PROCEEDINGS

of the

WESTERN FARM ECONOMICS ASSOCIATION

THIRTY-SEVENTH ANNUAL MEETING

JULY 15, 16, 17, 1964

CALIFORNIA STATE POLYTECHNIC COLLEGE
SAN LUIS OBISPO, CALIFORNIA

DEMAND AND PRICE MODELS FOR LIVESTOCK AND MEAT

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This paper is directed toward the livestock-meat economy, but much of what is to be discussed could be generalized to other commodities. What are economists attempting to accomplish with the quantitative formulation and estimation of demand and price models? A model is an abstract system of variables and relationships designed (1) to gain an understanding of real world phenomena in which one is interested and (2) to predict future events associated with those phenomena which the model was designed to explain. The ability to achieve both objectives would be of significant value as a guide to policy and decision-making in government and private sectors of the economy.

Economics is a science which embraces laws as do other sciences. With respect to a deductively formulated theory, economics contains accurate premises and well established conclusions. However, the applied economist must constantly be aware of limitations of methodology in current economic theory in his empirical investigation of real world conditions.

Concern has been expressed by some in the field of economics relative to the efficacy of existing economic theory and the ability of econometric techniques to explain and predict economic behavior. Do we expect too much from our quantitative models in relation to the prediction of future events? Does not the construction and testing of quantitative models lead to the development of economic knowledge even though they may be limited in their predictive abilities? Prediction of economic variables outside of the sample period, in most cases, has not been highly successful. Yet, econometric models have given quantitative expression to economic concepts essential to the investigation of many economic problems.

The objectives of this paper will be (1) to examine some of the limitations of methodology in economics and the associated problems with methods or techniques used in demand and price analysis and (2) to compare some empirical results of prewar and postwar demand and price models related to the livestock meat economy.

Limitations of Methodology in Economics

W. A. Cromarty, (ref. 9, p.365) in discussing free market price projections based on econometric models makes the following statement: "We are in the infancy stage of estimating economic interrelationships among agricultural commodities. The slowness of development is in part a result of three usual apologies given: lack of data, inadequate statistical techniques, and complexity of making statistical estimates." An additional major obstacle, Cromarty says, is failure to reformulate and reestimate our econometric models to meet the need of policy requirements. It might be added that a most essential problem in the development of predictive models is the limitation of methodology in contemporary economics.

This paper is not a discourse on methodology, but rather a discussion of techniques, equation analyses to be more specific, which are directed toward studies of the livestock-meat sector. However, like the economic

theorist who deems it necessary to delve behind the demand curve with indifference curve analysis, I think it important to briefly review what lies behind the economist's tools or techniques of analysis, namely the methodology used in economic science. 1/ Methods or techniques such as equation analysis are tools used to apply existing knowledge in the attempt to solve problems and establish guidelines for economic decision-making. This does not omit the possibility that such tools and techniques contribute to the pursuit of new knowledge.

F. S. Northrop (ref. 28) expounds two reasons for the failure of contemporary economic theory to obtain a theoretical dynamics and thus the problems associated with prediction. First, the basic postulates of economic theory refer only to the generic (form) properties of the subject matter rather than to the specific (content) properties. Second, the theory must account for the relation connecting the specific state of a given system with the possibility of deducing future states of the system.

Econometric techniques involve the quantitative formulation of laws and the statistical testing of such formulations. When theory is coupled with empirical observation, it may enable one to foresee some of the probable economic developments relative to the relationships under study.

All economists recognize that their field of inquiry is not capable of prediction in the physical science "sense of the word," since the researcher in economics cannot place the degree of trust in the stability of a described relationship as can physical scientists in some instances. The economist is well aware of changing conditions as a result of shifts in technological, sociological and psychological factors. Thus, laws of economics state that under given conditions given changes will occur.

A theory by its very nature is an abstract concept, i.e., it attempts to lay bare those essential variables which explain the underlying relationships involved. A "cluttering" of the relationships might result if a complexity of variables were considered. The empirical derivation of static supply and demand relationships reflect the postulates of supply and demand theory with their sets of given constants (tastes, technology, etc.). Wants and satisfactions are represented by variables which are quantified in terms of data generated by the marketing system. An empirical equation cast in the mould of an abstract theory cannot be expected to predict in a variant system with the accuracy desired by its formulator. Certainly, such a theory must be modified or extended by the researcher in studying specific situations. A quantitative model derived from its theoretical counterpart which is static and limited in its empirical content relative to human behavior is not likely to achieve large successes in the prognostication of future events.

