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by

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A question that creeps into the press after every new round of stagflation or surge in the unemployment rate is what good are economists? From a different viewpoint, the question might be posed in terms of the difference between the success of an econometrician vs. a statistician in modelling a price or output series. Nelson [1975] addressed this issue more directly by attempting to assess the differential performance in predicting prices with a mechanistic multivariate time series model vs. that of a carefully specified econometric model of the market which might have determined the price of interest.

The objectives of this paper will be to review and assess the potential role of economic theory in the process of model specification and estimation. Although I will focus on the supply side of the market, what I have to say generalizes to the measurement of the relation between any set of choices and their hypothesized determinants. In order to highlight the value of an econometrician over that of a statistician, I will begin by presenting a general multivariate time series model. Next, I will review what economic theory has to say about the determinants of choice, the nature of their relation to choices, as well as the specification issues theory leaves open. As you will see, I argue that the task, and therefore, the value of an econometrician is to simplify the general multivariate time series model through the combination of that model with the set prior information derived from economic theory. Thus, it may not be inaccurate to say that while both the statistician and econometrician could be expected to focus on the likelihood functions generating the data, we might expect the econometrician's specification to be more highly conditioned by a comprehensive, logically consistent set of prior restrictions. Most importantly, we would expect this distinction to hold independently of whether the econometrician is a Bayesian. Indeed, one might say that it is the task of any learning process to synthesize empirical evidence with prior beliefs. Finally, I will briefly review the current state of the arts on how this simplification may be accomplished and juxtapose these methods with the approaches being taken in current literature.

I. Neo-Classical Theory of Choice and Model Simplification

To proceed, suppose that we begin with what some might call a purely mechanistic multivariate time series model of the relationships among the elements of a vector time series (Z_t) of input and output levels involved in a firm's production activity and a vector of prices (q_t) for these products.

$$1)\quad \underset{m \times m}{H(L)}\ \underset{m \times 1}{Z_t} + \underset{m \times m}{F(L)}\ \underset{m \times 1}{q_t} = \underset{m \times 1}{u_t}$$

where $E(u_t) = 0$

H(L) and F(L) are double-sided lag operators, but not necessarily linear. Clearly, the model as stated already involves a set of restrictions which has excluded variables held to be irrelevant prior to examination of the data. However, as the model stands further simplification is obviously necessary.

To be specific, the list of necessary simplifications include; choice of forward and backward lag length for H(L) and F(L), prior aggregation of the m elements of Z_t or q_t to establish lower order aggregate vectors, and specification of the functional form of H(L) and F(L). This last issue is extremely complex since as written in its most general form we must consider not only the functional form of each equation, but also cross-equation restrictions. If we were to subscript the lag operators H(L) and F(L) with observation labels, the model might also be simplified by specifying the nature of parameter variation over observations. Finally, the properties of the covariance matrix of residuals must be specified.

Although we might expect both the statistician and the econometrician to begin by attempting to partition the vectors Z_t and q_t into sets of endogenous and exogenous variables, we might expect the econometrician to base that partition upon a hypothesis about how the firm behaves in the market place. As Granger [1969], Sims [1972], and Geweke [1978] have shown, the value of this exogeneity hypothesis is that it implies a large set of the parameters of 1) may be zero. As Geweke [1978] has shown the hypothesis implies that the leads on exogenous variables must have zero coefficients in any reduced form consistent with the partition and likewise any lags on the endogenous variables must have zero coefficients in regressions of current exogenous variables on past endogenous and exogenous variables. Imposing these restrictions and solving the resultant system for its reduced form would perhaps produce what Cochrane [1955] had in mind by the label supply response functions.

However, as recent literature points out, depending upon the detail with which the researcher specifies the behavioral hypothesis it may be possible to further simplify the model beyond the parameter restrictions implied by the exogeneity partition. In fact, I would argue that the large majority of past supply studies have stopped with the exogeneity specification and estimated a single reduced form in the choice response system. This practice seems to testify that either economic theory has nothing more to say, or that researchers have had strong priors which have rejected what it has to say. As a young economist, my naiveté leads me to hope that such priors were ill founded.

