CORNELL AGRICULTURAL ECONOMICS STAFF PAPER

WAGES, PRODUCTIVITY, AND PRICES: DEFINING THE STRUCTURE OF FOOD PRICE INFLATION

by

David R. Lee

July 1983

No. 83-15

Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

WAGES, PRODUCTIVITY, AND PRICES:

DEFINING THE STRUCTURE OF FOOD PRICE INFLATION

by

David R. Lee*

*The author is an assistant professor of Agricultural Economics, Cornell University. Helpful comments by Lana Hall and an anonymous reviewer are gratefully acknowledged. The author also wishes to thank David Harvey, NED/ERS/USDA, for furnishing information on food sector labor costs.

This paper was prepared for presentation at a Selected Papers session at the Annual Meeting of the American Agricultural Economics Association, Purdue University, West Lafayette, Indiana, July 31-August 3, 1983.

WAGES, PRODUCTIVITY, AND PRICES: DEFINING THE STRUCTURE OF FOOD PRICE INFLATION

In a recent AAEA Presidential address, Polopolus criticized agricultural scientists, including agricultural economists, for the insufficient attention they have given to analysis of the food and fiber system beyond the farm gate relative to that given to production agriculture. In calling for a redress of this imbalance, he cited not only the much greater magnitude of value added and employment beyond the farm gate compared to the production sector, but, "more significantly, productivity and inflation problems beyond the farm gate have affected national economic performance more persistently than gyrations in the farm economy per se."

While Polopolus' assessment of agricultural system research is generally accurate, in some specific areas, his criticism is less justified. Considerable study has been devoted, for example, to the determinants of food price inflation, albeit with an emphasis on those price changes originating in the farm sector. Several studies, however, including those of Popkin, Heien, Lamm and Westcott, and Belongia, have investigated some of the productivity and inflation-related issues stressed by Polopolus.

This paper builds on these and other studies of food price inflation in describing aspects of the underlying structure of U.S. food price inflation, based on the interrelationships of wages, productivity, and prices in U.S. food manufacturing. The first section of the paper is concerned with establishing the relationship, using a causal ordering approach, between unit labor costs or real wages[1] (nominal wages adjusted for labor productivity) in the U.S. food manufacturing sector and food prices at the wholesale and retail levels. After establishing these relationships, the paper then describes how the rate of change of real wages or unit labor costs may be considered as forming an "underlying rate" of food price inflation, in much the same manner as the underlying or "core" rate of general inflation has been described elsewhere (Callahan; Eckstein). Finally, other aspects of wage, productivity, and price interactions are discussed, including feedback relationships which tend to perpetuate price inflation. The emphasis throughout the paper is on describing a set of wage, productivity, and price relationships in the U.S. food sector which have received little attention in the literature, but which together form an important part of the underlying structure of food price inflation.

Unit Labor Costs and Food Prices

Common to cost-push pricing models of food price inflation is the assumption that increases in wage rates in the food processing sector, like increases in raw material prices, are carried through to retail prices as manufacturers are forced to raise prices to cover increased labor costs, and these increased prices are then passed on through each stage of the marketing chain. Increased labor costs are commonly represented by nominal wage variables in econometric models (Barr and Gale; Lamm and Westcott), whether incurred in processing or distribution stages. As Belongia has argued, however, the use of nominal wage measures to represent labor costs is of questionable validity given the fact that actual firm labor costs (unit labor costs or real wages) are a function of labor productivity rates as well as nominal wage changes. Consequently, failing to distinguish between nominal and real wages in food pricing models may confuse general inflationary forces affecting all sectors more or less equally with the effects of real factor cost shifts on price changes in a given sector.

