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DEMAND ANALYSIS AND DEMAND SYSTEMS IN PERSPECTIVE

by

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1. INTRODUCTION

Consumer demand theory is a topic of long standing in the history of economics. Between Gossen (1854) and recent work there is continuum of contributions deepening and widening the theory, increasing its intellectual appeal and its potential applicability. Applied work has an equally long tradition, starting with, say, the famous study by Engel (1857). The link between theory and empirical work, however, has generally been rather weak. Several reasons account for this separate development. Initially, theory was not developed with empirical applications in mind. Empirical workers would have had problems to understand what part of theory was of direct use for them. Reading Antonelli (1886) in English translation today one can imagine the empiricist's problems a century ago. A more recent expression of frustration with theory can be found in e.g. Cramer (1962). Moreover, datasets to put theoretical results to a test or to profitable use were lacking. At best, budget surveys or some time series on quantities and prices of some selected consumer goods were available. Budget surveys give an overall picture but basically only allow one to study expenditures on all commodities distinguished as a function of a single explanatory variable, income or the budget. Absence of sufficient price variation prevents the analysis of the full two-sided dimensionality suggested by theory. Demand studies for individual commodities tended to be adhoc and usually ignored the basic allocation aspect of demand behaviour which is the essence of the theoretical framework.

Even a combination of a well-specified theory, adequate data and appropriate estimation techniques is not sufficient to bridge the gap between theory and

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empirical analysis. Reasonably large and fast computers are a necessary ingredient in the mix. Even today with the presence of powerful hardware few studies are available allowing for full interaction consistent with theory which distinguish more than some eight different commodity groups. Computational problems are as yet not all overcome.

In principle, the "demand systems" approach attempts to apply the results of theory to an exhaustive description of the consumer allocation decisions in response to variation in his budget and in the prices of all commodities. In view of what has been just said it is not amazing that its emergence coincides with an advanced stage of development of theory, the availability of time series of some length on expenditures and prices and the presence of adequate computing equipment. The early concentration on systems with reduced interaction, mostly some type of additivity, is perhaps better explained by computational complications in handling more general systems than by any prior belief about the lack of the empirical importance of more specific interactions. The pioneering contributions of Leser (1941), Stone (1954) and Somermeyer and Wit (1956) are splendid examples of full exploitation of the possibilities at the time they were produced. Since then conditions have improved and the systems approach has taken off.

It is not the purpose of this article, however, to present an exhaustive description of the systems approach, its birth, infancy, adolescence and maturity. It is more the intention to give a subjective account of a personal involvement with this approach and of a personal perception of its potential and limitations. Research activity is very much linked to the personal history and the environment of the researcher. The interest in this account is not so much in the issues treated or the personalities involved but in their interaction.

2. FIRST STEPS

In the first years of the existence of the Econometric Institute at the (then) Netherlands School of Economics little applied work was done about consumer demand, although its first director, Henri Theil, had an interest in the field. His doctoral dissertation - Theil (1951) - was a reformulation of the Hicks-Allen theory in terms of shocks of consumer goods rather than in terms of flows. Also, Theil and Neudecker (1957) is a theoretical study with potential for applied work. Moreover, somewhere in his files Theil had data on the value of the land used by farmers who participated in the 1936 budget survey. When the present author left the Centraal Planbureau in The Hague to join the Econometric Institute in September 1960, among his first duties was the use of this material for an empirical study, which eventually was published as Barten, Theil and Leenders (1962). The third author, Leenders, participated in this project as part of an apprenticeship, then required of all students in econometrics. The project concentrated not only on wealth as a codeterminant of consumption but also on the structuring of family composition effects. It did not attempt to provide a theoretical basis for the applications, however.

Around the same time Houthakker (1960) appeared. It was intensively studied with possible applications in mind. This article suffered from an overdose of printing errors, forcing the reader to reconstruct the argument. A byproduct of this reformulation was what became subsequently known as the fundamental matrix equation of the theory of consumer demand - see e.g. Intriligator (1981).