1/ Methodology as defined here is the philosophy and logic as related to the discovery of new knowledge.

The term "statics" has been used considerably in economic literature as has its opposite term "dynamics." There are perhaps as many definitions for these terms as there are economists present at this session. A point that is generally clear is that we are not using the term "dynamics" as defined in the "physical science sense." Loosely speaking, "statics" embraces the "givens" of economic life (i.e., wants and means of satisfactions.) Dynamics is defined by econometricians with a stochastic framework. Marschak (ref. 25) defines models as dynamic if they have at least one of the two following properties: (1) at least one observable variable occurs in the structural equation with values taken at various points of time, and (2) at least one equation contains functions of time. Most economists would agree that taking into account the change or time path of a variable is an improvement over the static approach.

The random disturbance term in many quantitative models which represents the joint effect of explanatory variables that may appear in a system but are not directly considered in the model is quite often disturbing. The disturbance term recognizes that human behavior is not fully explainable. The disturbances are assumed to be of a random rather than of a systematic nature. The investigator is hopeful that the behavioral equation takes into consideration explicitly the major systematic influences and that the sum of any systematic influences remaining are in the disturbance term and behave as if random.

Kuznets (ref. 19, pp. 893-94) asks the question, "Can we be reasonably sure that the relations among the economic variables which we are attempting to measure are unaffected by concomitant changes in the social variables?" He answers his own questions by saying: "probably not, unless the time period under investigation is relatively short, shorter than is necessary for time series analysis of demand."

Marschak (ref. 25) states that random disturbances or shocks obey certain probability distributions and thus cut short the complicated causal explanation of why tastes, for example, fluctuate the way they do. Lee (ref. 21) suggests that it seems the responsibility of economists to develop a satisfactory theory of random disturbances which would lead to more correct specification of models.

Morgenstern (ref. 27) concerned with the accuracy of economic observations, implies that differences between calculated and observed variables may be due to a combination of both omission of social and minor economic variables (random disturbance term) and the degree of error in the basic observation of economic phenomena. Currently, estimating techniques are not sufficiently developed to clearly differentiate between errors in observations of explanatory variables and omission of social variables in an equation and the relative magnitude of their respective effects on differences between observed and calculated variables. Many of the variables included in the random disturbance term are probably comprised of noneconomic variables. Are economists willing to go outside the confines of economics or collaborate with other social scientists? Even if these seemingly overwhelming problems associated with errors in observation and the random disturbance term were to be overcome, another major obstacle remains. It is the assumption of constancy of the basic economic and social relationships underlying the equations of analysis insofar as the prediction of future events is concerned. Although the probability

distribution of residual errors in predicting equations may be known from distributions of past data, it must be assumed to remain constant for the period of prediction considered outside the sample. The probabilistic nature of estimating equations in itself is not the major difficulty. The possibility of shifts occurring in the probability relationships is the major source of concern.

Some Empirical Studies Of Livestock Food Products And Meat

The livestock-meat sector has provided a "happy hunting ground" for analysts since the initiation of quantitative analysis. In a relative sense, more available data, less restriction of production and marketing activities, and importance in policy decisions appear to be major reasons. The majority of analyses have been associated with meat products at the retail level. In system-of-equation studies the retail demand equation has been estimated most frequently. Relatively few studies have involved estimation of derived demand relations for livestock food products at the farm or ranch and feedlot level. 2/ Several consumer budget studies using cross sectional data have been undertaken in efforts to analyze consumer behavior relative to expenditures on meat products. Some models have been employed strictly for purposes of forecasting price of livestock and livestock food products. These latter type of price forecasting models are not necessarily constructed for purposes of estimating structural parameters such as price and income elasticities of demand. However, the use of existing economic theory is implicit in these formulations.