Based on the above distinction, we can state the conventional relationship between changes in nominal wage rates and unit labor costs (Branson):

(1) $\dot{ULC}_i = \dot{W}_i - (\dot{Y_i/N_i})$

where ULC is unit labor costs, W is the money wage, Y/N is labor productivity, i denotes industry i, and superscript "·" denotes rate of change. Adjusting money wage changes for changes in labor productivity means that the real labor costs incurred by food manufacturers shift with changes in $\dot{ULC}_M$, not $\dot{W}$. Since other non-labor costs including those for crude food and feedstuffs (CFF) and other intermediate factors of production (R_M) also enter the determination of wholesale price levels, a general function representing rates of change in the aggregate wholesale price level for food products (WP) may be written, following Popkin, as:

(2) $\dot{WP} = f(\dot{ULC}_M, \dot{CFF}, \dot{R}_M)$.

At the retail level, food price changes ($\dot{CP}$) may be considered, using a stage-of-processing approach, to be a function of changes in wholesale price levels, wholesale and retail unit labor costs (ULC_R), and other factors R_R (representing transportation and utility costs, profit levels, etc.), or in general form:

(3) $\dot{CP} = g(\dot{WP}, \dot{ULC}_R, \dot{R}_R)$

Equations (3) and (4) simply demonstrate the influence, at thusfar unspecified lag lengths, of real wage changes at the food processing level ($\dot{ULC}_M$) in the determination of wholesale food prices and, ultimately, retail price levels.

The directionality of the hypothesized relationship between real wage changes and retail food prices has been tested by Belongia for several food subsectors. Surprisingly, and in contradiction of the underlying assumptions of traditional cost-push pricing models, he is not able to reject the null hypothesis of no causality running from real wages to food prices in five of six food groups tested, including the overall food sector. This result, if correct, would not only imply that many prior food pricing models have been subject to serious specification errors, but would also suggest that the concept of cost-push pricing in the food sector is open to question.

In re-examining the type of approach taken by Belongia, we make use of the same basic theoretical approach represented by equation (3), which emphasizes the role of real wages or unit labor costs rather than nominal wages in determining food price levels. In addition, however, the approach taken here looks at the role of food processing labor costs in determining food prices at both wholesale (equation (2)) and retail levels.

A Causality Approach

Empirical causal ordering approaches have been used extensively in recent years to test the exogeneity of specific variables included in economic models. The concept of unidirectional causality generally employed is the following, after Granger: X is said to "cause" Y if and only if Y_t can be better predicted by using past values of X than by not doing so (with past values of Y being used in either case). Concepts of contemporaneous and feedback causality can be defined analogously. While space does not permit a review of the many empirical approaches to causality that have been taken, applications in agricultural markets have included analyses of variable interrelationships in livestock markets (Bessler and Brandt) and farm programs (Weaver), as well as in food pricing models (Heien; Lamm and Westcott; Belongia).

A number of different procedures have been proposed to test the existence of bivariate causal relationships (see review by Pierce). Recent Monte-Carlo analysis of three of the most commonly used procedures, the Granger, Sims, and Modified Sims tests, suggests that the Granger test has superior small sample properties and is computationally the most efficient procedure (Guilkey and Salemi; Geweke, Meese, and Dent). The Granger test is used here to test causal orderings between real wages and prices in the food sector.

Briefly, the Granger test is based on OLS estimation of the following equations:

$$(4) \quad Y_t = a_{10} + \sum_{j=1}^{J} a_{1j} Y_{t-j} + \varepsilon_{1t}$$

$$(5) \quad Y_t = a_{20} + \sum_{j=1}^{J} a_{2j} Y_{t-j} + \sum_{j=1}^{J} b_{2j} X_{t-j} + \varepsilon_{2t}$$

where j represents the number of lagged values (1, 2, ..., J), and ε_{1t} and ε_{2t} are white noise residuals. Testing the hypothesis that X does not cause Y amounts to testing the null hypothesis that $b_{2j} = 0$ for j = 1, 2, ..., J. This is done by estimating both constrained (4) and unconstrained equations (5), and using the resulting residual sum of squares estimates (SSE_1, and SSE_2, respectively) to calculate the F-statistic:

$$(6) \quad F^* = \frac{(SSE_1 - SSE_2)/J}{SSE_2/[T-(2J + 2)]}$$

where T equals the number of time series observations. Rejection of the null hypothesis is equivalent to the statement that X does cause Y. Use of the F-test (6) assumes that no significant autocorrelation exists in residuals of equations (4) and (5). The transformation here of the original series into variables representing first difference percentage changes (following equations (1) - (3)) avoided the problems potentially caused by serial correlation of error terms.

