FOOD DEMAND ANALYSIS

Implications for Future Consumption

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Sponsored by
The S-165 Southern Regional Research Committee
and
The Farm Foundation

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August 1986

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IMPLICATIONS FOR FOOD DEMAND OF CHANGES IN COMPETITIVE STATE WITHIN MARKETING CHANNELS

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The purpose of this paper is to examine the effects that changes in pricing methods associated with changes in competitive status may have upon the ability to measure demand at various stages of food marketing systems. The concern here is not so much with competition in the market structure and conduct sense usually associated with such inquiries as with their price discovery mechanisms. Are these pricing mechanisms sufficiently flexible and do they react sufficiently rapidly to allow market equilibrium to be established in each period, or do markets sometimes operate in a disequilibrium state? The question of whether markets are always in equilibrium or can be in disequilibrium casts a new light on the issue of competitive status. Markets in disequilibrium may or may not have satisfactory economic performance as far as profits are concerned, but they do present great difficulties for demand analysis.

These difficulties are imbedded in disequilibrium market theory, so the first task of this paper will be to compare disequilibrium and equilibrium market theory in order to show the source of these demand analysis difficulties. The realism of applying disequilibrium theory in food production markets will be assessed, and applications to beef marketing will be discussed. Finally, the implications of changing structure and pricing methods for demand analysis in the future will be discussed.

Disequilibrium Market Theory

Much of the impetus for disequilibrium market theory has come from the need to reconcile theories of individual choice involving utility and profit maximization with Keynesian macroeconomic theory which predicts protracted disequilibrium. Slowness of wages, prices, consumer habits, and similar variables to adjust is held to be responsible for involuntary unemployment and other manifestations of disequilibrium (Patinkin, 1965, pp. 335-343). Grossman (1971) argues that disequilibrium constraints in one economic sector lead to "spillover effects" in other sectors, so that disequilibrium effects can spread from, say, banking and finance to markets for goods and services.

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In individual commodity markets disequilibrium theory is explicitly dynamic and focuses on the <u>tatonnement</u> process of price adjustment after a shift in either supply or demand. Simply put, prices may not adjust rapidly enough to such a shift to re-establish equilibrium within the observed time interval.

A simple model in continuous time illustrates the issue. The model is specified with demand and supply functions and a Walrasian price adjustment process specifying price change as a function of excess demand:

$$D(t) = \alpha_1 P(t) + \beta_1 X1(t) + U_1(t) \qquad [1]$$

$$S(t) = \alpha_2 P(t) + \beta_2 X2(t) + U_2(t) \qquad [2]$$

$$\dot{P} = (D(t) - S(t)) \qquad [3]$$

Maintenance of equilibrium in the face of shifts in demand and supply depends upon the rate of change in P(t), which is measured by the parameter λ. If $\lambda = \infty$, the rate of change in P(t) is instantaneous and equilibrium is always maintained. With something less than instantaneous response there is the possibility that equilibrium will not be re-established within a given time interval.

A discrete version of this simple model can be specified in a form which makes the issue of price adjustment a testable hypothesis. In place of the Walrasian adjustment, price is specified as a partial adjustment to an imputed moving equilibrium (PAMEQ), a specification developed by Bowden (1978, pp. 75-83). A simple PAMEQ model is as follows:

$$D_t = \alpha_1 P_t + \beta_1 X1_t + U1_t \qquad [4]$$

$$S_t = \alpha_2 P_t + \beta_2 X2_t + U2_t \qquad [5]$$

$$P_t = \theta P_{t-1} + (1 - \theta) P^*_t, \qquad [6]$$

where P^*_t is the equilibrium price for the system. Imagine this model to be in equilibrium at t=0. A change in the exogenous variables X1 and X2 or in either of the disturbances in t=1 generates pressure for change in the price. If this pressure is rapidly translated into actual change, the new equilibrium price may be attained in period t=1 and the market will "clear." However, if "frictions" exist in the price adjustment process, P^*_1 may not be attained in period t=1.