Although studies of consumer demand have traditionally dealt with models which were conditioned with priors derived from economic theories of consumer choice (e.g., see the work of Frisch [1959], Theil [1965], Parks [1969], George and King [1971]), on the supply side such attempts have been limited. In fact, the literature seems to suggest that researchers concerned with measurement of production functions have typically chosen to lean heavily on Hoch's [1958] conditions for shelter from the simultaneous equation bias which Marschak and Andrews [1944] established would result if we ignore rules upon which choices were based. The alternative avoided is the specification of a possibly inaccurate hypothesis concerning the nature of those choice rules. Perhaps this is done due to reticence for specifying a behavioral hypothesis, alternatively it may be attributable to the relative ease of direct estimation of a production function. To explore what additional empirical implications a specific behavioral hypothesis might have,let us consider the traditional profit maximizing case. As we proceed we can consider the robustness of the implications under alternative behavioral hypotheses.

Not much progress can be made unless we suppose the existence of a convex transformation function relating efficient combinations of net outputs and inputs. If, in addition, we postulate any decision or behavioral objective for the firm which is linear and continuous in incentives, the necessary conditions for optimal choice define a set of choice rules for choosing net products. However, of greatest importance is the link established by the first order conditions between information upon which choices are based and the technology of the firm. Given this result, prices and other information are mapped into the set of optimal choices in a very special way. In particular, the choice functions must be consistent with the convexity of technology, as well as monotonic and homogeneous of degree zero in all prices. Furthermore, the continuity and differentiability of the behavioral objective and technology imply that cross price derivatives of choice must be symmetric, i.e. $\partial yi/\partial Pj = \partial yj/\partial Pi$.

What is perhaps most important about these properties is that they may be expected to hold for choice functions derived from nearly any imaginable marginalist objective constrained by a continuous, differentiable, convex technology. Unfortunately, our theory of choice has little more to say about the empirical determinants of choice. Although the first-order conditions clearly link the functional forms of the choice functions to that of the production function, it gives us no hints about the latter. This leaves open a wide range of issues concerning further simplification of our model of choice. Although convexity, continuity and differentiability are critical assumptions or maintained hypotheses their validity is an empirical issue. Recent work by Weaver [1978e, 1979] suggests that the discontinuous nature of incentives established by supply control policy implies that supply functions during some programs are discontinuous. Similarly, the existence of such regularity properties as homotheticity, homogeneity, separability and jointness is an empirical issue of great interest, but one which is left unresolved by our theory of choice. Researchers have typically recognized that knowledge of the separability properties of the technology provides the foundation for the simplification of product and price vectors through the use of aggregate indexes. However, Diewert [1970] has demonstrated the intuitive proposition that an index is nothing more than a subfunction of the more general function which operates on the components of the index. This being the case, the functional form of the general function implies the functional form which should be used for the indexes. Given the absence of strong prior knowledge concerning functional form, Diewert presents indexes which will provide second-order approximations of any arbitrary subfunction. In the past, researchers have been unable to consider the issues of homotheticity, homogeneity and jointness because available functional forms incorporated *a priori* restrictions on these properties. However, a wide range of functional forms are now available to the researcher which grant the researcher control over such prior restrictions, see Fuss and McFadden [1978]. Clearly, although each of these issues is of interest in its own right, within the context of supply analysis they represent specification issues about which our theory of choice has little to say.

In summary, we may conclude that to estimate any supply relation the researcher must at least make a specification decision concerning what set of variables is relevant and an exogeneity partition of those variables. To accomplish this, the econometrician will likely specify a behavioral hypothesis. It was argued that, conditional on convexity of technology, for a wide class of behavioral hypotheses a fairly extensive set of simplifications on our multivariate time series model is implied: exogeneity restrictions, continuity and concavity of the dual, monotonicity and linear homogeneity in prices, and a symmetry property in price response. However, we acknowledged that convexity, and continuity are empirical issues which are subject to uncertainty. In addition, we noted various properties of functional form (homotheticity, homogeneity, separability, and jointness) whose validity are likewise subject to uncertainty. Thus, we are left in a position of recognizing that our theory of choice suggests a large number of simplifications which may be made in our choice response model. Unfortunately, the validity of these simplifications is not established by the theory, but remains an empirical question.