The Data

The data used in testing the causal relationship between food sector real wage costs and prices measure three major variables: money wages, rates of labor productivity, and food prices. Monthly rates of change in nominal hourly wages were calculated for the overall Food and Kindred Product sector (SIC 20) from data contained in the Bureau of Labor Statistics' Employment and Earnings publication. A major difference between Belongia's approach and that taken here is that Belongia used wage rate changes for the entire manufacturing sector, while the current analysis uses wage data specific to the food manufacturing sector.

Because commonly available monthly or quarterly industrial productivity data is not sufficiently disaggregated (to the food sector level) for the requirements of this analysis, it was necessary to construct a monthly labor productivity series for the food sector from several sources. This was done assuming the standard definition:

$$(6) \quad \text{Index of Hourly Productivity} = \frac{\text{Index of Total Production}}{\text{Index of Total Hours}}$$

$$= \frac{\text{Index of Total Production}}{\text{Index of [(Ave. Hours Worked) x (Ave. No. of Production Workers)]}}$$

All variables in (6) were expressed in index form (1967 = 100). An index of total food sector production (nonseasonally adjusted) was obtained from the Federal Reserve System's Industrial Production publication. Indexes of average weekly hours and average numbers of production workers in the food sector were derived from Employment and Earnings, enabling construction of a monthly index of total hours worked. The ratio of the two indexes representing total production and total hours yields an index of labor productivity in food manufacturing[2], from which monthly percentage changes were obtained. Monthly changes in retail food prices were obtained from the total food component (nonseasonally adjusted) of the Consumer Price Index. Monthly wholesale price changes for food products were derived from the food component of the Producer Price Index. Monthly observations were obtained for the January, 1954 through December, 1980 period yielding 324 monthly observations on all variables. As suggested by equations (1)-(3), all data were expressed in terms of monthly percentage changes.

Results of Causality Analysis

The results from using the Granger test to test the hypothesis that real wage rate changes cause changes in food prices are given in Table 1, with reference to both wholesale prices and retail prices, and for different lag lengths. Previous research has indicated the sensitivity of causal ordering results to lag selection (Geweke; Feige and Pearce). Resolution of the lag parameterization problem may require the use of data-based approaches (Bessler and Brandt) or, preferably, may be based on *a priori* knowledge of the system analyzed. The latter approach has been used here. Given the results of previous research on lags in food sector pricing (Barr and Gale; Heien; Lamm and Westcott; Lamm; Hall, et al.), lags of from one to six months were tested for wage to wholesale price causality and from three to ten months for wage to retail price causality. In each case, use

Table 1: Results of Granger Causality Tests

Lags (months)	F-Test Values Resulting from Tests of: Real Wages (1) & Wholesale Prices (2) (1)-->(2)	(2)-->(1)	Real Wages (1) & Retail Prices (3) (1)-->(3)	(3)-->(1)
1	4.47*	.62	-	-
2	3.14*	.47	-	-
3	3.43*	.59	1.52	.96
4	3.89**	.55	1.83	1.70
5	2.32*	.56	2.99*	2.26*
6	2.58*	1.91	2.88**	3.16**
7	-	-	2.38*	2.49*
8	-	-	2.35*	2.74*
9	-	-	2.25*	1.79
10	-	-	2.07*	2.62*

*Denotes statistical significance at .05 level.
**Denotes statistical significance at .01 level.

of the Ljung-Box modified test for autocorrelation of error terms demonstrated no statistically significant evidence of autocorrelation.

The results of Table 1 demonstrate, except at very short lag lengths (for retail prices only), that the null hypothesis that real wage rate changes do not lead to food price changes is conclusively rejected at both wholesale and retail levels. The demonstration of causality at the wholesale level means that changes in producer prices for manufactured foods and related products are significantly influenced by changes in unit labor costs in the food processing industry. Furthermore, these costs are passed on at very short lag lengths, confirming a priori expectations. Tests for instantaneous causal relationships, however, did not reveal instantaneous causality running from real wages to wholesale prices.