For a possible application time series were needed on consumer demand expenditures or quantities and prices. For the period after the second World War or rather from 1948-1958 such data could be found on an annual basis in publications by the Centraal Bureau voor de Statistiek. To have more observations, data for the 1921-1939 period could be employed. Part of this material was only available as "raw material" in the files used to construct the data base for the macromodelling project of the Centraal Planbureau, headed by P.J. Verdoorn. Verdoorn generously made this information available, but when he learned that it was the intention to estimate a demand system under additivity he strongly advised to try to do something more realistic and more interesting. The data work resulted in an unpublished report by Barten and Vorst (1962). Verdoorn's suggestion led to the development of the idea of "almost additivity" which amounts to an (a priori) selected limited deviation from additivity.

Almost additivity even more than additivity requires the joint estimation of all equations of the system. Joint estimation was a familiar concept at the Econometric Institute where A. Zellner had worked in 1960-1961. Zellner (1962, 1963) on "Seemingly Unrelated Regression" and Zellner and Theil (1962) on "Three-Stage Least-Squares" were common fare for most researchers at the Institute in those years.

There were also some doubts about the reliability of the data. To prevent nonsensical point estimates if was decided to use "mixed regression" introduced by Theil and Goldberger (1961) and further elaborated by Theil (1963). As it turned out the original data behaved rather nicely and to use mixed regression was not really necessary.

Around the same time Theil acquired a Bull computer for the Econometric Institute. It was a used one and not immediately available. In the meantime the computers at the Bull Computer Center in Amsterdam could be used. Computer programming had to be learned. The staff at Bull charged one of its younger employees with the task of advisor, if not guide, for the computer aspects of the project : A.H.Q.M. Merkies. The two of us spent some lonely nights at the Computer Center in Amsterdam. Daytime was too precious, the program being iterative and the computer slow. Three iterations for each of the two variants was all that could be done, but we were very happy with it.

Ex post, the project published as Barten (1964) must be considered ridiculously ambitious : a system of 14 commodity groups is even now viewed as large. At that time, the share of luck in this undertaking was not realized and the relative ease by which results were obtained was taken for granted. Still, some delays were experienced and the report was just finished when I left for Berkeley to teach (and in the course of that learn) econometrics during one academic year.

3. THE ROTTERDAM SYSTEM

The initial success inspired further work. Theil, in the beginning close supervisor and mentor, took henceforth an active part in further developments. He addressed himself to the issue of functional specification, which was originally treated in a pragmatic manner. His work on information theory led him rather naturally to the specification of what has become known as the Rotterdam system - see Theil (1965).

The major attraction of that specification is its property that all the theoretical restrictions on demand equations could be formulated in terms of linear restrictions on constants to be estimated, not involving variables. Econometrically, this is no doubt an advantags. As subsequentely demonstrated in Barten en Turnovsky (1966) the specification is also convenient in dealing with demand for aggregated commodities under separability of preferences. There were also natural leads to the formulation of constant utility index numbers, a topic further pursued by Kloek (1966).

However, the euphoria was somewhat disturbed by McFadden (1964) who, as also was done later by Goldberger (1969), pointed out that the Rotterdam system, taken exactly, implies constant average budget shares, which is indeed a somewhat degenerate case, perhaps respectable in production theory (Cobb-Douglas) but not at all in demand analysis and there patently unrealistic. The issue of the acceptability of the Rotterdam specification has been debated since, one of the more recent contributors being Barnett (1979). In this debate my own attitude is one of somewhat agnostic pragmatism : (i) any selection of constant parameters in econometric specifications is provisional, approximative; (ii) the data will usually not be very informative when it comes to choosing between alternative functional forms; (iii) convenience of estimation plays a role too. The fact that the Rotterdam system is in first differences is to me a more serious drawback. Interesting dynamic patterns have little chance to show up, while the system is not very useful for cross-sectional studies.