How does one assess the abilities of various quantitative models in relation to explanation and prediction? Most would agree with Christ's answer, and that of others, to the above question: "The ultimate test of an econometric model, as of any theory comes with checking its predictions." (Ref. 7, p. 43) I would add that statistical measurement and consistency with theory are intermediate objectives of econometric models, but that the ultimate objectives as with any science is prediction. Christ (ref. 7) presents procedures for testing the validity of econometric models and classifies them as tests of internal consistency and extrapolation and prediction. The former test includes such procedures as checking magnitude, algebraic sign, and sampling variance of estimated structural coefficients, and the calculation of disturbances. The test relative to the assumption that disturbances are not serially correlated is also considered. In testing successes in prediction, Christ points out three methods, the tolerance interval test, the use of naive models 3/ as a comparison technique with

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2/ Such an analysis has been initiated by the Western Regional Livestock Marketing Committee.

3/ Naive models have no underlying theoretical basis, but are used as a benchmark for comparison purposes.
Naive model I = $Y_{c_t} = Y_{a_t} - (Y_{a_t} - Y_{a_{t-1}})$
where Y_{c_t} = calculated observation in time period t, and Y_{a_t} = actual observation in time period t.
Naive model II = $Y_{ct} = Y_{a_{t-1}} + (Y_{a_{t-1}} - Y_{a_{t-2}})$ where variables are defined above.

the estimating model, and the comparison of calculated disturbances among various estimating techniques utilized in a given study.

Most published econometric work includes tests of internal consistency and comparisons of calculated disturbances between different methods of estimation. However, tests of prediction 4/ outside the sample period are not abundant. A major reason, of course, is that the researcher uses as many years as are available for the analysis, publishes, and then embarks on other things. There are a few individuals who test models for their predictive ability after several years have elapsed. Testing models constructed by other researchers is an arduous task. It is evident that there is not complete agreement on different estimating techniques to be used in econometric investigation. It is further evident that complete agreement has not been reached relative to objective criteria for judging the predictive ability of various models. Data problems arise with regard to revised series from the sample period to the period of prediction. A problem as to specifically how data was synthesized for particular variables by the formulator of the model presents itself to those interested in assessing a model's predictive powers.

Some Prewar Analyses

Karl Fox (ref. 13) studying changes in the structure of demand for farm products for prewar and postwar periods illustrated differences between actual and estimated changes in retail and farm price for livestock food products and meat outside of the sampling period. The time period was 1922-41, and the estimating technique was the traditional least squares method in logarithms of first differences. In his analysis for livestock food products and meat, high R^2's and statistically significant coefficients were obtained in all cases. Fox checked actual and estimated changes for two postwar years for retail price of all meat, beef, pork and farm price of cattle and hogs. 5/ Estimated and actual changes for the two postwar periods of change were also calculated for all meat animals, cattle and hogs. For estimated retail price, three estimates were within one standard error, one was within two standard errors, and two estimates were off by more than two standard errors. An interesting point to note is that the two estimates outside of two standard errors were for changes in beef and pork retail prices from 1952-1953. There was a pronounced change in actual retail, terminal, and farm price for 1952-1953. Estimated changes in farm prices for all meat animals, cattle and hogs for 1952-53 fell within one standard error. As Fox indicated at the time of printing, his check on predictions was limited in scope and significance. 6/ The two-year periods of change (1952-53 and 1953-54) should probably not be considered sufficient for testing the applicability of the prewar equations to postwar data. Further application of the estimated prewar equations to postwar data could provide significant insights regarding the hypothesis of a relatively stable consumer behavioral relationship over the years.

4/ Test of prediction is used here in the sense that observations outside the sample time period have already been generated.

5/ Deviations between actual and estimated prices for 1947-52 (ref. 12) were checked against error tolerance. A portion of the deviations were attributable to readjustment after the war period. Some deviations might also have been the result of structural change.

6/ He did indicate, however, that the tests tended to support the assumption that demand structures for major farm products had undergone only moderate changes in the past decade.

Kuznets (ref. 19) in his review of some selected market demand studies for prewar analyses appraised the performance of alternative estimating procedures (least squares and limited information) for food and particular livestock food products. Estimates of income and price elasticities of demand from both techniques for livestock food products displayed close agreement. This was not so true, in general, with respect to meat. Price elasticities of demand 7/ at retail for meat with assorted estimating techniques and different variables in the dependent position ranged from -.24 to -.93. However, the majority of estimates fell between -.62 and -.79. Estimates of income elasticity of demand for meat were very consistent, between .50 and .59. Estimates of price elasticity of demand for beef were -.77, -.79, -.94 and -1.20, with income elasticities of .73, .83, 1.00, and .65, respectively. A price elasticity of demand for beef at the farm level was estimated at -.84. In pork studies price elasticities of demand were -.81, -.86, -1.18, and -.91. Their respective income elasticities of demand were .72, .78, 1.09, and .77. An estimate of price elasticity of demand at the farm level for pork was -.65.