II. Knitting Theory and Data Evidence Together

Benefits and Costs of Model Simplification

Although the set of theoretically derived restrictions reviewed in the prior section serves well to identify an economist's potential contribution to the measurement problem, it fails to value that potential contribution. As our statistician would be anxious to remind us, although we have a theory from which we may derive hypotheses, the validity of those hypotheses may not be supported by the data. In such a case, the specification decision becomes one which must be made in an environment of uncertainty. While Occum's razor alone would suggest that we stand to gain from simplification, a condition for this intuitive result to hold is that such a simplification must render our model an accurate characterization of the process generating the data. Likewise, if we inappropriately simplify our model we would expect to lose by most criteria.

This point is made more precisely by the traditional illustration of the risk[1] of a restricted vs. an unrestricted least squares estimator. Although Tiao and Box [1974] among others have reminded us that the mean squared error measure of risk is hardly a universal measure of goodness of fit[2] it is of interest as a measure of closeness for many standard estimation problems. Thus, based on such a risk criterion a traditional result of the pre-test literature (see e.g., Wallace [1972, 1977], Wallace and Ashar [1972], Bock, Yancey and Judge [1973]) is that although the MSE of

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[1] Here risk is defined as the expected value of the loss (L) incurred by using $\hat{\theta}$ as an estimator of θ; i.e. $E[L(\hat{\theta}, \theta)]$.

[2] For example, they point out that if we attempted to employ it to estimate the reciprocal of the mean of $y \sim N(\theta,1)$, $M.S.E(\bar{y}^{-1})$ is infinite.

the unrestricted estimator is constant, that of the restricted estimator is monotonic in the "true" F-statistic which presents a classical test of the restriction on the population equation. This being the case neither estimator dominates over the entire range of this F-statistic, a result which clearly illustrates the possible benefits from imposition of a restriction which is consistent with the data vs. the loss which would result from its inconsistency with the data. The decision problem is clearly that of a choice of an estimator in the face of uncertainty concerning the size of this F-statistic relative to an appropriate critical point. Following Wallace and Ashar's example, if we have the following models:

unrestricted: $Y_t = \beta_1 X_{1t} + \beta_2 X_{2t} + \varepsilon_t \qquad t = 1, \ldots T$

$$\varepsilon_t \sim N(0,\sigma^2)$$

restriction: $\beta_2 = 0$

then least squares estimators may be written:

restricted: $b_1^R = \dfrac{\Sigma X_1 y}{\Sigma X_1^{\,2}}$

unrestricted: $b_1 = \dfrac{\Sigma X_2^{\,2} \Sigma X_1 y - \Sigma X_1 X_2 \Sigma X_1 y}{\Sigma X_1^{\,2} \Sigma X_2^{\,2} - (\Sigma X_1 X_2)^2}$

