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LIMITS ON PRICE ANALYSIS

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"All the [mature] sciences...have...internal connectedness...This connectedness...gives the sciences great stability and power to assimilate more information...Another property that sets genuine sciences apart from those that arrogate to themselves the title without really earning it is their predictive capability..." (Medawar, p. 4).

In a recent book, Sir Peter Medawar distinguishes between those questions that scientific research can and cannot answer. My paper has a more modest goal. Price analysts have never pretended to answer deep philosophical questions, but rather have tried to understand agricultural markets. The general objective of price analyses is to make forecasts and simulations that assist private and public decision-makers. Progress has been made toward this general goal, but limitations clearly exist to obtaining precise forecasts and useful simulations. This paper is about the progress that has been made and the limitations that exist.

Examples from the supply, demand and marketing margin literature are used to illustrate the progress and limitations. In particular, I contrast the progress that has been made in supply analysis with the progress in demand analysis. I then suggest ways in which some of the problems might be addressed. Space constraints, however, do not permit an exhaustive discussion of these topics.

Progress and Limits

Supply Analysis

While factor markets continue to be a neglected area relative to product markets, the analysis of farm product supply constitutes one of the areas in which substantial improvements have been made in the past three decades. This progress has been both conceptual and empirical, and it has occurred, I think, because of the perceived limitations of early models and because of the expertise agricultural economists brought to bear on these limitations.

Changes in relative prices are a key to understanding supply response, and as Gale Johnson has pointed out, factor prices in agriculture are sometimes correlated with product prices. When this is the case, relative prices change little, and supply responses are small even though product prices may change a lot. But when product prices rise relative to factor prices, farmers have an incentive and the financial resources to adopt new technologies. Once adopted, they are not given up in the face of declining prices (Cochrane). Likewise, asset fixity and differences in rates of culling and expansion contribute to asymmetric supply responses,[1] and these concepts too have been incorporated into empirical models (Glenn Johnson; Traill et al). Further, Chavas and Johnson, as well as others, have stressed the importance of different degrees of response to given price changes during various stages of the production process for livestock products.

With lags in production, quantity supplied clearly is a function of expected prices, and although expectations are unobservable and, hence, difficult to measure, innovative proxy variables for measuring expectations have been proposed (e.g., Nerlove; Gardner 1976).[2] Moreover, since actual prices will deviate from those expected, price risk is likely to be an important determinant of supply (Just), and apparently producers do perceive changes in price risk that have measurable effects on market supply (e.g., Hurt and Garcia).

Progress also has been made in incorporating the effects of government programs into models of crop supply (e.g., Houck, et al; Green et al), but the evidence regarding the forecasting accuracy of models incorporating these variables is mixed (Lee and Helmberger). If rational expectations models are appropriate for agricultural markets, then neither conventional supply specifications nor those with government program variables are sufficient to obtain precise forecasts of the effects of changes in governmental policies because the policy changes influence the parameters of the model (for an illustration see Fisher).

A major problem is to sort out the relative importance and usefulness of recent developments in supply analysis for forecasting and simulation. Very different specifications sometimes fit historical data equally well. For example, in modeling soybean acreage response, Gardner (1976) considered alternative measures of expected prices, stressing futures prices as plausible measures of expectations. In contrast, Houck and his colleagues emphasize the importance of government program variables as determinants of soybean acreage. Both specifications fit roughly the same sample period with large R^2's (Table 1). Both Gardner and Houck had innovative ideas. Perhaps futures prices and government program variables could be combined into the same equation, but the effects of government programs probably are reflected in futures prices. Thus, discriminating between these two models (or among other models) is likely to be difficult.

Another problem is that certain important exogenous variables that affect supply are difficult to measure. Improvements in technology are often the most important shifters of supply functions. Yet historical effects of technical change are difficult to disentangle from other trending variables and even more difficult to predict. Moreover, biological processes have an inherent randomness, and supply equations can have large random components.

My main point, however, is that agricultural economists, while using conventional economics as a base, pushed back the conceptual and empirical frontiers of supply analysis as applied to the farm sector. These developments arose, I believe, because the inadequacies of early studies were recognized, because good supply models were needed for policy analyses, and because agricultural economists applied their special knowledge of the farm sector to the solution of these problems. This does not mean that we now have perfect models of supply response in agriculture; the empirical analysis of farm supply is difficult; but remarkable progress has been made.

Demand Analysis

Similar progress has not been made in demand analysis in the past 20 years. This is true, in part, because of the success of earlier contributions to demand analysis (e.g., Fox; H. Schultz; Waugh). Consequently, demand studies in the 1960s started from a "higher" level. A common, though not exclusive, practice was to make real prices a function of quantities consumed, where consumption was assumed to be largely predetermined by production. Thus, the important explanatory variables were per capita quantities, including those for close substitutes, and real per capita income. These functions usually explained the annual variations in real prices quite well.

These early studies provided a foundation for a host of time-series analyses of the demand for individual commodities (for a review, see Tomek and Robinson). The early models have been refined. Alternative functional forms have been analyzed; various deflators have been considered; monthly and quarterly data have been used to estimate seasonal effects; distributed lag specifications have been introduced; and so on.

In some markets, it has been useful to disaggregate total demand into various components, such as processed and fresh uses. Thus, another development involved model specifications where total supply is allocated among competing demands (e.g., Meinken; Houck and Mann; Gallagher, et al). In these models, supply is typically treated as predetermined, while the alternative uses and prices are simultaneously determined. Not surprisingly, with the growth of international trade for a number of agricultural products, the foreign demand component of such models has received increasing attention.