Parameter θ in equation (6) is the "coefficient of friction" for price adjustment, the "frictions" being impediments to sufficiently rapid price change. The theory does not say what such impediments might be, but such things as institutional pricing rules, formula pricing, or simply delays in obtaining, transmitting, and interpreting price information are plausible reasons for slow price adjustments. Natural boundaries for the value of θ are $0 \leq \theta < 1$, with 0 representing the capacity to fully adjust to equilibrium. The natural interval for θ excludes 1, because $\theta = 1$ implies no adjustment whatever. Prices can be frozen, of course, but the economics of fixed prices are not of interest here.

Specifying prices as a PAMEQ function has scientific merit in that it makes market-clearing equilibrium a potentially testable hypothesis rather than an assumption imposed upon the specification. In this regard it is analogous to a static specification becoming a testable hypothesis within the context of a dynamic commodity model. It should be noted that dynamic models are usually equilibrium models in that they define market-clearing prices and quantities in each period, albeit these are short-run equilibrium points converging on a long-run steady state. Although these short-run solutions are sometimes referred to as disequilibriums, they are quite different from the non-clearing disequilibrium behavior treated here (Bowden, 1978, p. 19).

Implications for Demand Analysis

Markets operating in disequilibrium pose more difficult analytical problems than markets operating in equilibrium. The major problem lies in the interpretation of quantities. In equilibrium markets observed quantities are readily interpreted. By virtue of the market-clearing characteristic of equilibrium, observed quantities transacted are equal to the sum of stock and flow quantities demanded and also equal to the sum of stock and flow quantities supplied. The situation is even simpler in strict flow models, but the main point is that all observed quantities lie on all the demand and supply curves specified for the commodity or commodities in question. In disequilibrium markets, on the other hand, observed quantities may lie on the demand curves or the supply curves, but seldom both at the same time, or possibly they may not lie on any of them.

The short-side model first proposed by Fair and Jaffe (1972) specifies the first case, in which observed quantities lie on either the demand or the supply curves, but lie on both only in the special case of market equilibrium. For a strictly flow commodity, the short-side model is specified with demand, supply, and price functions like those in equations (4), (5), and (6), and an additional function specifying observed quantities transacted which is,

$$Q_t = \min(D_t, S_t). \qquad [7]$$

Equation (7) postulates a quasi-rationing system in which Q_t, the observed quantity, is restricted to D_t or S_t, whichever is lower. At prices below equilibrium, quantity supplied is less than the quantity that would be demanded without restrictions, so $Q_t = S_t$. The opposite situation holds for prices above equilibrium, in which case $Q_t = D_t$. In the short-side model, therefore, the loci of transactions are the segments of the demand and supply curves lying to the left of the equilibrium intersection point. These loci are indicated by the heavily shaded portions of the demand and supply curves in Figure 1A. Ranges of observable prices and quantities are from P_1 to P_2 and from Q_1 to Q_2.

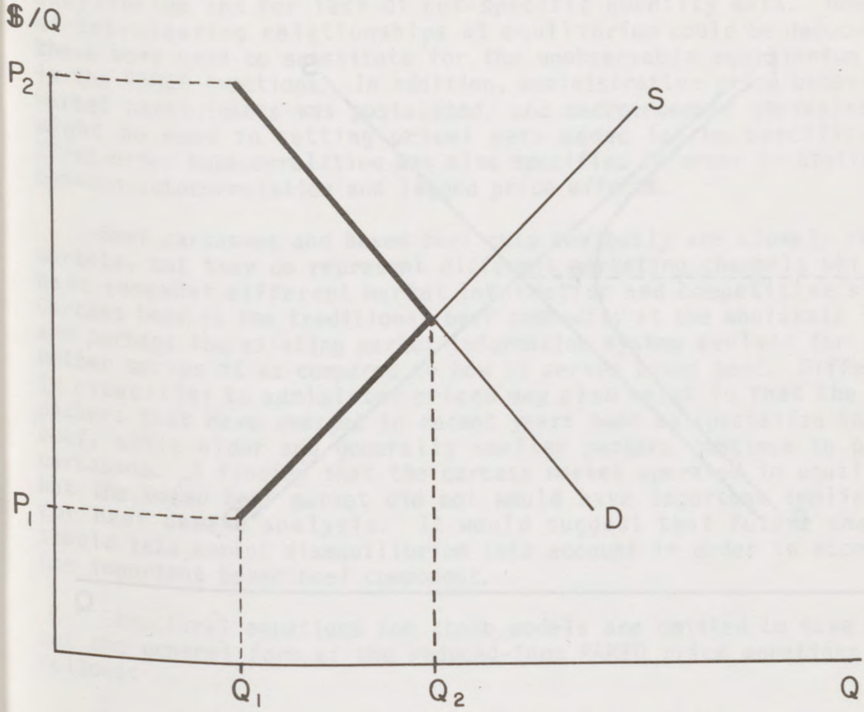
Consistent demand and supply estimation under these conditions requires somehow separating samples of observations according to whether they represent quantities demanded or supplied. Application of conventional procedures in which observed quantities are interpreted to lie on both functions most likely will lead to biased parameter estimates.