and the mean squared errors may be written

$$MSE(b_1^R) = \sigma^2/\Sigma X_1^{\,2}(1 + \lambda r^2)$$

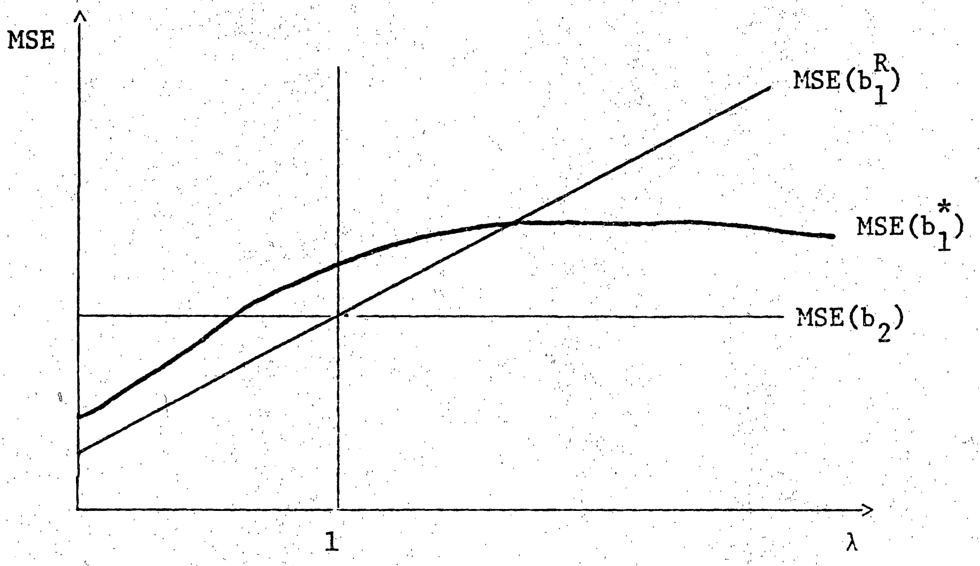
where r^2 is the correlation between X_1 and X_2

$$\lambda = \frac{\beta_2^{\;2}}{V(\beta_2)} \quad \text{which is measured by } \mu = \frac{b_2^{\;2}}{S_{b2}^{2}} \sim F_{1,T-3} \text{ under } H_0\!:\beta_2 = 0$$

and $MSE(b_1) = \sigma^2/\Sigma X_1^{\;2}(1 - r^2)$.

Figure 1 reports the graph of the MSE against λ which clearly illustrates that for $\lambda < 1$ inclusion of X_2 would amount to an overspecification error while for $\lambda > 1$, omission of X_2 would render the model underspecified. In each case, the researcher could gain according to the MSE criterion if he knew λ.

Figure 1



The purpose of this section shall be to review several alternatives for incorporation of priors of theoretical origin into our estimation procedure. In general, we have two strategies available which depend upon whether simplification of our general multivariate model occurs before or after we analyze the data and will therefore, be labelled pre- and post-data simplification.

Pre-Data Simplification

Pre-data simplification involves what Leamer [1978] calls the construction of a working hypothesis. That is, recognizing that the vectors in our initial multivariate time series model might include nearly any measurable variable (e.g., the N.B.E.R. data bank), we begin by specifying a hypothesis which eliminates a large number of variables prior to estimation or observation of the data. In a Bayesian sense, we condition the likelihood function of the multivariate model with the strong prior that a large set of parameters are exactly zero. In doing so, we risk mis-specification and larger variances of estimators, but hope to gain additional precision in the case when our prior is consistent with the data. Alternatively, we might seek to trade potential benefits for potential losses by specifying a more diffuse prior. These alternatives are clearly presented in Zellner [1971]. From the above illustration we may plainly see that pre-data simplification by MSE minimizers amounts to a prior statement concerning the magnitude of the F-statistic testing the restriction (e.g., μ in the above example).