Perhaps the major development in demand analysis, however, has been the construction of elasticity matrices or the fitting of systems of equations subject to the constraints suggested by theory (e.g., Brandow; George and King; Heien 1982; Johnson, et al). Sets of internally consistent demand elasticities have value, and agricultural economists have been innovative in making empirical applications of theoretical constructs to the demand for foods. Nonetheless, concerns remain about the applicability of constraints based on a theory of individual consumer behavior to market data. Constrained demand systems provide poorer forecasts than unconstrained equations (Brandt, et al).

Both the conventional time-series and demand systems studies reflect economic and statistical theory, but little in the models is unique to the food and fiber sector (except the assumption of predetermined supply and the use of inverse demand functions). Some demand analyses seem especially technique oriented. One cannot escape the feeling that familiar models, using secondary data, are accepted uncritically and that the latest technical methods are employed as fads rather than because they provide more sensible or useful results. Room should exist in our research agenda for the appraisal of new methods, but a display of technical skills is not a substitute for carefully specified models and relevant data sets.

Prior to 1960, price analysts did not have high speed computers to facilitate data mining, and as a consequence, analysts knew their data and specified models thoughtfully. This reduced the chance of aberrant observations influencing the results. For example, a special beef program in 1934-36 apparently affected beef consumption while having little influence on market prices (Breimyer, p. 47). Adjusting for this program influenced the slope coefficients of the beef equation. In contrast, analysts today rarely ask whether a particular event, such as the price controls of 1973, has influenced the data being used.

Important changes have occurred in food and fiber markets that, for the most part, have not been reflected in model specifications or in the data used in these models. This perhaps was inevitable because, on the one hand, price analyses have a commodity orientation while, on the other hand, markets have become increasingly complex, i.e. farm commodities are being processed into many different products. We know, of course, that the average size of households in the United States has been declining, that the population is growing older, that the percent of women participating in the work force has been growing, that the number of years of education has trended upward, and so on.

These older, educated, generally affluent consumers are faced with more choices than in the past. In the food sector, enormous growth has occurred in the number of fast food restaurants, and these restaurants have diversified into a wide range of menu items. At the same time, a revolution has been occurring in the frozen foods departments of grocery stores. Consumers have choices of frozen entrees, regular frozen meals, gourmet frozen dinners, ethnic frozen foods, and low calorie frozen dinners. The delicatessen is becoming a more important department of food stores. Choices are expanding elsewhere as well; the list is almost endless.

These choices presumably are being made in the context of economic and, perhaps, other constraints. Budget constraints exist, and assuming demands are separable into major categories, then the demand for a particular category of food is limited by the amount of income that consumers are willing to allocate to that group of foods. Per capita consumption (which is not necessarily synonymous with demand) of meats, cheese and eggs, for example, grew about 50 pounds per capita between the early 1950s and early 1980s, but over half of this growth occurred in the 1960s and early 1970s (Table 2). Clearly past trends need not persist.

Food demand is increasingly influenced by changing socio-economic characteristics of consumers and by style, habit and impulse (Padberg and Westgren). Improved education about nutrition and health probably is influencing the demands for various foods. Thus, shift variables associated with these changes probably have become increasingly important.

Still another area of change is in the structure of food and fiber markets. The general trend is toward more concentration in particular industries, but the proliferation of products makes appraisal of the nature of competition complex. The processing of red meats, for example, has become more concentrated. It seems safe to say, however, that the growth in the poultry meat sector has provided increased competition for red meat. Perhaps disequilibrium models of market behavior deserve more consideration (Ziemer and White), but the limited evidence to date is not very encouraging about the applicability of these models to agricultural markets (Ferguson). Advertising also may be playing a more important role in the demand for foods.

At the same time, different rates of growth in technical change have influenced relative prices. A notable example is poultry meats. Although demand has grown dramatically, supply has grown even faster; consequently real prices have trended downward over the past 30 years.

Finally, the behavior of the error component of demand functions deserves more attention. A number of econometricians have made the point that the error terms of behavioral equations may not have the classical properties. In addition, the number and size of shocks in agricultural markets is larger today than in the past. This is related, in part, to the increased integration of domestic with international markets, and hence the importance of shocks is likely to continue. Some of these changes in demand are "one time" events which appear as outliers, and outliers can have large effects on empirical results. Some shocks, however, seem to have permanent effects on the level of demand that are not fully explicable in conventional terms (for examples see Tomek 1979; Paul et al, p. 12; and citations in Tomek and Robinson, p. 338).

The consequences of some of these problems are reflected in the beef and pork equations shown in Table 3. Two 18-year periods are compared: 1924-41 and 1966-83. Clearly the conventional models fit the recent period less well than they fit the earlier period, and the deterioration in explanatory power is worse for beef than pork. Partial regression leverage plots of the per capita consumption of pork against the price of beef indicate that a strong, logical relationship existed in 1924-41, but not in 1966-83 (Figures 1 and 2). My conclusion is not that pork has no effect on beef demand (for evidence to the contrary, see Table 4), but that the beef model is misspecified for the more recent period.

The difficulty of modeling the current demands for beef and pork is further illustrated in Figures 3 and 4. From 1966 to the present, the demand for beef shifted rapidly to the right and then back to the left. (The lines shown in Figures 3 and 4 are freehand, not statistical, fits.) The shifts for pork are less pronounced, but in both cases, the equations fitted to the 1966-83 sample period yield poor forecasts of real prices for 1984.

