{PPIFP}(-2) + \underset{(0.118)}{0.216}\,\dot{WAGER} + \underset{(0.011)}{0.015}\,\dot{PPIEP}$$

$$+ \underset{(0.011)}{0.019}\,\dot{PPIEP}(-1) - \underset{(0.003)}{0.002}\,Q2 - \underset{(0.003)}{0.006}\,Q3 - \underset{(0.003)}{0.008}\,Q4$$

$$DW = 2.495 \qquad \hat{p} = -.263 \qquad RMSE = .0093$$

$$(2)\quad \dot{WAGER} = \underset{(0.002)}{0.012} + \underset{(0.101)}{0.331}\,\dot{CPIA}(-2) + \underset{(0.102)}{0.311}\,\dot{CPIA}(-3) - \underset{(0.011)}{0.029}\,\dot{UMP}$$

$$- \underset{(0.002)}{0.005}\,Q2 - \underset{(0.002)}{0.005}\,Q3 - \underset{(0.002)}{0.003}\,Q4$$

$$DW = 1.523 \qquad \hat{p} = .229 \qquad RMSE = .0066$$

$$(3)\quad LABRD = \underset{(136.871)}{3904.482} + \underset{(.003)}{.047}\,RETSALES + \underset{(13.059)}{75.230}\,Q2 + \underset{(15.070)}{212.093}\,Q3 + \underset{(13.060)}{127.482}\,Q4$$

$$DW = .178 \qquad \hat{p} = .888 \qquad RMSE = 66.877$$

$$(6)\quad \dot{CPIA} = \underset{(0.005)}{0.225}\,\dot{CPIF} + \underset{(0.005)}{0.786}\,\dot{CPIMF}$$

$$DW = 2.814 \qquad \hat{p} = -.409 \qquad RMSE = .00074$$

$$(8)\quad PCDEMR = \underset{(22.970)}{948.536} - \underset{(22.139)}{70.875}\,RLPRFR + \underset{(2.009)}{22.565}\,RLINCD - \underset{(3.919)}{7.308}\,DUM73 - \underset{(0.849)}{0.386}\,Q2 - \underset{(0.977)}{0.633}\,Q3 - \underset{(0.863)}{1.189}\,Q4$$

$$DW = .391 \qquad \hat{p} = .754 \qquad RMSE = 4.039$$

<u>Wholesale Sector Model</u>

$$(13)\quad \dot{PPIF} = \underset{(0.008)}{-0.027} + \underset{(0.039)}{0.468}\,\dot{PRF} + \underset{(0.308)}{0.705}\,\dot{WAGEM} + \underset{(0.256)}{0.421}\,\dot{WAGEM}(-1) + \underset{(0.007)}{0.017}\,Q2 + \underset{(0.008)}{0.027}\,Q3 + \underset{(0.006)}{0.022}\,Q4$$

$$DW = 1.962 \qquad RMSE = .0170$$

$$(14)\quad \dot{WAGEM} = \underset{(0.004)}{0.011} + \underset{(0.094)}{0.178}\,\dot{CPIA}(-1) + \underset{(0.100)}{0.234}\,\dot{CPIA}(-2) + \underset{(0.096)}{0.131}\,CPIA(-3) - \underset{(0.009)}{0.008}\,\dot{UMP}$$

$$- \underset{(0.040)}{0.080}\,\dot{LABMD} - \underset{(0.005)}{0.003}\,Q2 - \underset{(0.010)}{0.005}\,Q3 - \underset{(0.002)}{0.004}\,Q4$$

$$DW = 2.069 \qquad RMSE = .0055$$

$$\text{(15) LABMD} = 5023.52 - 956.109\ \text{RELWGM} - 5.989\ \text{UMP} + 119.474\ \text{Q2} + 733.384\ \text{Q3} + 460.025\ \text{Q4}$$
(260.150) (983.587) (0.858) (17.452) (19.969) (17.486)

DW = 0.973 $\hat{p} = .512$ RMSE = 73.805

$$\text{(18) PCDEMM} = 0.510 - 0.317\ \text{RLPRFR} + 0.053\ \text{RLINCD} + 0.038\ \text{DUM73} + 0.015\ \text{Q2} + 0.042\ \text{Q3} + 0.028\ \text{Q4}$$
(0.048) (0.045) (0.003) (0.007) (0.002) (0.002) (0.002)

DW = .618 $\hat{p} = .675$ RMSE = .0083

Note: Numbers in parentheses are standard errors. Durbin-Watson (DW) statistics and estimated autocorrelation coefficients ($\hat{p}$) are from initial uncorrected equation estimates. RMSE denotes root-mean-squared error. Numbers in parentheses following variable names denote lag lengths.

Endogenous Variables

CPIA - CPI for all items (1967 = 100)
CPIF - CPI for food (1967 = 100)
DEMM - Index of food manufacturing demand (1967 = 100)
DEMR - Index of retail food demand (1967 = 100)
LABMD - Labor demand in food manufacturing (mill. production worker hrs.)
LABMS - Labor supply in food manufacturing (mill. production worker hrs.)
LABRD - Labor demand in food retailing (mill. hrs.)
LABRS - Labor supply in food retailing (mill. hrs.)
PCDEMM - Index of per capita wholesale food demand (1967 = 100)
PCDEMR - Index of per capita retail food demand (1967 = 100)
PDYM - Index of labor productivity in food manufacturing (1967 = 100)
PDYR - Index of labor productivity in food retailing (1967 = 100)
PPIF - PPI for food (1967 = 100)
PRODM - Index of food manufacturing production (1967 = 100)
PRODR - Index of retail food production (1967 = 100)
RELWGM - Real hourly wage in food manufacturing (1967 $/hr.)
RELWGR - Real hourly wage in food retailing (1967 $/hr.)
RETSALES - Index of retail food sales (1967 = 100)
RLINCD - Real personal disposable income (bill. 1967 $)
RLPRFR - Real price of food at retail (1967 = 100)
ULCR - Index of unit labor costs in food retailing (1967 = 100)
ULCM - Index of unit labor costs in food manufacturing (1967 = 100)
WAGEM - Hourly wage for production workers in food manufacturing ($/hr.)
WAGER - Hourly wage in food retailing ($/hr.)