Of course, there are a number of well-known methods of reducing what non-Bayesians argue is the chance for subjective error in specifying the prior during pre-data simplification. Perhaps the most tractable among these is sensitivity analysis of the posterior distribution for changes in the prior. A good example of this is Leamer's [1972] Bayesian estimation of distributed lags where the sensitivity analysis focuses on varying the mean and variance of a normal-gamma or Raiffa and Schlaifer [1961] "natural conjugate" prior. As Leamer notes, the benefits of such an exercise would be expanded if a prior distribution were employed whose shape could be more substantially varied in the analysis. In fact, an alternative has been considered in more recent work by Dickey [1970, 1975] and Leamer [1978] which has argued that the conjugate prior treats prior information as if it has been generated by a previous sample following the same process as the sample and so fails to recognize a fundamental difference between prior and sample information. More specifically, the resulting posterior is unimodal and a weighted average of the sample and prior's location, see e.g. Leamer and Chamberlain [1976] for an interesting discussion of this standard result. Dickey [1975] suggests that given the nearly definitional conflict between prior and sample information the posterior should be multimodal with the prior and sample locations included in the set of modes. As Dickey [1975] has shown, if β is distributed by a Student prior independent of the precision (σ^{-2}) and if the latter is distributed by a gamma distribution, the posterior is multimodal with modes lying along a curve in the parameter space falling between the prior and sample location. Responding to these graphics, he ribaldly labelled this locus of modes the curve décolletage. In an effort to establish a prior which is sufficiently rich as to include all potentially relevant density functions, Leamer [1978] has abandoned the notion of complete specification of the prior and has pointed out that Dickey's curve décolletage is a special case of what might be interpreted as an information contract curve implied by an ordinal prior (i.e. one in which prior densities assigned to iso-density surfaces are assumed only to monotonically decline).

Thus this function requires composition with another function (which he calls a labelling function) to fully specify the prior and, therefore, the posterior p.d.f. However, he shows that since an ordinal incomplete prior may be mapped into a prior p.d.f. by proper choice of the labelling function, the information contract curve contains all possible posterior modes. Although the usefulness of this may seem elusive it presents a way to place k-2 restrictions on a k dimensional parameter space through an ordinal specification of the prior. This leaves the researcher with a 2-dimensional line along which the posterior mode must lie given a labelling of the ordinal specification.

Perhaps a more tractable alternative for relaxing the fixed weighted average property of Bayesian estimators based on conjugate priors has been suggested by Efron and Morris [1971] which allows restriction of the maximum amount by which the Bayes estimate deviates from the maximum likelihood estimate. This approach is a data dependent means of relaxing the commitment to the Bayesian prior and so might properly be labelled as a post-data simplification method.

Post-Data Model Simplification

Despite our creativity in dealing with the problem of specifying the prior, Leamer [1974] has reminded us that although pre-data simplification is decidedly necessary, it is inconsistent with what many might consider a more reasonable learning strategy. More specifically, Leamer [1978] reminds us that while Watson tempted Sherlock Holmes to proceed by the classical technique of formulating hypotheses before their clues had been carefully catalogued and assessed, Holmes replied in a scolding tone "No data yet, . . . It is a capital mistake to theorize before you have all the evidence. It biases the judgements."[3] Fortunately, Holmes has an advantage over us which allows us to ignore the intuitive appeal of his remark, namely the luxury of new information (the confession) with which he may finally test his hypothesis and which is absent from an economist's experiences. Nevertheless, non-experimental data and the weakness of our priors forces us to consider post-data alternatives.

Although my enumeration of alternatives may break with convention I shall include in this group estimators proposed by Stein [1955], James and Stein [1961] and Strawderman [1971], classical and Baranchik [1964] positive part-Stein rule pre-test estimators, and Leamer's Holmesian estimators. A useful way of classifying these post-data alternatives is by the nature of the stopping or selection rule employed.

As we saw in our consideration of a restriction on a linear regression model, the choice between the restricted vs. the unrestricted model could be based upon the statistic λ if it were known. To form a stopping or selection rule, we are tempted to employ the data dependent estimate of λ, an F-statistic under the restriction, labelled μ and compare it against a critical point, μ_α. However, doing so makes our model selection data dependent or based on sample information a situation which for most researchers dissolves the believability of our results. Retrieving our example, the estimator based on such an informative stopping or selection rule is the so-called classical pre-test estimator:

$$b_1^* = \begin{cases} b_1^R \text{ if } \mu \leq \mu_\alpha \\ b_1 \text{ if } \mu > \mu_\alpha \end{cases}$$

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[3] Doyle [1888], A Study in Scarlet.