The poorer fit of the beef model is consistent with the hypothesis that new demand shifters are at work or that structural changes have occurred. Early in the 1966-83 sample period the demand for beef was growing in part because of the growth in franchised fast food outlets. More recently beef has faced increased competition from chicken and other commodities in fast-food outlets, and perhaps also because of concern about high fat diets. In contrast, the demand for pork did not benefit from the growth in the fast-food sector in the early years (Duewer), but may now be benefiting a little from the decision of fast-food firms to feature breakfasts. At the same time, pork probably is being hurt by health concerns. The general point is that conventional price analysis models do not perform as well for recent periods as they did for earlier periods.

Marketing Margins and Lags

Price analysts have maintained an interest in marketing margins, partly because the size and changes in margins have been a public policy issue. Existing data on margins have been subjected to considerable analysis, particularly from the viewpoint of the transmission of changes in farm product prices to the retail level. A complete model, however, should take account of the effects of changes in retail demand on raw product prices. Likewise, changes in nonfarm input prices, such as wage rates, must be reflected in complete models (Gardner, 1975; see also Lamm and Wescott).

Studies of the transmission of farm prices have rarely been integrated into full models of agricultural markets, while analyses of margins that are part of larger models do not examine possible lags in price transmission (e.g., Ikerd). Furthermore, inconsistencies appear to exist between retail demand and price transmission studies. On the one hand, price transmission studies of monthly data suggest that farm price changes are transmitted rather quickly to the retail level (e.g., Heien, 1980) but on the other hand, analyses of retail demand using quarterly data suggest important, though difficult to identify, lag structures between changes in quantities and changes in prices (e.g., Table 4). That is, specifying a distributed lag response improves R^2, but the preferred specification is far from obvious.[3] The unstable results perhaps reflect the types of specification errors discussed previously. The evidence for lags is sufficiently strong, however, that one would like a better understanding of price adjustments than are contained in existing studies of price transmission or of retail demand. If important lags exist, then retail prices in the long run are more flexible than previously thought.

Another problem is that existing data do not reflect changes in product form resulting from the diversification of food products. Retail prices are collected for a limited number of items at a limited number of outlets. The retail price of beef, for example, is based on fresh beef sold in grocery stores. Thus, the prices of beef sold in frozen dinners or through fast food chains are not measured, and as a consequence, an analysis of margin behavior for beef now represents an analysis of a smaller percent of beef sales than in the past. Moreover, since frozen food and restaurant prices likely are stickier than fresh meat prices, the analysis of existing data does not give a complete picture of the transmission of farm-level cattle prices to the retail level or of margin behavior for beef.

Expanding the Limits

In this section, I suggest some ways in which price analysis might be improved. My comments are confined to model building, data selection, and econometric procedures.

Model Building and Evaluation

Improvements in models occur when limitations in existing models are perceived and when our expertise as agricultural economists is applied to these specification issues. To do high quality research, an agricultural economist must go beyond existing theory and techniques to understand the institutional, biological and physical peculiarities, shocks and special events, and changes in market structure that influence market behavior. This understanding may, in turn, suggest modifications of theoretical concepts, improvements or additions in measuring variables such as age distribution and preferences, and the need (or lack thereof) for new statistical models and associated estimation methods.

Our profession does, of course, have persons who understand the institutional realities of agricultural markets, but these often are not the persons doing quantitative price analyses. Somehow, modeling must become more firmly based on the information available about the agricultural economy, and this knowledge base needs to be expanded. Graduate training in agricultural economics also should be reviewed to determine whether or not it is adequately bridging the gap between abstract theory and applications of this theory to the agricultural sector.

Even with the best of scholarship, however, models will be influenced by experimentation with existing data, i.e., by pretest or sequential estimation. Given the current state of knowledge about the economy, pretesting can be valuable; we learn from the data. But pretesting also can give misleading results. Researchers tend to search for results that validate preconceived notions. The levels of confidence associated with estimates are much smaller than those implied by classical statistical procedures (i.e., the level of type I error is larger, see Leamer; Lovell; Wallace). Consequently, pretesting should be seen as part of the process of developing hypotheses, which must then be subjected to further test.[4]

Our profession also needs to make greater use of past research. Too often, graduate students and their advisers are unfamiliar with the literature, and little is done to critique and update previous empirical analyses.

But, for research to have value to future analysts, results must be reported clearly and honestly. The range of alternative specifications that has been considered should be characterized, and the sensitivity of the empirical results to these alternative formulations should be reported. The reader must have sufficient information to determine the range of alternative specifications considered by the analyst and the consequences of these specifications for the empirical results (Leamer).

Inevitably, statistical criteria will influence the choices of models, and improvements in these criteria are the domain of the econometrician. As applied economists, however, we need to remember that statistical tests are conditional on the underlying model. There is no substitute for critical thinking and knowledge in specifying models.

Data

Errors in variables are a potentially serious problem. Observable variables may not measure the underlying economic concept (e.g., past market price as a measure of expected price); shocks may have created outliers; or the series may contain numerical errors. The analyst must take time to understand the data and their limitations. Fortunately, numerical methods and computer software are available to help identify influential observations and to help assess the degree and consequences of multicollinearity (Belsley, et al).

It is more difficult to determine whether or not the observed variable is a correct measure of the economic concept than it is to detect influential observations. But this is an important question to ask. Our expertise and judgment as agricultural economists remain important in defining relevant concepts and how they should be measured. If existing variables from governmental sources are becoming obsolete, we must work with government agencies to improve these series.