Somewhat related to the issue of functional specification was the one of specification of the covariance matrix of the system. Initially, the cue was taken from the multinominal distribution with a covariance matrix in terms of average budget shares. Later on this was replaced by one in terms of the (constant) marginal budget shares and next extended to a specification proportional to the Slutsky matrix, an idea already implied by Theil and Neudecker (1957). It has been further pursued by Theil (1971, 1975a).

A consequence of the allocation nature of the model is the singularity of the contemporaneous covariance matrix. This issue was approached from various angles. Barten and Kloek (1965) solved it in the context of generalized least-squares. For actual estimation the problem could be and was circumvented. Later on it was found that simple deletion of one equation from the system was all that was needed to deal with this complication.

Here it may be mentioned that an initial suspicion of the cardinal nature of the whole approach turned out to be unjustified. Cardinal utility is not implied by any of the specifications of the system. Some interpretations, however, make only sense under cardinal utility. In modern demand theory utility is only an intermediate concept in between the assumptions about the preference order and the demand functions to be estimated. Utility is an interpretative tool. Its ordinal or cardinal nature does not make any difference for the demand functions.

Specification issues were not the only ones to be further refined after the first promising steps. These was also room for improvement of the data.

4. DATA BASE

The data base of the first round was in several respects deficient. Moreover, it seemed possible to extend it from 1958 through 1962, even through 1963. An additional ambition was to provide a link between the prewar and the postwar data. It also seemed to be appropriate to apply the Theil-Kloek work on index numbers. This programme constituted an almost completely new data project.

The purpose of this project was to construct for the Netherlands, and for as many years as possible, time series of data of relatively narrowly defined expenditure groups and the corresponding prices. The latter part turned out to provide most problems and in particular where it was not expected : the period 1948-1960, for which little published price indexes were available. Access to the files of the Centraal Bureau voor de Statistiek (CBS) helped out to a certain extent. However, other sources and sometimes persons had to be consulted. The intention to have also price information for 1938 and 1939 on the same footing as for 1948-1962 caused extra work and visits to e.g. wine merchants and poulterers. With the help of G. van der Most, another student-apprentice, all the information collected was arranged in time series on expenditures and prices for 99 items over 1921-1939 and for up to 108 items for 1938, 1939, 1948-1963. These were combined into time series of expenditures and prices for 16 major items for the period 1921-1963 with the exception of 1940-1947. These again were merged into time series for four major groups : food, pleasure goods (vice), durables and remainder. Finally, time series for total consumption and its price index were produced. The Bull Computer at the Econometric Institute provided valuable services for all the nontrivial calculations.

An attempt was made to document sources and steps. The result is Barten (1966a). It is hard to believe that ever anyone has read this rather arid recital of items, weights, sources. It is even more difficult to believe that ever someone has written it. Anyway, the text was only meant to support the tables, which have served their purpose. The four-way classification was immediately put to use for Barten (1966b, 1967, 1968).

5. LOOKING BACK

The Rotterdam era of the Rotterdam model came to an end when Theil definitely left for Chicago and I went to Louvain. Somermeyer, taking over from Theil, continued demand analysis but naturally in the context of his "allocation model".

Looking back at the work done on demand at the Econometric Institute before that moment, the two stages are clearly different. The first one was opportunistic : taking existing techniques, concepts, data and weaving these into a relatively simple and unpretentious fabric. The second stage was more thorough, not a matter of picking flowers here and there to form a colourful nosegay. It was much more turning over the soil, seeding, harvesting. Still, it also integrated the classical ingredients of econometrics : theoretical work, statistical methodology, data collection, into a working demand system.