The predictive performance of the two estimating techniques cited above yielded percentage forecast errors for livestock food products and meat for postwar years which varied from 2 to -27 percent. In evaluating this performance Kuznets remarked: "It has not been possible to compute forecasts for each of the studies included in this review so that a general statement cannot be fully supported. The general tendency, however, is clear: analysis based on interwar data, whatever method was employed, by and large failed to account for the behavior of the dependent variables, at least in the immediate postwar years." (Ref. 19, p. 892)

Hildreth and Jarrett (ref. 17) in their well-known investigation of the livestock-feed economy, estimated demand for livestock products at the farm level using least squares and limited information techniques for the period 1920-49. Utilizing tests of prediction previously mentioned, for 1950, the residual error fell outside the two standard error interval. Hildreth and Jarrett suggested that a residual error may fall in the critical region as a result of statistical accident, an incorrect specification of the model, or as a result of structural change. Although a one-year test for the highly aggregative model seemed hardly sufficient, the authors indicated the possibility of structural change since the relatively "good fit" in prewar years failed to predict successfully for 1950.

How does one evaluate stability or lack of stability in demand relationships for meat products? Evidence of structural change may be detected in an ex-post situation or may be considered in an analysis if a change in structure is anticipated. The possibility also exists that a fairly stable relationship may hold for periods of time.

Fox (ref. 13) mentions demographic and economic change as factors affecting structure of demand. Three possible methods of investigating

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7/ It should be noted that some of the estimates are reciprocals of price flexibility coefficients. When reciprocals of price flexibilities are interpreted as price elasticities of demand it is assumed that consumption of the commodity in question is not measurably affected by other commodities.

the stability of demand relationships over the last forty years are: 1. A qualitative assessment of those factors not explicitly considered in equation analysis. 2. A comparison of estimates of prewar equation analyses with postwar observations, and, 3. An estimation of new equations for the postwar period and comparison with prewar analyses. The predominant qualitative approach in method (1), by itself, does not seem sufficient. Method (2) has been attempted by some, but no conclusive evidence has been established.

Some Postwar Analyses 8/

Results of some postwar analyses are shown in Appendix Table I. Estimates of price and income elasticities of demand and tests for internal consistency of most models are presented. Some differences in elasticity estimates are to be expected since various estimating techniques, explanatory variables, and methods of data construction were utilized. Also it must be assumed that the models used in deriving the estimates were correctly specified. Any significant differences between ranges of estimates between different time periods may provide insight into possible change in structural relationships.

The results of studies shown in Appendix Table I, in general, indicate "correct" algebraic signs and statistically significant coefficients. 9/ Income coefficients for postwar analyses exceeded their standard errors and at times displayed wrong signs. Tests for serial correlation in residuals, when reported, were mostly inconclusive.

Price elasticities of demand at retail for red meats for prewar and postwar analyses appear different. Whether the difference is significant in a statistical sense is open to question. The range of price elasticities of demand at retail for beef and pork within the prewar and postwar periods is large, leaving little or nothing to be said about changes between periods. Price elasticities at the farm level appear to be decreasing over time, but evaluation is difficult since only one study was observed for most products.

Most economists expect that income elasticities of demand for meat products should be lower for the postwar years. 10/ Some postwar analyses relating to livestock food products and meats have displayed statistically insignificant income coefficients, and in some instances, negative signs. 11/ 12/

8/ Several models include prewar observations.
9/ Other coefficients were not presented because of space limitation.
10/ Whether or not income elasticities between prewar and postwar periods are significantly different is open to question. Fox (ref. 13) suggested a possible reduction of 5 to 10 percent.
11/ Kashiwa and Wyckoff (ref. 38) obtained an income elasticity of demand for beef for the U.S. of 1.5 for the period 1947-59.
12/ Hassler (ref. 16) derived an income elasticity of demand for beef and pork of .84 and -.24 respectively. (Calculated at the mean of a data series for the period 1949-59.)