In addition, new sources of data and new ways of using existing data must be found. Cross-section studies of demand--a topic not discussed in this paper because of space limitations--obviously are a rich source of information about household behavior. Such studies, however, have not been notably successful as a basis for forcasting. Research is needed on how to forecast more successfully from cross-section analyses (for an example, see Sexauer). Pooling time-series and cross-section observations has proven useful in some studies, but it is unclear whether such data sets can be developed for foods and fibers. The data associated with computerized checkout systems in grocery stores could become an important source of information for studying retail demand. Micro data from households and stores also may provide insights for identifying variables to measure demand shifts in other studies.

Grocery store data, however, do not provide measures of demand for food eaten away from home, but data for the study of institutional demands for commodities like beef and potatoes may be difficult to obtain. An alternative is to study derived demands at the farm-level, but this too is becoming increasingly complex because the demands for raw products are being derived from a larger number of end uses.

In sum, the limits on demand analysis can be expanded by looking at a broader range of data and variables and by trying to obtain a synergistic effect from these studies. But we also must recognize that existing data are unsuitable for answering some questions.

Econometric Methods

Applied economists now have available a wide range of econometric models and estimators. These models involve various assumptions about the nature of the error terms, about the generation of the variables, and about whether the parameters are fixed or random. Appropriate estimators follow from the assumed model.

Given the modest quality of our models and data, the stock of quantitative tools is not a serious limiting factor to advances in price analysis. In the past, the development of new estimators has been seen as important, and, of course, estimators should be consistent with the processes generating the data. But, today, expectations about the benefits from new econometric methods are lower than in the past because we have had the opportunity to see the latest fads rise and fall. We have come to understand that improvements in methodology are in vain if they must be applied to mediocre data (Malinvaud, p. 614).

The approbation given econometric methods by price analysts, however, sometimes limits progress in price analysis by shifting incentives away from improving models and data. For example, a paper applying a novel econometric procedure to mediocre data may be judged to be a more meritorious contribution than a paper applying a conventional econometric method to novel data or to an improved model.[5] Yet, as I argued earlier, the major advances in supply analysis have come from improved models, not from new estimation methods. Thus, as we write research proposals and review manuscripts, we must keep in mind that significant contributions to knowledge are not limited to, nor do they necessarily require, the latest wrinkle in econometrics.

The challenge to applied economists is to select econometric tools that are appropriate to their problems. In the 1950s, for example, simultaneity was seen as a relatively important problem, and errors in variables were barely mentioned. Now, it seems clear that biases related to specification error and errors in variables are often more important than those related to simultaneity. The important point is that the researcher must ask, what are the relatively important statistical problems and then, what econometric methods address these problems?

Concluding Remarks

The areas in need of greatest improvement are demand and marketing margin analysis. As I have indicated, however, both models and data have become increasingly inadequate relative to the growing complexity of food and fiber markets. Existing secondary data seem especially inadequate for studying product demands in retail markets, and fundamental work needs to be done to obtain relevant data. At present, price analysts may need to concentrate on farm- and wholesale-level demand, because observations at this level presumably reflect the total demand for farm products derived from the various retail uses.

Progress is likely to come from a multifaceted approach. Better basic concepts will lead to more appropriate models and improved data, and conversely conceptual insights depend on empirical observation. Clearly, pushing back the limits on price analysis is a difficult challenge. This challenge can be met best when we are agricultural economists, not just technicians. Breakthroughs in research will come from imagination and judgment based on a sound knowledge of the agricultural economy as well as of theory and methods. Our unique contribution as agricultural economists is to exploit that knowledge.

Footnotes

President address.

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1. Increases in production in response to higher prices can be constrained by the biological production process; no such constraints exist for culling.

2. Eckstein presents a model of agricultural supply in a rational expectations framework, but Eckstein's and Nerlove's models appear to have identical reduced form equations. Fisher shows that the rational expectations hypothesis provides a reduced form similar to distributed lag reduced forms.

3. The coefficients are relatively unstable over the alternative specifications. Curiously, the lagged quantity of pork alone provides better statistical fits than the current quantity alone, while including both current and lagged quantities of pork result

in the current quantity variable having a small t ratio. One wonders whether the demand structure has changed, whether important variables have been omitted, or whether problems exist in the data series. Chavas concluded that the demand for beef had a structural change in the 1970s, but this is disputed by Moschini and Meilke. Conclusions from such tests are, of course, conditional on having a correct model.

4. The danger of pretesting has increased because computing has become inexpensive. Given a fixed data file, the marginal cost of an additional regression equation is tiny. It is easy to substitute computing for critical thinking. As a result, the empirical results reported from current price analyses probably have been culled from a huge number of computer runs. Inevitably, if a large number of alternative specifications is tried, "significant" results will be found, but these results will likely reflect the peculiarities of the sample rather than fundamental relationships of the population. Clearly, with pretesting, results are not statistically significant at some prespecified level, like five percent, chosen from a t table, and authors should refrain from implying that they are.

5. This perhaps is a pervasive problem in economics. As Rivlin (p. 4) said 10 years ago, "Ingenious efforts to tease bits of evidence from unsuitable data are much applauded; designing instruments for collecting more appropriate information is generally considered hack work."