At the retail level, real wage changes in the food manufacturing sector are also found to cause changes in food prices, though at short lag lengths (up to four months) this relationship is not statistically significant. These results also confirm prior research results which suggest that additional time is required for the transmission of wholesale price changes to the retail level. Taken together, the two sets of results contradict those reported by Belongia, which were based on more highly aggregated wage data, and strongly reinforce the traditional concept of "cost-push" pricing in the food industry.

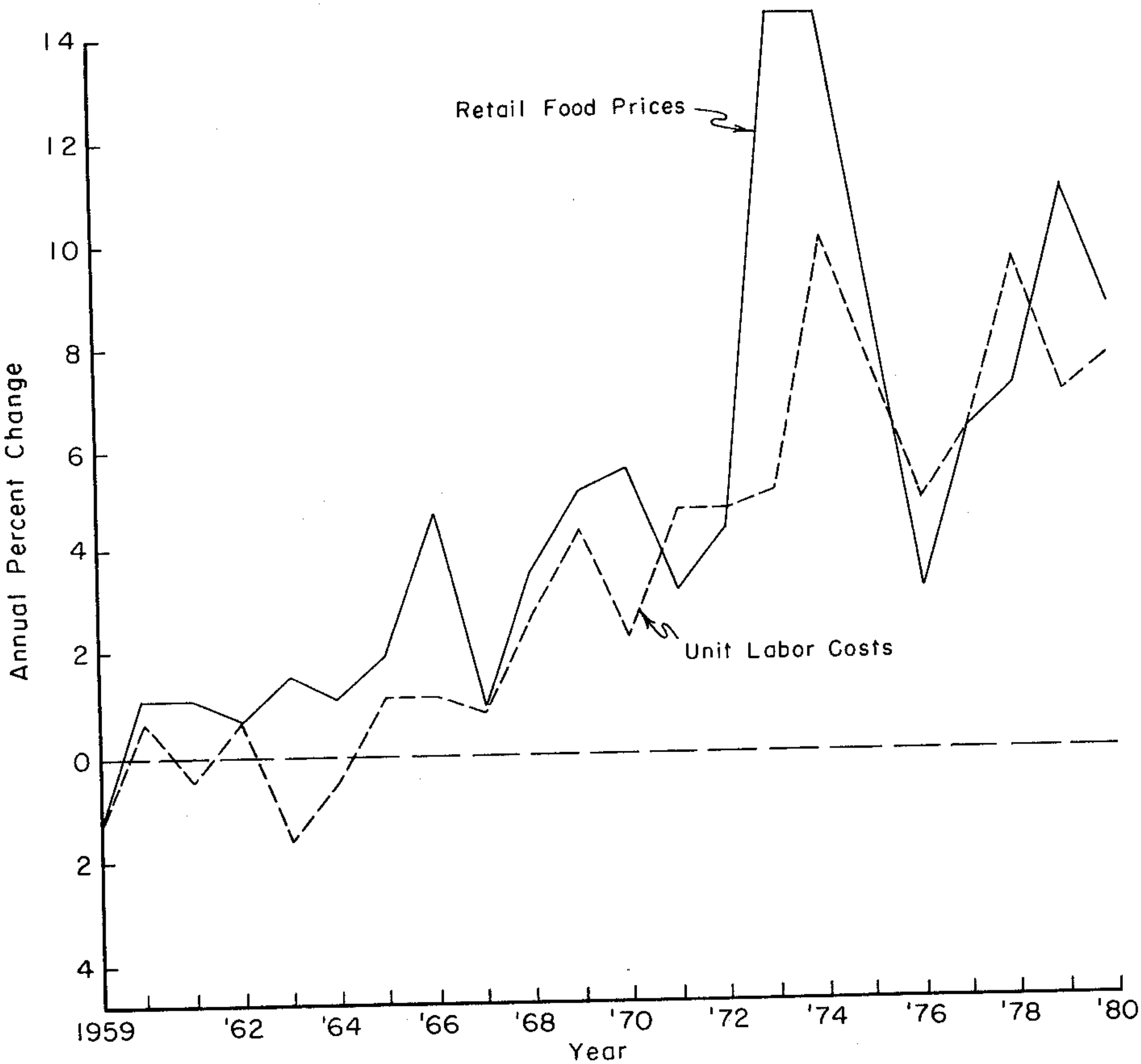
Previous research also suggests the likelihood of a feedback causal relationship running from overall prices to real wage changes, given the impact of inflationary shocks on workers' price expectations, which in turn take the form of cost-of-living adjustments in wage contracts (Vroman). For these reasons, the causality running from wholesale and retail food prices to real wage changes was also tested. No significant causality was found at the wholesale level, while causality at longer lag lengths (five months and greater) was found at the retail level. In interpreting these results, it must be remembered that the food component represents less than 20 percent of the overall CPI which is often used in wage escalator clauses. Despite this fact, Table 1 reveals that the wage level response to changes in retail food prices is significantly stronger than the response to wholesale price changes, which is in accord with expectations, given COLA-induced price-wage feedback. It is somewhat surprising that causality at any lag is evident in the retail price - real wage relationship given that the non-food component is substantially larger than the food component. The latter is relatively volatile, however, which likely accounts for the result.