Unfortunately, as Figure 1 indicates the mean square error of b_1^* is not a weighted average of the MSE(b_1^R) and MSE(b_1), instead Wallace and Ashar [1972], Bock, Judge and Yancey [1973] among others have noted it has higher MSE than either b_1^R or b_1 over a wide range of λ. Thus, if we knew λ we would clearly be better off to choose either b_1 or b_1^R, whichever minimizes MSE at the known λ. Because the MSE of the pre-test estimator may be written as a function of the critical F-statistic employed in classical tests of the parameter restriction, a voluminous literature (e.g., Sawa and Hiromatsu [1973], Brook [1976], Toyoda and Wallace [1975, 1976]) has considered how that critical point might be optimally chosen to reduce, over the entire range of the F-statistic, the difference between the risk of the pre-test estimator and that of the minimum MSE estimator (either b_1 or b_1^R). Given diffuse priors on the F-statistic, or alternatively, on the restricted coefficient, use of an optimal critical point with a pre-test estimator allows us to minimize this MSE loss which results from our ignorance.

Sclove [1968] and Efron and Morris [1973] have shown that Stein [1955], James and Stein [1961] and Strawderman [1971] estimators may be interpreted as Bayesian estimators in which prior information concerning precision is structurally equivalent to the sample information. The posterior mode as in the Bayesian case is a weighted average of a prior mean and the sample location. In this case the weights are proportional to the F-statistic required for a classical test of the hypothesis that a least squares estimator would equal a prior mean of zero. Thus, we may interpret these estimators as post-data methods in which specification of priors is accomplished with the aid of the data. This has sometimes been labelled empirical Bayesian estimation. Despite the fence straddling conceptual position of these estimators, Stein [1955], James and Stein [1961], Sclove [1968], Efron and Morris [1973], and others have proven that such estimators dominate maximum likelihood estimators in a M.S.E. sense. A twist to these estimators was given by Baranchik [1964] and Stein [1966] who blended the Stein-rule type estimator with the pre-test selection rule to produce a Stein-rule estimator in which the sample mean receives weight only if the F-statistic exceeds its critical point. However, as Sclove [1968] has noted the optimal critical point is difficult to identify since the risk of the estimator is unwieldy. Nonetheless, in more recent work Judge and Bock [1978] and Aigner and Judge [1975] demonstrate that when viewed as an estimator in its own right, Stein positive-part estimators proposed by Baranchik [1964] and Sclove [1968] are uniformly dominant over unrestricted least-squares, classical pre-test, and Stein estimators.

Each of the above estimators employ what Leamer [1974] has labelled an informative stopping rule. On an intuitive level, their final estimator is a discontinuous function of sample evidence and a strong prior stated in terms of a point parameter restriction. In an important sense, Leamer points out that the restricted model may be rejected a priori as false. It would be rather surprising if such a point restriction would be consistent with the data. An alternative which moves away from this property that the restriction produce the true model and in the direction of the Bayesian concept of degree of belief is that of mixed estimation introduced by Theil and Goldberger [1961] and Theil [1963] as an extention of Durbin's [1953] work.

In an attempt to reconcile the scarcity of data with the need for model simplification Leamer [1974] argues that what is necessary is a systematic means of accurately discounting the value of sample evidence when post-data simplifications are made. Given such a system the researcher could accurately assess the relative cost of pre- vs. post-data simplification. Leamer proposes that the model space by simplified prior to estimation in a way which allows consideration of the acceptability of the pre-simplification by a Bayesian estimation of the bias which may have been induced. His proposed methodology allows the researcher to eliminate simplification which appears inappropriate and proceed to estimate a fuller model. So long as our priors on the expanded model are constrained by those which we held for the pre-simplified model our post-data model construction activities do not deteriorate the information value of our sample.