Table 1. Soybean Acreage Response Functions, U.S., 1950-72 and 1950-74

Equation	Explanatory Variables					R^2
	FPS_t	FPC_t	A_{t-1}	t		
(1)[a]	7.2	-10.2	0.55	0.59		0.98[d]
	(3.6)[c]	(2.0)	(2.4)	(1.3)		
	PS/PC_{t-1}	PSS_t	PFC_t	DPC_t	A_{t-1}	
(2)[b]	5.6	2.4	-3.9	-9.7	0.87	0.99
	(3.0)	(1.3)	(2.0)	(1.1)	(16.5)	

a Dependent variable = millions of acres planted; A_{t-1} = dependent variable lagged; t = time (1950=1, 1951=2, etc.); FPS = price of Jan. soybean futures contract in April-May; FPC = price of Dec. corn futures contract observed in April; 1950-74 sample period (Source: Gardner 1976, p. 83).

b Dependent variable and A_{t-1} as in note a; PS/PC = ratio of soybean to corn prices received by farmers; PSS = effective support price for soybeans; PFC = effective support price for corn; DPC = effective diversion payment rate for corn; 1950-72 sample period (Source: Houck, et al, p. 40).

c t-ratios.

d Corrected for degrees of freedom.

Table 2. Per Capita Consumption of Selected Animal Products, U.S.

Time Period	Red Meats: Beef	Red Meats: Pork	Red Meats: Other	Poultry Meat	Fish	Cheese	Eggs	Total
	pounds per capita[a]							
1950-54	53.5	62.7	11.2	26.9	11.4	7.6	48.4	221.7
1955-59	63.8	60.0	11.0	31.7	10.5	7.9	45.8	230.7
1960-64	68.0	59.8	8.9	37.4	10.6	8.9	41.2	234.8
1965-69	78.5	58.2	6.8	44.5	10.9	10.2	39.9	249.0
1970-74	83.7	62.5	4.6	49.6	12.1	13.0	37.9	263.4
1975-79	87.9	56.0	4.3	54.4	12.8	16.1	34.7	266.2
1980-83	77.4	63.6	3.0	63.4	12.7	19.2	33.7	273.0

a Retail-cut or ready-to-cook equivalents. Sources: Hiemstra, Stephen J. <u>Food Consumption, Prices and Expenditures</u>. USDA Agr. Econ. Rep. No. 138, 1968 and <u>Food Consumption, Prices, and Expenditures</u>. USDA Stat. Bull. 713, Nov. 1984.

Table 3. Inverse Demand Relations, Beef and Pork, U.S.

Sample Period	Explanatory Variables[c] Inter	QBF	QPK	QCH	INC	TRD	$\bar{R}^2$	DW
	--------beef price dependent--------							
1924-41	106.4	-1.492	-0.505	-	0.044	0.118	.93	1.85
	(13.55)[a]	(10.16)	(6.62)		(12.22)	(1.25)		
1966-83	104.9	-1.306	0.230	-2.639	0.060	3.899[b]	.62	2.06
	(1.40)	(3.42)	(0.74)	(4.72)	(3.42)	(0.65)		
	--------pork price dependent--------							
1924-41	108.4	-0.418	-1.315	-	0.049	-1.068	.97	2.09
	(15.96)	(3.29)	(19.90)		(15.57)	(13.09)		
1966-83	110.6	-0.393	-1.161	-1.310	0.039	-0.441	.89	1.97
	(2.77)	(1.96)	(6.29)	(2.00)	(4.26)	(0.52)		

a t-ratios in parentheses; DW = Durbin-Watson statistic.

b TRD = natural logarithm of time for 1966-83 period.

c Arithmetic means, annual observations, 1924-41: PBF = 66.5 cents/lb. (price deflated by CPI, 1967=1.0); PPK = 59.4 cents/lb. (deflated by CPI); QBF = 42.8 lb./capita; QPK = 60.9 lb./capita; INC = 1208 $/capita (deflated by CPI), TRD = 9.5. Means, 1966-83: PBF = 90.7 cents/lb (deflated by CPI); PPK = 67.8 cents/lb (deflated by CPI); QBF = 82.6 lb./capita; QPK = 60.2 lb./capita; QCH = 43.5 lb./capita; INC = 3114 $/capita; TRD = 9.5; log of TRD = 2.022.

Table 4. Selected models of retail beef prices, U.S., 1975-I to 1983-IV

Estimation method	Explanatory variables[a]													
	Inter	QBF	QBF-1	QPK	QPK-1	QCH	INC	PBF-1	D1	D2	D3	$\bar{R}^2$	DW[c]	ρ[d]
OLS	139.2	-5.344	-	-0.228	-	-8.577	47.79	-	2.092	8.648	10.48	.31	0.72	-
	(2.26)[b]	(3.83)		(0.19)		(4.34)	(2.80)		(0.61)	(2.11)	(2.48)			
OLS	11.49	-2.739	-	-1.266	-	-3.796	36.95	0.810	1.394	5.418	3.677	.87	2.08	-
	(0.39)	(4.16)		(2.34)		(3.90)	(4.88)	(10.86)	(0.93)	(2.96)	(1.88)			
OLS	49.21	-3.540	-	-	-1.495	-4.748	35.79	0.750	4.459	8.072	7.086	.87	2.03	-
	(1.39)	(4.46)			(2.63)	(4.99)	(4.84)	(10.31)	(2.80)	(5.22)	(4.09)			
GLS	209.5	-4.524	-	-	-2.470	-4.732	18.09	-	4.457	6.559	7.965	-	-	0.52
	(2.77)	(3.18)			(2.03)	(2.62)	(1.06)		(1.83)	(2.54)	(3.13)			(3.65)
GLS	242.3	-3.770	-2.756	-	-3.204	-6.713	30.59	-	6.192	9.306	7.760	-	-	0.61
	(3.33)	(2.94)	(2.05)		(2.80)	(3.14)	(1.68)		(2.68)	(3.27)	(3.43)			(4.63)

a QBF = consumption of beef, lb./capita, retail weight (mean = 20.8); QPK = consumption of pork, lb./capita (14.8); QCH = consumption of young chicken (11.3); INC = disposable income, deflated by CPI, $1000/capita (3.270); PBF, dependent variable = retail price choice beef, deflated by CPI, cents/lb. (89.9); D1, D2, D3 = seasonal dummy variables; -1 subscript = one quarter lag. Sample period = first quarter 1975 through fourth quarter 1983, with lags starting in fourth quarter 1974.

b t-ratios shown in parentheses.

c DW = Durbin-Watson statistic, which strictly speaking is not applicable to the models with the lagged dependent variable.

d ρ = estimated first-order autocorrelation parameter of error term.