Estimation problems become even more troublesome in the incomplete information model proposed by Bowden (1978, p. 12). In Bowden's model incomplete information about the true levels of demand and supply coupled with slow price change prevents buyers and sellers from operating along the demand and supply functions. Instead, quantities and prices adjust along a "clearing path" such as the curve FEG in Figure 1B. Bowden suggested that in some markets, notably the labor market, clearing in terms of quantities might not take place even at the equilibrium price. (Frictional unemployment always seems to exist.) Thus, in Figure 1B, clearing path FEG never intersects the price-quantity equilibrium point. Of course, clearing-paths could intersect the equilibrium point, but this case is secondary to the main point of incomplete information disequilibrium models, namely that quantity observations may not lie on either the demand or supply functions let alone on just one of them.

Realism of Market Disequilibrium

Is market disequilibrium a realistic basis for food demand analysis? The notion of slow rates of change in prices is attractive because of the apparent widespread occurence of "sticky" retail food prices, but the corollary of quasi-rationing to reconcile quantity differences is at odds with the conventional view of retail food marketing. Rationing implies shortages, but plethora seems a more accurate term to describe the quantity situation facing consumers. However, there is some evidence of informal rationing at the retail level. The importance of "specials" on retail food pricing has been noted many times, but comparatively little attention has been paid to

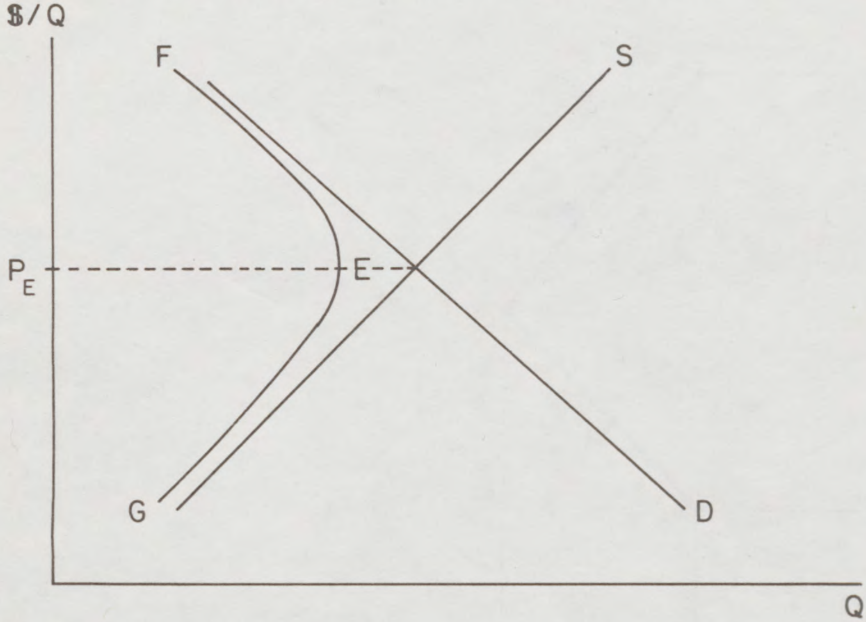
Figure 1A. A Short-side Disequilibrium Model



the quantity restrictions that often accompany them. "Two to a customer" or some such limit is common and is in accord with the low-price, excess-demand regime of a market in disequilibrium. Comparable behavior on the supply side is found in the discard provisions of fruit and vegetable processors' production contracts, in the orderly marketing provisions of fresh fruit and vegetable marketing orders, and in the third degree price discrimination system used by milk marketing orders. All these are consistent with the disposition of excess supply in disequilibrium markets.