III. Overview of Currently Employed Methods of Model Simplification

From our consideration of the potential contribution of an economic theory of choice to the simplification of models designed to measure that choice, we concluded that although the assumptions of convexity, continuity, differentiability and a marginalist behavioral objective implied a substantial set of restrictions on our multivariate model (exogeneity, positive definiteness of the dual, monotonicity and homogeneity in prices and symmetry), the validity of those assumptions is of course an empirical question. Furthermore, we identified an additional set of regularity properties (homotheticity, homogeneity, separability, and jointness) the validity of which is entirely an empirical question. Thus, we come to the not surprising conclusion that the economist's contribution to model simplification is subject to uncertainty. Next, we reviewed a variety of pre-data and post-data methods for conditioning sample information with simplifications suggested by a theory of choice. In brief, these amounted to alternative schemes for weighting the two sources of information where weights are based on a combination of prior and sample information. Before concluding, I would like to briefly review applied work in which the simplifications suggested by theory have been considered. In order to proceed most efficiently, it is useful to classify the simplifications into three groups, those related to: 1) fundamental properties of technology: convexity, continuity and differentiability; 2) the behavioral hypothesis: the exogeneity partition, monotonicity, and homogeneity of degree zero in prices, and symmetry; and 3) regularity properties of the technology: homotheticity, homogeneity, separability and jointness. To cover all applied work in this area would likely triple the length of this paper, so I will only focus on a small subset of applications which I hope will serve as an illustration and an introduction to the literature.

As we will see the majority of applied work has implicitly employed the post-data classical pre-test estimators which as noted in the previous section are dominated by positive part Stein rule estimators and by Bayes estimators based on proper priors. Therefore, I will conclude this section by assessing the usefulness of results based on such methods.

Fundamental Properties of Technology

Methods of investigating the properties of convexity, continuity and differentiability are at an emergent stage. In fact, methods for investigation of differentiability have yet to sprout. Focussing first on convexity, two approaches are represented in the literature: parametric and non-parametric. Each constitutes a post-data approach to the issue. Non-parametric methods have been pursued in the stream of literature following from Hildreth's [1954] proposal for an estimation method which is free of prior specification of functional form and only constrained to be concave. His initial proposal was followed by refinements by Hanson and Pledger [1976] who proved consistency of the least squares estimator, and Hudson [1969], Dent [1973], and Dent, et al. [1977] whose work has explored various methods based on estimation of approximations obtained through polynomial segmentation. Also, following Hildreth's work is that of Afrait [1967], Diewert [1971], and Hanoch and Rothchild [1972] who present a method free of any parametrization of the production function for investigation of quasi-concavity, monotonicity and homotheticity. Parametric methods include those proposed by Judge and Takayama [1966] for regression estimation subject to inequality constraints as well as those focussed on post-data testing of the convexity of estimated flexible functional forms. Although the parameters of generalizations of the Leontief functional form may be conveniently restricted to make the form convex (Diewert [1973]), and to allow classical pre-test estimation, this is not the case for the translog functional form. For this reason, typical applications using the translog have employed methods focussed on inspection of the definiteness of the Hessians of estimated functional forms. An appealing alternative has been offered by Lau [1978] which employs a re-parametrization (a Cholesky factorization) of the Hessian which is imposed as a restriction of the model's parameters and allows the use of post-data simplification methods.

As for methods which allow consideration of discontinuity, if priors exist concerning the point of discontinuity a variation of Tobit estimation appears fruitful. The usefulness of such a method of dealing with discontinuity in choices introduced by agricultural control policies is explored in a study of program participation by Weaver [1978e, 1979a]. Alternatively, if priors are held concerning the number of regimes, though the switch points are unknown, Quandt's [1972] switching regression framework may be useful. Although the classical pre-test method of Chow tests for alternative methods of pooling observations remains the dominant method employed in the literature. Leamer [1978] has clearly pointed out the usefulness of alternative pre- and post-data approaches in this context.

Empirical Implications of the Behavioral Hypothesis

Investigation of the empirical implications of an exogeneity partition has been a relatively recent addition to the literature. Although one of the first applications (Sims [1972a]) was to the problem of specification of factors of production which are not variable within the observation interval the majority of applied literature focuses on identification of the relationship between macro variables such as money and income (Sims [1972]). Despite this, Geweke's recent work suggests that the methodology presents a general framework to assess the exogeneity partition in any choice or market model. An example of an application to agricultural supply is recent work by Weaver [1979b] which investigates the exogeneity of acreage allotments with respect to acreage planted.