FIGURE 1. PARTIAL-REGRESSION LEVERAGE PLOT, PRICE OF BEEF AND QUANTITY OF PORK, 1924-41

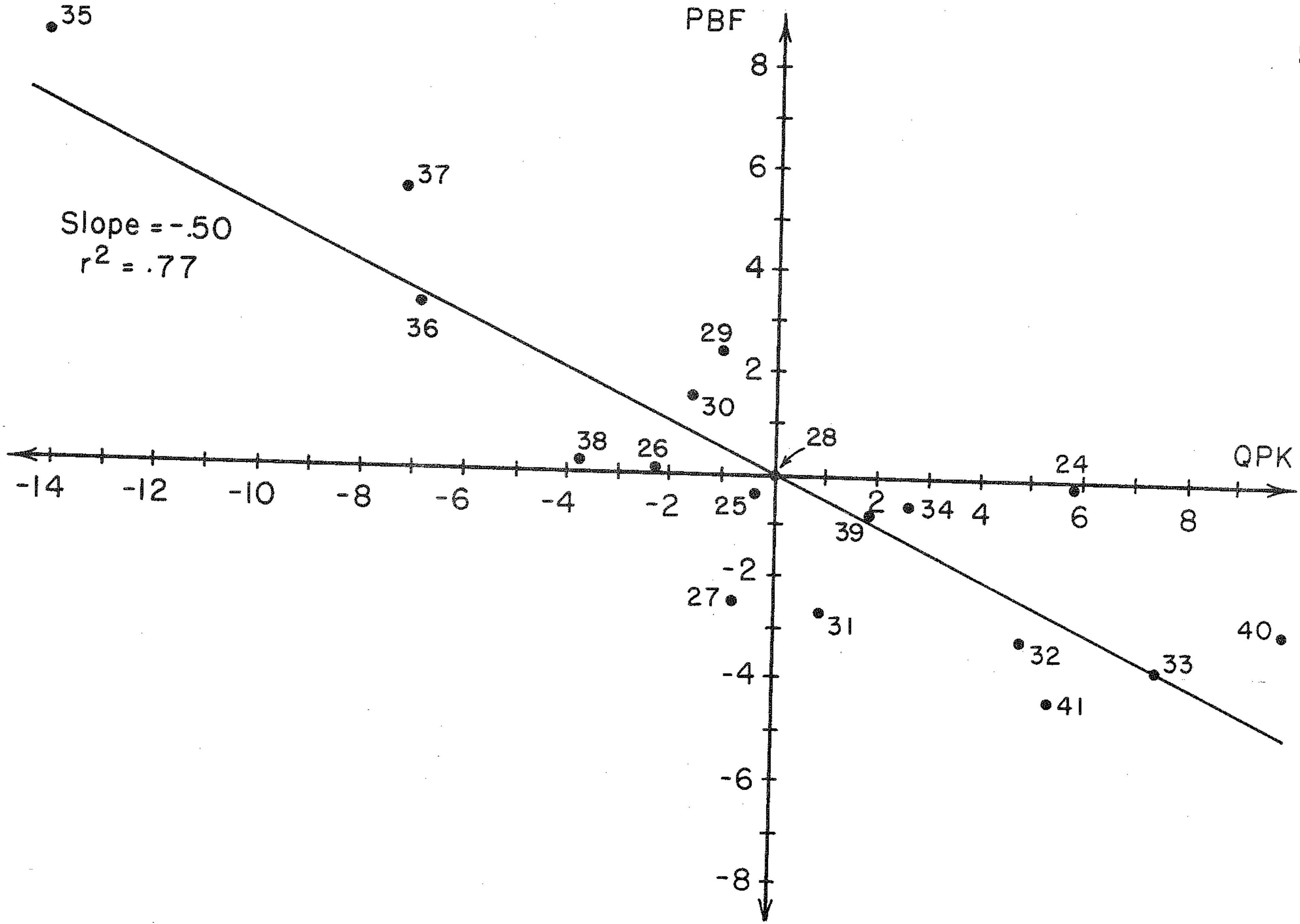


FIGURE 2. PARTIAL-REGRESSION LEVERAGE PLOT, PRICE OF BEEF AND QUANTITY OF PORK, 1966-83.