TABLE I. A SUMMARY OF SOME ESTIMATES OF PRICE 1/ AND INCOME ELASTICITIES 2/ OF DEMAND FOR LIVESTOCK FOOD PRODUCTS AND MEAT AT THE FARM AND RETAIL LEVEL

RETAIL LEVEL

	Prewar		Prewar and Postwar		Postwar	
	n^{D}_{P}	n^{D}_{I}	n^{D}_{P}	n^{D}_{I}	n^{D}_{P}	n^{D}_{I}
Red meat	.62 to .79 3/	.50 to .59			.29 to .44 4/	.07*, .35* 4/
Beef	.77 to 1.20	.65 to 1.00	.76 to 1.00	.58 to .97	.55 to .89 5/	.06*, .09* 4/
Pork	.81 to 1.18	.72 to 1.09	.75 to 1.13	.68 to .86	.73 to .91	.01*, .26* 4/

FARM LEVEL

	Prewar	Prewar and Postwar	Postwar
	n^{D}_{P}	n^{D}_{P}	n^{D}_{P}
Beef	.84 4/	.72, .74 4/	.68 4/
Pork	.65 4/	.42, .55	.35, .37

1/ Some price elasticities are reciprocals of price flexibility coefficients. Per capita production was used in some studies.
2/ A range of elasticities is presented unless otherwise specified.
3/ Signs ofprice elasticity estimates disregarded.
4/ Based on one study.
5/ Does not include long run n^{D}_{P} of .99 and 1.0 as computed by Tomek and Cochrane.
*/ Not statistically significant at the 5 percent level.

Income elasticities in Table I displayed both of these characteristics, while some income flexibility coefficients were not significant and others exhibited incorrect signs. A range of estimates of income elasticities of demand for the postwar period are not available for comparison with prewar estimates.

Most postwar analyses have not included tests of prediction. Reasons for this have already been mentioned. Some studies compared actual and estimated observations within the sample period. (Ref. 5 and ref. 20.) Two recursive models (ref. 15 and ref. 23) were used in predicting livestock supplies and prices. The predictions tend to deviate from actual observations as postperiod trials progress outside the sample period. However, it may be argued that the test period was not sufficient in length to justify any immediate conclusions. Standard errors of forecasts were not available for the models.

SOME FINAL REMARKS

If behavior patterns are evolutionary in nature, as assumed, then a stable relationship underlying demand analyses may well exist. It may also be reasonable to assume that within such a time series taste patterns or other nonobservable factors could cause changes in structural parameters. Changes in behavioral relationships with respect to price elasticities, cross elasticities, and income elasticities of demand for meat products may have effects through the entire system. Consumer income and change in particular sectors of the marketing system may have a significant impact on structural parameters in the derived demand for livestock products.

There is not much doubt that econometric analyses perform an essential role in providing insight relative to economic relationships. Confidence in the predictive ability of models for more than a few years past the sample period may be on somewhat shaky ground since the assumption of stable relationships underlying the technique when applied to economic behavior may not be realized. It is well to emphasize the fact that econometric models must not only be checked for internal consistency, but should further be tested for their predictive ability. Reformulation and continual testing of models seem to be essential for use in short term predictions. Some "conditional normative" economic models (location models for the livestock-meat economy for example) are dependent upon "positive" equation models for input data; hence, the importance of testing and revision of "positive models," becomes even greater.

Finally, perhaps the key to a theory of random disturbances lies in the ability of economists to formulate a general theory of economic development. A theory of change related to those economic and noneconomic variables which are the unobservables in econometric analyses may provide the necessary framework to explain behavioral patterns in the economic system.

DISCUSSION: DEMAND AND PRICE MODELS FOR LIVESTOCK AND MEAT

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Dr. Malone's paper has served well to summarize current thinking on problems of model specification in empirical economic research. He has contributed to the recognition of three crucial elements:
(1) tests of the results of models following empirical measurement.
(2) specification of the probability distribution of residual error, and
(3) the degree of detail that is desirable in the specification of empirical models.

I will comment briefly on each of these major points with the purpose of underlining Dr. Malone's discussion as well as to raise questions that are suggested by his remarks.

Dr. Malone provides a workable definition of a model but I would add that a model may usefully be viewed as consisting of two distinct parts. These are (1) the economic content and (2) the empirical content.