The Structure of Food Price Inflation

Having established the relationship between real wage costs and food prices, several implications follow. To begin with, in recent years, economists have come to distinguish the overall rate of price inflation from the so-called "underlying rate" of inflation, the latter having been described in a number of alternative ways (Callahan): the CPI minus food and energy components; the CPI minus food, energy, home purchases, taxes, financing and insurance components; the PPI minus food and energy components; unit labor costs; etc. The primary difference between these various measures of "structural" inflation are that some measures explicitly exclude volatile components such as food and energy, while other measures construct an estimate by aggregating real costs of production (Eckstein's "core" inflation).

The results derived in the previous section provide support for the second approach to measuring "underlying" inflation, in that even in the relatively volatile food sector, real wage rates or unit labor costs provide an underlying structural dimension to sectoral inflation, as they do for general inflation (Eckstein; Nordhaus). The extent to which this is the case is illustrated in Figure 1, in which annual rates of change of food prices are plotted along with the annual rate of change in unit labor costs in the food sector. The latter is measured by a weighted index of unit labor costs in food manufacturing (weight = .56) and food retailing (weight = .44). This composite index accounts for more than three-quarters of the total labor cost component of the food marketing bill. Although the relationships evidenced in Figure 1 do not reveal the extremely high correlation between unit labor cost changes and price changes that have been estimated for general price inflation (Callahan), there nevertheless

FIGURE 1. ANNUAL RATES OF CHANGE OF RETAIL FOOD PRICES AND FOOD SECTOR UNIT LABOR COSTS: 1959-1980



does appear to be a close relationship between rates of change in the two variables, especially in recent years. The use of aggregated data in Figure 1 obscures the specific lag relationships between changes in real wages and food prices demonstrated above.

In summary, this analysis has directed primary attention to the applicability of the concept of cost-push pricing in explaining food price inflation at the wholesale and retail levels. Although cost-push or "pass-through" pricing is commonly observed at the firm level (Bloom) and has been incorporated in prior studies of pricing in the food sector (notably Heien), recent research has cast doubt on the legitimacy of the cost-push pricing concept in the food industry. The results of this analysis, however, provide empirical support for the validity of this concept at the aggregate sector level.

The approach presented here further suggests the usefulness of viewing changes in unit labor costs as an underlying element of the structure of food price inflation. An additional element of this inflationary structure is represented by the feedback relationship from general inflation (including the volatile food component) to nominal wage changes. Research is currently underway analyzing this price-wage linkage.