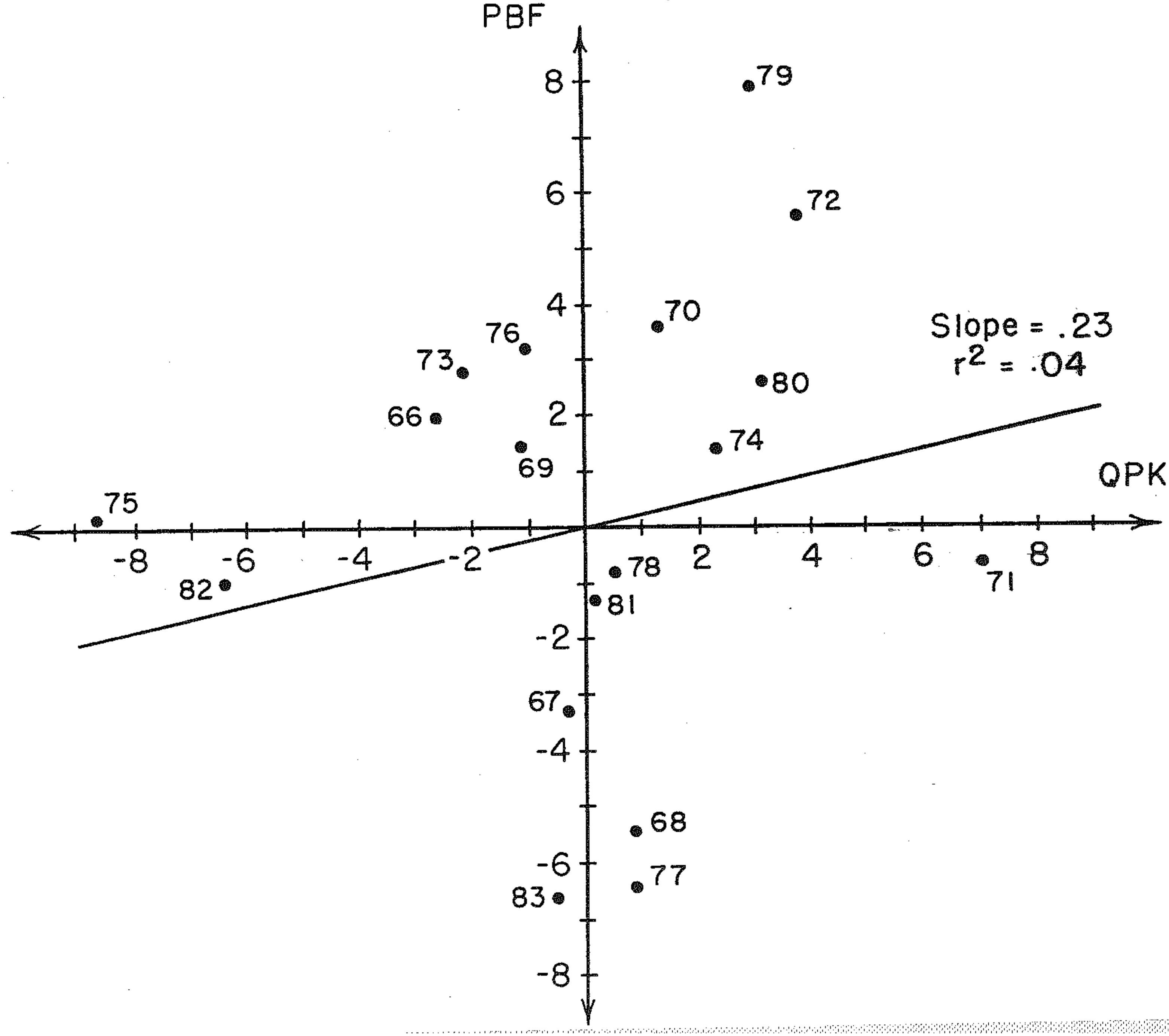


FIGURE 3. BEEF CONSUMPTION AND PRICES, U.S., 1966-84

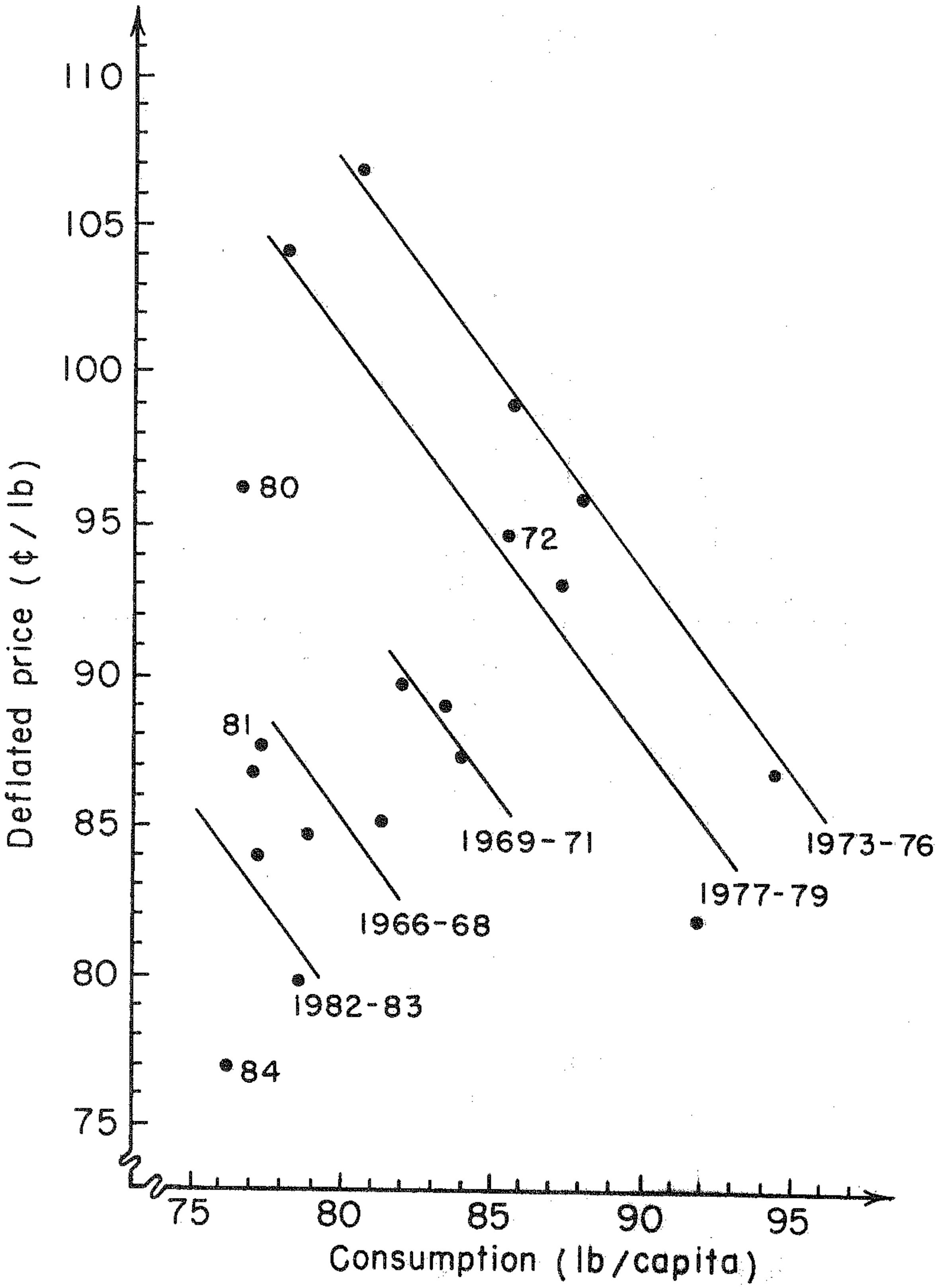