Incomplete market information would seem to be an even more common cause of disequilibrium. Gradual price change in the face of incomplete market information seems realistic, but what is to be made of the quantity issue? Bowden (1978, p. 11) suggests that it may not be possible to specify quantity adjustment processes when information is incomplete, these being part of the information problem. In such cases a reduced form approach can be used to circumvent the necessity of specifying an adjustment process. This reduced form can be used to test for equilibrium and can stand on its own as a price analysis tool. If the markets are found to be in equilibrium, then conventional procedures can be used for demand analysis.

Figure 1B. An Incomplete Information Disequilibrium Model



Application of PAMEQ to Beef Markets

Wholesale beef markets appear to operate in a state of incomplete market information so that Bowden's reduced form PAMEQ model seems appropriately applied to them. Most beef (estimated between 75-90%) is sold on a forward formula basis whereby forward contracts specify cuts and quantities to be delivered a week or so hence. Everything is specified in these contracts but the price. Price is determined by formula as so many cents over or under the Yellow Sheet wholesale price quoted on the delivery date of the contract (National Provisioner, Oct. 28, 1978, p. 113). Market information under these conditions can not be precise, because the major operative force on the demand side is a distribution of expectations about the future demand affecting prices settling past contracts. Thus, while current supply may be reflected in price, current demand is not. No straightforward market clearing mechanism is apparent under these circumstances.

Wholesale beef models at two levels of the market were specified and estimated, one for carcasses and one for boxed beef. More specifically, markets for (a) choice steer carcasses, yield grade 3, 600-700 pounds and (b) boxed choice beef strips were specified. Demand, supply, cold storage stocks demand functions, and PAMEQ price functions were specified, but neither model had market clearing functions for lack of information about market clearing out of equilibrium and for lack of cut-specific quantity data. However, market-clearing relationships at equilibrium could be deduced, and these were used to substitute for the unobservable equilibrium price in the PAMEQ functions. In addition, administrative price behavior by market participants was postulated, and macroeconomic variables that might be used in setting prices were added to the specification. First-order autocorrelation was also specified in order to distinguish between autocorrelation and lagged price effects.

Beef carcasses and boxed beef cuts obviously are closely related markets, but they do represent different marketing channels which may have somewhat different market information and competitive states. Carcass beef is the traditional beef commodity at the wholesale level, and perhaps the existing market information system evolved for it and better serves it as compared to how it serves boxed beef. Differences in capacities to administer prices may also exist in that the large packers that have emerged in recent years tend to specialize in boxed beef, while older and generally smaller packers continue to produce carcasses. A finding that the carcass market operated in equilibrium but the boxed beef market did not would have important implications for beef demand analysis. It would suggest that future analyses should take market disequilibrium into account in order to accomodate the important boxed beef component.

Structural equations for these models are omitted to save space, but the general form of the reduced-form PAMEQ price equations is as follows:

$$P_t = \theta P_{t-1} + (1 - \theta)\ [(1/G)\ (f^S X_t^S - f^D X_t^D + f^K X_t^K - K_{t-1})]$$

$$+ \theta f^A X_t^A + U_t,\ U_t = \rho U_{t-1} + E_t \qquad [8]$$

where (1/G) represents a combination of structural parameters on price and where $f^S X_t^S$, $f^D X_t^D$, and $f^K X_t^K$ represents the structural parameters and exogenous variables for beef supply, demand, and cold storage stocks demand respectively. Note that the demand-related variables enter the specification as negatives.

If disequilibrium effects are unimportant, the terms inside the brackets in equation (8) will essentially determine price, and the adjustment parameter θ will approach zero. Likewise, if the markets operate at equilibrium their prices are not being administered, and the compound parameters f^A will also approach zero. If the markets operate in disequilibrium because of overt noncompetitive behavior (price setting), parameters f^A will be significant. If incomplete market information is the cause of disequilibrium, then θ will be greater than zero, but f^A will not.