The former identifies relevant economic variables and the form of the interrelationships among them. For example, in a model of the demand for meat, the price of meat, quantity taken of meat, prices of substitute commodities and consumer incomes would usually be specified as the relevant variables. Relations among these variables would also be specified as to form, e.g., quantity taken is dependent upon the other variables, assuming that consumers are price takers.

Empirical content of a model includes such considerations as (1) the form of the data (time series, cross section, degree of aggregation) and (2) the appropriate techniques of measurement (linear in logs vs quadratic, systems of equations vs single equation).

Granted, in a complete model the empirical content depends on the economic content. Choice of the systems of equations approach in our example requires the prior economic specification that both the quantity supplied and demanded are simultaneously determined by price. But as a matter of methodology, viewing the model in two parts would tend to guard against the tendency for economists to search for economic models which "fit" existing statistical techniques or to despair at considering certain problem areas because of inadequate data. It seems that in too many instances researchers have been trapped into viewing construction of economic models from the vantage point of the statistician. A consequence of this is that the technique becomes the primary mover in our approach to economic problems.

I would underline the statement that models need to be subjected to more and better tests, particularly with respect to their predicitive ability. However, internal consistency (proper signs and magnitudes of structural coefficients) and accurate prediction are necessary but not sufficient grounds for accepting specific models.

It is conceivable that results can be internally consistent with accepted economic theory and even that they predict the variable accurately, yet the theory may not be a true representation of actual economic behavior. The results of an empirical study of future-price movements were internally consistent with the concept of hedging as the transfer of a risk premium to speculators (1, pp. 401-402). Gray found that another theory, one representative of actual economic behavior, was equally consistent with the empirical results (2, pp. 31-34). Clearly, a test more powerful than internal consistency was needed. In this example consideration of another variable, the government-loan program, provided the test. Moreover, results of studies based on the risk premium idea would accurately predict the behavior of future prices (at least during years in which the government-loan program was operative), but then the researcher would be right for the wrong reasons.

One more question arises in this regard. What if no "real world" data are available for testing a model's predictions? Nerlove (3) postulated that lags occur in consumer response to price changes and that the response pattern is of the form:

$$q_t - q_{t-1} = b \quad (q^*_t - q_{t-1})$$

where q_t is the quantity taken in time, t, b is the coefficient of adjustment, and q^*_t is the long-run equilibrium quantity. Since q^*_t is not in fact observable, how is it possible to test the predictive ability of the model? Perhaps the only sufficient approach to the testing of an economic model is, as demonstrated in the above example and as argued by Working, "...testing against alternative hypotheses" (4, p. 1429).

The statement, "A 'cluttering' of the relationships might result if a complexity of variables were considered", somewhat confuses the issue since Dr. Malone goes on to encourage modification and extension of theory by the researcher. I take the latter to mean that theory must be made more specific, i.e., it has to be "cluttered" in order to provide a meaningful guide to the quantification of most economic relationships. If the object of building price models is to be the development of elegant, uncluttered theory, then our task is simply that of putting "meat" on the old "bones" of neoclassical theory.

I agree that attempts to specify the probability distributions or the exact nature of the disturbance terms in econometric models are necessary. A general theory of economic development may well facilitate the specification of changes in taste over time as well as many of the "social" variables, including demographic considerations. I would suggest, however, that a more thorough specification of models (more "cluttering") would substantially decrease the importance of the disturbance term and the necessity of specifying it. Thus, part of the solution (one perhaps more attainable) is that we need to wean ourselves from the notion that elegant models are necessarily preferable to the cluttered variety.

Finally, perusal of the results of the 7 postwar demand analyses summarized in Malone's Appendix Table 1 suggests that economists have been too enamored of the nicities of statistical refinement, and have neglected the search in other problem areas. One neglected problem area that appears highly significant is that of the demand for factors of production - specifically, the demand for feeder cattle. Neglect of this area may perhaps be attributed in part to an abhorrence of "cluttered" models and contentment with quantification of existing theory. Models soon become cumbersome when an attempt is made to specify relationships at the factor level and relatively little theory exists in the area of factor demand.

These considerations again suggest that the most promising methodological approach is to define problem areas, construct models, and then search for the techniques and data that will aid in quantification. We need to be more problem-oriented and less bound by our techniques of measurement.

Citations

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