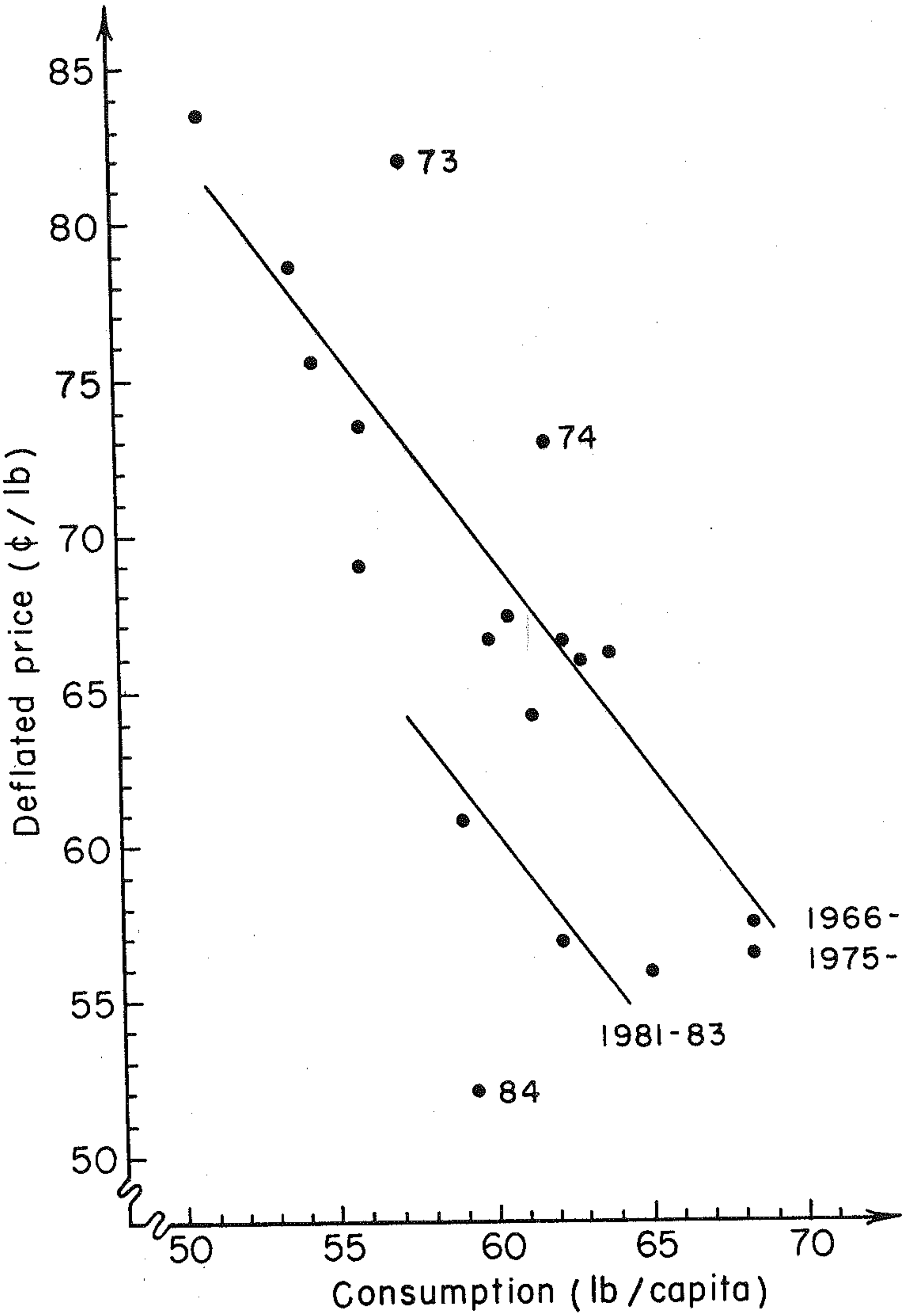


FIGURE 4. PORK CONSUMPTION AND PRICES, U.S., 1966-84



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