---

[1]In this paper we assume equivalency between unit labor costs and "real" wages. While the two are, strictly speaking, different by a factor representing the ratio of the rate of labor productivity in period (t-1) to period (t), in the data used for the present analysis, the two measures were correlated at the .999+ level and thus are used equivalently.

[2]In following standard procedures for estimating labor productivity, the present analysis abstracts away from the considerable and well-known problems involved in differentiating measurements of labor productivity from measurements of total factor productivity.

REFERENCES

Barr, Terry N., and Hazen F. Gale. "A Quarterly Forecasting Model for the Consumer Price Index for Food." Agricultural Economics Research 25(1973): 1-14.

Belongia, Mike. "A Note on the Specification of Wage Rates in Cost-Push Models of Food Price Determination." Southern Journal of Agricultural Economics (1981): 119-124.

Bessler, David A., and Jon A. Brandt. "Causality Tests in Livestock Markets." American Journal of Agricultural Economics 64(1982): 140-144.

Bloom, Gordon F. Productivity in the Food Industry. Cambridge, Mass: MIT Press. 1972.

Branson, William H. Macroeconomic Theory and Policy. New York: Harper and Row. 1972.

Callahan, David W. "Defining the Rate of Underlying Inflation." Monthly Labor Review (1981): 16-19.

Eckstein, Otto. "Tax Policy and Core Inflation: A Study Prepared for the Use of the Joint Economic Committee, Congress of the United States." April 10, 1980, 96th Congress, 2nd session.

Federal Reserve System, Board of Governors. Industrial Production. 1954-1980.

Feige, E. L., and D. K. Pearce. "The Casual Causal Relationship between Money and Income: Some Caveats for Time-Series Analysis." Review of Economics Statistics 61(1979): 521-33.

Geweke, John, Richard Meese, and Warren T. Dent. "Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence." Journal of Econometrics, forthcoming, 1983.

Geweke, John. "Feedback Between Monetary Policy, Labor Market Activity, and Wage Inflation in the U.S., 1955-1978." Social Systems Research Institute Workshop Series #8115, University of Wisconsin - Madison, April, 1981.

Granger, C. W. J. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." Econometrica 37(1969): 424-38.

Guilkey, David K., and Michael K. Salemi. "Small Sample Properties of Three Tests for Granger-Causal Ordering in a Bivariate Stochastic System." Review of Economics and Statistics 64(1982): 668-679.

Hall, L. L., W. G. Tomek, N. L. Ruther, S. S. Kyereme. "Case Studies in the Transmission of Farm Prices." Agricultural Economics Research #81-12, Cornell University, August, 1981.

Heien, Dale M. "Markup Pricing in a Dynamic Model of the Food Industry." American Journal of Agricultural Economics 62(1980): 10-18.

Lamm, R. McFall. "Dynamics of Food Price Inflation." Western Journal of Agricultural Economics 4(1979): 119-132.

Lamm, R. McFall, and Paul C. Westcott. "The Effects of Changing Input Costs on Food Prices." American Journal of Agricultural Economics 63(1981): 187-196.

Ljung, G. M., and G. E. P. Box. "On a Measure of Lack of Fit in Time Series Models." Biometrika 65(1978): 297-303.

Nordhaus, William. "What's Behind Today's Disinflation." New York Times, October 31, 1982.

Pierce, David A. "Relationships - and Lack Thereof - between Economic Time Series, with Special Reference to Money and Interest Rates." Journal of the American Statistical Association 72(1977): 11-22.

Polopolus, Leo. "Agricultural Economics Beyond the Farm Gate." American Journal of Agricultural Economics 64(1982): 803-810.

Popkin, Joel. "Consumer and Wholesale Prices in a Model of Price Behavior by Stage of Processing." Review of Economics and Statistics 56(1974): 486-501.

U.S. Department of Commerce, Bureau of Labor Statistics, Employment and Earnings. 1954-1980.

________. Productivity Measures for Selected Industries, 1954-1980. Bulletin 2128, April, 1982.

Vroman, Wayne. "Union Contracts and Money Wage Changes in U.S. Manufacturing Industries." Quarterly Journal of Economics. 97(1982): 571-594.