Equation (8) is essentially a reduced-form price equation. With some additional assumptions, namely that error terms E_t are normally distributed and contemporaneously uncorrelated between different market levels, single equation estimation methods can be used. An iterative estimation process was used to search over the possible values of the autocorrelation coefficients (to four decimal places) between -1 and +1 to find the least-squares parameters (Theil, 1971, pp. 417-421, 425).

The analyses were performed for the years 1979-83 using weekly observations of prices and FIS slaughter data and monthly observations of other variables. These latter variables were held constant during their constituent weeks. An additional adjustment was made for cold storage stocks in 1982. Stocks were reported on a quarterly basis in 1982 but monthly in other years. The 1982 cold storage data were smoothed to a monthly basis by interpolating quarter to quarter changes. The sample had 241 observations after adjusting for missing data, mostly during Christmas weeks.

Identical specifications of demand, supply, and cold storages stocks demand functions were used for the carcass and boxed beef products. One reason for identical specification is that the two products obviously are closely related and should have common demand and supply functions. Another reason for identity is to detect any differences in pricing behavior for the products. They represent different levels of the wholesale beef market and could have different rates of adjustment to equilibrium or differences in response to price administration.

Exogenous variables in the demand functions were pork and broiler prices and per capita consumer income. Supply functions were specified by wage rates and by federally inspected beef output lagged one week. Interest rates and lagged stocks specified stock demands. Variables representing general consumer demand and general business activity were used to specify the administrative pricing components. Parameter estimates, variable identification, and data sources are presented in Table 1.

Lagged price coefficients are statistically significant for both products. The parameter on lagged price is somewhat larger for boxed beef than for carcasses, but it is not clear that this difference is meaningful. Adjustment rates appear to be slow in both markets. In both cases adjustments to equilibrium, as indicated by the reduced forms for equilibrium prices, account for only a portion of the variation in weekly prices. These results are consistent with market disequilibrium, although of course they are not conclusive proof that these beef markets are in disequilibrium. Results are conditional upon model specification, and it is possible that specification errors have been made in the demand, supply, and cold storage stocks demand functions. In this regard, little can be made of the values of the reduced form parameters, but their signs can be examined for consistency. The negative sign for income is conceptually sound since

Table 1. PAMEQ Reduced-Form Estimates for Carcass and Boxed Beef Prices[a]

Dependent Variable[c]	Lagged Dependent Variable	Exogenous Variables[d]									
		Supply Related		Demand Related			Stock Demand-Related		Administered Price-Related		Autocorrelation Coefficient
		$X1_t$	$X2_{t-1}$	$X3_t$	$X4_t$	$X5_t$	$X6_t$	K_{t-1}	$X7_{t-1}$	$X8_{t-1}$	
$P1_t$	.8355 (0.35)	8.158 (2.80)	-0.1185 (.00661)	.01941 (.0134)	.009031 (.0344)	-5.977 (1.87)	0.1244 (.0610)	-.01034 (.00570)	.04558 (.0500)	.03067 (.0301)	-.0908
$P2_t$	.9641 (.0227)	27.76 (6.44)	-.00852 (.0150)	-.5391 (.0381)	.1284 (.0788)	-16.43 (4.33)	-.02175 (.153)	.00829 (.0161)	-.02965 (.126)	.00584 (.0776)	.0498

[a]Standard errors in parentheses.

[b]Variable definitions and sources: P1 = Choice steer, yield grade 3, 600-700 lb. carcass weekly prices, cents per lb. (National Provisioner, 1978); P2 = LCL boxed beef, choice 175-125/25 strip, bone in, weekly prices, cents per lb. (National Provisioner, 1978).

[c]Dependent variable and regression statistics: P1: $\bar{P}1$=100.7¢/lb., S=6.2¢/lb., $\bar{R}^2$=0.82, $\bar{S}$=2.7¢/lb.; $\bar{P}2$: P2=197.0¢/lb., S=23.8¢/lb., $\bar{R}^2$=0.94, $\bar{S}$=6.0¢/lb.