Two problems may be noted with past applications of the Granger [1969] and Sims [1972] methodology. Despite Geweke's point that the exogeneity partition must be investigated in the context of a fully specified model (a point which Granger [1969] and Sims [1972] also made), many past applications have employed bivariate models which may result in the typical bias attributable to the exclusion of explanatory variables. Although researchers might argue that introduction of additional variables is impractical, what they mean is that expedience does not allow time for careful specification of a full model or collection of data necessary to measure its parameters. Thus, I would argue that the issue of exogeneity is of little interest if addressed independently of model specification. Finally, to my knowledge all exogeneity tests have involved classical hypothesis tests which imply resulting estimators are of the pre-test, post-data variety.

As for monotonicity, homogeneity of degree zero in prices and symmetry, two approaches have been taken. Although no statistical tests of monotonicity or homogeneity in prices have been employed,[4] initial work by Berndt, et al. [1973] and Christensen, et al. [1973] employed a classical hypothesis test of parameter restrictions which were consistent with

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[4] Whittaker and Shumway and Chang in Weaver [1978] present a non-statistical evaluation of the homogeneity constraint based on a criteria of the number of correct signs.

the property of symmetry as a test of the behavioral hypothesis. I would argue that such a test is inappropriate since the alternative hypothesis is not a subset of the parameter space. Specifically, if choice response is not symmetric, then technology is either not continuous or not differentiable, a condition under which continuous choice functions fail to exist. A similar result does not hold for the proposition "not monotonic" or "not homogeneous of degree zero." If these properties do not hold, then our behavioral hypothesis may be invalid but we have not rejected the continuity that is incorporated in our multivariate model. A feasible alternative approach concerning symmetry is to impose the restrictions prior to estimation, a strategy which runs the risk of specification error.

Regularity Properties of the Technology

With minor, though noteable exceptions, specification decisions concerning homotheticity, homogeneity and jointness have to date been based on classical post-data pre-testing. Weaver [1978b] presents an example where a flexible functional form was employed to investigate these hypotheses for a multiple product agricultural technology. Results of this analysis indicated that homotheticity and homogeneity could be rejected. However, non-jointness and several separability hypotheses were not rejected by the data. de Janvry's [1966] use of factor and cluster analysis to partition a product vector into separable subsets was a noteable attempt at post-data simplification which preceeded the use of restricted flexible functional forms. However, as George and King [1971] pointed out the partition is not unique and is conditional upon the prior specification of measures employed in the analysis. An additional exception is the Bayesian approach applied by Box and Cox [1964] to the estimation of non-linear functional forms. Zellner [1971] reviews applications by Zellner and Revandar [1969] of such an approach to the study of production functions.

Summary

In brief summary, the current practice in applied research has been to rely upon post-data evaluation of potential model simplifications, in fact the only examples of application of various improved alternatives reviewed in Section II known to this author are illustrative ones implemented to compare the alternatives to traditional methods. For example, Aigner and Judge [1975] evaluated the extent to which James-Stein estimators dominate classical pre-test estimators in three applications. In general, their results illustrate the theoretical result that the potential benefit of James-Stein estimators is dependent upon the nature of collinearity in the sample. Only in one application (the re-examination of the Weiss data set), do they find that the condition for dominance of the James-Stein estimator is met. In this case, results obtained from a pre-test estimator were in general robust though inadmissable. As for Leamer's [1974] suggested alternatives, his re-consideration of Bode's Law remains the only application. Leamer's more recent suggestion that priors be specified incompletely allowing the reader to choose a particular mode depending upon more completely specified priors has likewise seen little application. However, in a recent working paper Leamer and Leonard [1979] present example applications which demonstrate the suggestion deserves further exploration.

Given the theoretical appeal of these alternatives, one must conclude they represent an important approach for future attempts to specify econometric models of choice. On the other hand, of equal importance is the question: Are these alternatives likely to lead to substantial improvements in our ability to explain and predict choices?

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