Exogenous Variables

CPIMF - CPI for non-food items (1967 = 100)
DUM73 - Dummy variable (=0: 1960-72; =1: 1973-82)
INCD - U.S. personal disposable income (bill $)
POP - U.S. population (millions)
PPIE - PPI for fuels and energy (1967 = 100)
PRF - Index of prices received by farmers (1967 = 100)
UMP - U.S. civilian unemployment rate (%)
Q_i - Quarterly dummy variables ($i = 1,...,4$)

Table 2: Dynamic Multipliers for a 1% Increase in Farm Prices

Endogenous Variable	Quarter 1	2	3	4	Total Multiplier*
Prices:					
CPI-food	.167	.055	.061	.007	.290 (4)
CPI-total	.037	.012	.014	.002	.065 (4)
PPI-food	.405	.002	.023	.005	.435 (4)
Real Food Prices	.127	.042	.047	.006	.222 (4)
Wages:					
Retail	.000	.000	.013	.016	.042 (7)
Manufacturing	.000	.007	.011	.011	.036 (6)
Real wages:					
Retail	-.038	-.012	-.001	.014	-.022 (7)
Manufacturing	-.047	.002	.001	.005	-.028 (7)
Employment:					
Retail	.033	.012	.013	.002	.061 (5)
Manufacturing	.002	.000	.000	.000	.001 (1)
Unit Labor Costs:					
Retail	.046	.017	.031	.019	.127 (6)
Manufacturing	.087	.038	.044	.016	.191 (6)
Food Demand					
Retail	-.013	-.005	-.005	-.001	-.024 (4)
Manufacturing	-.083	-.032	-.032	-.006	-.154 (5)
Labor Productivity					
Retail	-.047	-.016	-.017	-.003	-.083 (5)
Manufacturing	-.095	-.031	-.028	-.006	-.161 (5)
Real Income	-.038	-.012	-.014	-.002	-.066 (4)

*Numbers in parentheses indicate maximum quarterly lags of effects.

Table 3: Dynamic Multipliers for a 1% Increase in Energy Prices

Endogenous Variable	Quarter 1	2	3	4	Total Multiplier*
CPI-food	-.008	.001	.016	.058	.755 (11)
CPI-total	.167	.161	.182	.166	1.614 (11)
PPI-food	-.027	-.009	.033	.084	.902 (14)
Real Food Prices	-.173	-.156	-.162	-.106	-.974 (11)
Wages:					
Retail	-.029	-.040	.032	.116	1.049 (15)
Manufacturing	-.031	.005	.057	.093	.823 (14)
Real wages:					
Retail	-.194	-.196	-.147	-.049	-.758 (11)
Manufacturing	-.197	-.151	-.121	.072	-.880 (11)
Employment:					
Retail	-.007	-.002	.002	.010	-.170 (16)
Manufacturing	.003	.010	.011	.010	.042 (9)
Unit Labor Costs					
Retail	-.024	-.032	.049	.139	1.374 (15)
Manufacturing	-.041	.029	.102	.140	1.339 (14)
Food Demand					
Retail	-.013	-.010	-.013	-.014	-.160 (13)
Manufacturing	.014	-.014	-.030	-.039	-.493 (14)
Labor Productivity					
Retail	-.005	-.009	-.015	-.025	-.320 (13)
Manufacturing	.012	-.024	-.035	-.052	-.532 (13)
Real Income	-.166	-.158	-.178	-.163	-1.585 (11)

*Numbers in parentheses indicate maximum quarterly lags of effects.

Table 4: Dynamic Multipliers for 1% Increases in Farm and Energy Prices over Four Quarters

Endogenous Variable	Quarter 1	2	3	4	Total Multiplier*
CPI-food	.067	.139	.247	.293	1.677 (14)
CPI-total	.155	.129	.230	.293	2.318 (13)
PPI-food	.256	.294	.397	.412	2.080 (14)
Real Food Prices	-.088	.010	.017	.000	-.770 (13)
Wages:					
Retail	-.067	-.089	-.004	.101	1.406 (15)
Manufacturing	-.069	-.026	.034	.092	1.113 (14)
Real wages:					
Retail	-.219	-.213	-.229	-.188	-1.227 (11)
Manufacturing	-.222	-.150	-.189	-.197	-1.338 (11)
Employment:					
Retail	.005	.028	.050	.051	.355 (14)
Manufacturing	.003	.012	.017	.013	.071 (11)
Unit Labor Costs:					
Retail	-.046	-.045	.080	.193	2.030 (15)
Manufacturing	-.065	.089	.240	.275	2.234 (14)
Food Demand					
Retail	-.015	-.018	-.033	-.040	-.257 (13)
Manufacturing	.003	-.105	-.179	-.167	-1.060 (14)
Labor Productivity					
Retail	-.020	-.044	-.079	-.093	-.606 (14)
Manufacturing	.000	-.114	-.171	-.190	-1.112 (14)
Real Income	-.155	-.127	-.224	-.285	-2.265 (13)

*Numbers in parentheses indicate maximum quarterly lags of effects.

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