It is also worth to note that all was done in more or less splendid isolation. There have been hardly any contacts with Somermeyer, an expert of long standing in the field, working in The Hague, apart from the year he spent in Canada, and with Cramer in Amsterdam, whose international reputation as a demand analyst was already well established by that time. Such absence of communication is, sadly enough, not uncommon in the field of scientific research, where frequently colleagues of the same institution discover at an international conference that they share the same interest. Although such myopia might be a fact of life, it should not be encouraged.

This narrative might create the unjustified impression that demand systems were a monopoly of Rotterdam. One needs only to mention Houthakker and Taylor (1965) or to refer to the relatively numerous applications of the Linear Expenditure Systems to demonstrate the contrary.

6. FURTHER DEVELOPMENTS

Since the early 1960's research in the context of demand systems has developed in various directions. It is not the intention to survey these here in detail. I simply mention them to show how rich its framework turned out to be.

Following Houthakker and Taylor (1965) dynamic specifications were formulated and tested. In the cause of that deeper issues of intertemporal utility had to dealt with.

The parallels with production theory were realized and expertise from that field was grafted onto the existing lines of research producing the "duality" approach, basically deriving demand functions as minimizers of a specified cost function for fixed utility levels.

Another line of research concentrated on the selection of the most attractive functional form. Such a form should display acceptable theoretical properties, provide a reasonable good explanation of the data and be relatively easy to estimate. To find a functional form dominating others in every respect is too much to expect. Staying as close as possible to the old work horse of the double logarithmic specification appears to work well empirically.

Testing various propositions of demand theory has resulted in another stream of papers. The outcome appears to be negative for the empirical validity of theory. Recent work on the properties of the test statistics used suggest, however, a heavy bias against the null-hypothesis (of the theory to hold) for the usual size of system and sample. The bias is presumably caused by the use of an estimated matrix of disturbance covariances across equations rather than the true one. As yet no simple correction formula is available.

The applicability of individual demand theory on an aggregate level came under fire from the side of a group of mathematical economists. Indeed, such applicability only holds under restrictive conditions on the covariance of the distribution of preference characteristics and individual resources. Functional form choice can reflect these restrictive conditions, but the main question, of course, is their realism. One distinguishes conditions for exact aggregation and those for consistent aggregation, the latter being weaker.

Negative test results and aggregation problems might have discouraged some researchers about the use of the rational behaviour model for aggregate data.

Happily enough, the revealed preference approach, as taken by Maks (1978) with data for the Netherlands, and by Varian (1980) with data for the United States, appear to confirms rather than contradict the hypothesis of aggregate rationality.

While most demand systems attempt to describe allocation of a given amount of total expenditure, some have been developed to deal with income, i.e. provide an explanation of current saving too. Recently, the analysis has been extended to the choice between leisure and work for a wage. Total expenditure as the amount to be allocated is then replaced by full or potential income.

Demand systems provide a natural framework to study the "structure of preferences". Research in this area has mostly involved the hypothesis of separability of preferences or of the utility function. In this context separability refers to that in non-overlapping groups of original observable commodities or in transformations of these. The exploitation of the ideas of household production function would seem very natural in the context of demand systems, but little has been done in this direction.

Related to this topic is the one of taking into account variations in preferences across households, e.g. household size and composition, social status, etcetera. These effects show up primarily in budget or panel data and less in time series. This type of research brings one on common ground with market analysts, psychologists and social scientists.

As this brief non-exhaustive non-systematic survey demonstrates, the territory between demand theory and empirical analysis is covered by a network of approaches, most of them opened up in the last decade only. Is there reason for complacency ? I think that the profession as a whole has achieved something, but that there are certain weaknesses about which I would like to say a few words.

7. PRACTICAL USE OF DEMAND SYSTEMS

The contribution of demand theory to empirical analysis is foremost in the structuring of the responses of demand to changes in the price system. Demand systems are meant to reflect this structure of interactions. Unfortunately, statistically the effect of changes in relative prices appears to be rather weak in the sense of low absolute values of regression coefficients and large estimated standard errors. At the same time demand systems allow usually little freedom for correctly specifying income effects, which seem to be much more important from an empirical point of view.