[c]Variable definitions and sources: X1 = monthly SIC 20 wage rate, $ per hour (Dept. of Commerce, Survey at Current Business); X2 = lagged weekly beef output, FIS slaughter, million lbs. (USDA); X3 = weekly price of fresh pork loins, 14-17 lbs., cents per lb. (National Provisioner, 1978); X4 = weekly price of broilers, 9-city average, cents per lb. (USDA); X5 = monthly per capita personal income, 1,000 $ annual rate (Dept. of Commerce, Survey of Current Business); X6 = monthly average Federal Funds rate, per cent (Federal Reserve Bulletin); K = lagged monthly cold storage beef stocks, million lbs. (USDA); X7 = lagged monthly consumer expenditures, nondurable goods, millions of 1972 dollars (Dept. of Commerce, Survey of Current Business); X8 = lagged monthly index of leading economic indicators, 1967=100 (Dept. of Commerce, Business Conditions Digest).

demand-related parameters enter as negatives of their structural counterparts. Results for pork and broiler prices are less satisfactory since only the pork price parameter in the boxed beef function is negative.

Incomplete market information rather than overt noncompetitive pricing practices appears to be responsible for the disequilibrium states that appear to exist. Neither of the variables hypothesized to affect administrative price behavior was found to be significant. These results are also conditional upon correct specification. Possibly prices are administered in a more subtle way than postulated here, but incomplete market information seems sufficient to explain the disequilibrium states that appear to exist. Thus, it is not necessary to invoke administered pricing to explain slow price adjustments in these markets.

Implications for Demand Analysis in 2000

Results of this analysis have implications for beef markets and for other food commodities with similar market structures. As for beef, while these results are by no means definitive, they do suggest that equilibrium should not be assumed *a priori* in future demand analyses. The results are consistent with those markets' operating out of equilibrium, at least in the short run, so an assumption of equilibrium may lead to biased parameter estimates and poor forecasting performance. Some hard conceptual digging needs to be done to clarify relationships among quantities in these markets before consistent demand analysis can be achieved. Even then, it may not be possible to estimate the demand functions postulated here without much finer quantity data than currently exist.

The incidence of disequilibrium in other food commodity markets is unknown, but many have the kinds of institutional arrangements associated with disequilibrium. Trends towards more vertically coordinated marketing arrangements and more formula-like pricing systems are readily apparent and have often been commented upon. Given the continuance of these trends, disequilibrium may become more common in the future, whatever its current incidence. Though it is by no means clear that investments in remedial actions to ensure that markets operate in equilibrium can be justified, there seem to be three directions that such remedies could take: (a) direct intervention in market structures, (b) improvements in market information systems, and (c) improvement of estimation techniques.

Direct intervention in market structure might not be legally feasible, irrespective of its economic desirability. Evidence of overt noncompetitive behavior in contravention of antitrust laws would be needed for direct intervention. Price conspiracies could be attacked, but the more subtle approaches to price administration that seem to be associated with disequilibrium market theory may not be covered under these laws. Disequilibrium caused by incomplete market information might not provide any legal basis for intervention.

Improvements in market information systems would seem to be the natural approach to disequilibrium where incomplete market information is the cause. However, public or private investments in obtaining more complete information would have to be justified by a favorable benefit-cost ratio in terms of improvements in market efficiency. Markets in disequilibrium are by definition less than perfectly efficient, but the question of how much benefit would accrue to more complete information would be vital. Careful studies of the disposition of quantities, along the lines advocated above for beef, would be required to show how the new information could be utilized. The fact that added information would make the task of demand .pa estimation easier and more accurate would, as usual, be secondary to improvements in the commercial functioning of the markets in question.

Improved estimation techniques might be able to provide consistent estimates of demand functions even in the face of continuing market disequilibrium. Some progress has been made along these lines. Recently developed techniques, such as the maximum likelihood approach suggested by Maddala and Nelson (1974), are capable of handling a very restricted version of the short-side model. This version assumed that prices are not subject to disturbances. In the more general case of price functions with disturbances, however, the situation is less satisfactory. Monte Carlo analysis has shown that current estimation methods perform very poorly with this model (Bowden, 1978, pp. 190-194). Finally, little or no progress has been made with consistent demand estimation in the imperfect market information case, even though this use may be the most common type of disequilibrium situation.

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