Rare are the cases where more refined demand systems form part of a larger macroeconometric model. Builders of such models tend to fall back on L.E.S. or ad hoc specifications. Complete systems of demand appear to be formulated and estimated for their own sake and not as part of a broader framework for empirical analysis useful for prediction and/or policy design.

In the eyes of the practitioner a demand system, in the current traditional sense, is too rigid to absorb all the empirically important special features of individual commodities. Johansen (1981) calls "the requirement that all demand functions constituting the system shall be "of the same form", differing only in the value of the parameters" a strait-jacket. He especially would like to accomodate more variety in the representation of income or Engel effects. I would like to go further and have more freedom to introduce also specific other determinants than income and prices in the demand equation for a commodity without being forced to include these in the same manner in all other equations. While Johansen partitions the set of commodities in subsets with a regular demand system which are merged into an overall system, I would like to have freedom for each commodity demand function.

Such freedom, as any freedom, has its price. Whether the price is to be paid depends on the evaluation of this freedom. For the practitioner the adding-up and homogeneity conditions are of vital importance. He will be less hotblooded about symmetry. If he is willing to sacrifice it, the following scheme could serve his purpose.

Let q_{it} be the quantity of commodity i and let z_{it} be the set of "direct" determinants of demand for commodity i. This set might include total income, own price, prices of close substitutes, but also family size, weather conditions, kilometers of highway, etcetera. Let $\gamma_i(z_{it})$ be an arbitrary function of z_{it} which is homogenous of degree zero in income and prices. This condition is relatively easy to impose. What about the adding-up condition, i.e. the condition that the sum of the expenditures per commodity equals the budgety ? In principle, there are two ways to impose this. The first alternative is to specify for i,j = 1, ... n :

$$(1)\quad q_{it} = \gamma_i(z_{it}) + \beta_{it}(y - \Sigma_j\, p_{jt}\, \gamma_j(z_{jt}))\ /\ p_{it}$$

where p_{it} is the price of commodity i and β_{it} satisfies $\Sigma_i \beta_{it} = 1$, while n is the total number of commodities. The second term in this expression acts as a kind of additive correction term. Another possibility is a multiplicative scheme

$$(2)\quad q_{it} = y_t \cdot \gamma_i(z_{it})\ /\ \Sigma_j p_{jt} \gamma_j\ (z_{jt})$$

It is obvious that imposition of Slutsky symmetry would severely limit the freedom of choice for the $\gamma_i(\ )$.

Estimation of (1) or (2) is not necessarily straigthforward. Joint estimation of all equations is intellectualy appealing, but perhaps rather heavy. Another procedure might be an iterative scheme starting with a first estimate of $\gamma_i(z_{it}$ and then using this result in a second round in the part representing the budge constraint. This second round would yield new estimates for the $\gamma_i(z_{it})$ which then are used in the third round in the budget conditions, and so on until subsequent estimates of $\gamma_i(z_{it})$ are almost the same.

The approach sketched here would allow for considerable flexibility both in the choice of functional form as in that of special determinants. It maintains some of the coherence implied by theory. It is somewhere in between free-wheeling adhockery and rigorous conformity with theory. It depends on the purpose of the exercise whether the middle ground between these extremes is a comfortable place to be.

8. CONCLUDING REMARKS

One can agree with Johansen that "the development of complete systems of demand functions has been one of the most important trends in research on consumer demand in the last couple of decades". Its potential in this respect is not at all exhausted. Many of the different research directions sketched above have by far not yet been pursued until their natural end. Still, those systems have been more a framework for structuring our knowledge about consumer demand than a tool for forecasting and policy. Otherwise said, their intellectual appeal has been and is greater than their operationality. I hope that this latter aspect will get more attention in the not too distant future.

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