



Analyzing Demand Behavior

A Study of Energy Elasticities

Douglas R. Bohi

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Foreword

Consumer responses to the energy price increases of the 1970s convinced the general public of what economists had long preached: "Price matters." However, neither economists nor the public have been very satisfied with the answers to the more difficult question: "But by how much?" In the case of energy, no conclusive answer is yet possible, but the numerous studies that investigate demand elasticities do offer a basis for understanding better the process of estimating demand.

Analyzing Demand Behavior: A Study of Energy Elasticities takes econometric studies as data; it examines their assumptions, investigates their methodologies, contrasts the data sets they use, and compares their results. In the end, the limitations and the promise of econometric demand analysis are illuminated for those who use them—decision makers in government and industry. At the same time, pitfalls, sources of error in interpretation, and advantages and disadvantages of alternative procedures are laid out for demand estimators themselves.

By examining an array of studies dealing with the same or related phenomena, the author is able to sort out the ways in which decisions made by researchers affect their results. This is important when demand studies are used as a guide for policy. This analysis demonstrates that estimates can be substantially different, depending on the choices the researcher makes among alternative statistical models, types of data, and estimation methods.

Because the studies examined here were about consumer response to energy prices, the reader also learns a great deal about energy demand—disaggregated by fuel and by consuming sector. Hence, this book can be of immediate use in understanding the likely effects of such policies as decontrol of natural gas, restrictions on oil imports, or marginal cost pricing of electricity. Numerical demand estimates can be compared and some of the differences among them explained. Even though these specific estimates may become dated with shifts in the economy and in energy use patterns, the insights provided are essentially timeless; they can be used in interpreting new studies as they come along.

More important, though, this book will advance the practice of demand estimation generally. By informing users what they can and cannot expect from researchers, it can sharpen the criteria that are used to commission such studies and judge their results. By alerting researchers to some special problems of estimation, it can help them avoid pitfalls and blind alleys; these can be especially serious when rapid changes are taking place in the economy. And by offering a careful critique of the state of the art, it can provide guidance for students and analysts new to demand estimation.

Analyzing Demand Behavior offers no new estimates of demand elasticities for energy. Nor does it provide a detailed description of the different studies examined; for that the reader is directed to the studies themselves. What this work does offer is the considered judgment of its author as to what wisdom can be inferred about the role of econometric demand estimation in formulating policy and understanding demand behavior.

March 1981

Milton Russell, *Director*
Center for Energy Policy Research

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This study is based on research performed under a grant to Resources for the Future from the Electric Power Research Institute. Its goal was a comprehensive survey of the econometric literature on energy demand elasticities and an evaluation of the reliability of the estimates for forecasting purposes. In the process of completing that work, I became increasingly aware of widespread misunderstandings about what has been accomplished in the literature and about what econometric tools can be expected to achieve. This volume addresses some of these misunderstandings by paying less attention to details in the literature and by emphasizing the connections among the problems of demand analysis, the approaches used, the estimates obtained, and the interpretation of results. Although the subject matter is energy, the same problems of estimation and application arise in connection with demand for virtually any commodity. Also, while the studies referred to here cover a period up to the beginning of 1980, and specific results will become dated with new information and research, the issues addressed will continue to persist and should be understood by practitioners and policy makers alike.

I would like to thank Albert Halter and James Eyssell of the Electric Power Research Institute for their assistance with the work on the original research grant, and Nancy Olewiler for her extensive comments on that version. V. Kerry Smith and Michael Toman read early drafts of parts of that manuscript and offered helpful suggestions.

For this work, I am indebted to Edward Erickson, Robert Halvorsen, and Raymond Kopp for their comments. I am most appreciative of the advice and comments of Milton Russell, who guided this manuscript through several drafts to its present form. I am of course solely responsible for any deficiencies that remain, some of which no doubt exist because I did not sufficiently heed the advice given.

This manuscript has also benefited from the help of Anne Farr, who tirelessly and efficiently typed many drafts; Shelley Matsuba, who had the laborious job of checking facts and references; and Ruth Haas, who edited the manuscript with her usual care and patience.

March 1981

D. R. B.

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chapter 1

Introduction

A price elasticity of demand is a convenient way of summarizing how changes in market price or quantity consumed affect each other. It is the ratio of two percentages—the change in quantity consumed that results from a change in price, or vice versa. A reliable measure of this relationship would be valuable in a wide variety of applications involving pricing decisions. For example, accurate information about elasticities of demand for energy products would make it possible to answer many energy policy questions. The effectiveness of an excise tax in reducing gasoline consumption, or the impact of a reduction in oil imports on the domestic price of crude oil would become readily apparent. The fact that there are no confident answers to such questions is an indication of the nature of available information on demand elasticities. This is true for all demand elasticities, not just energy. Furthermore, in view of the comparatively large body of research that exists for energy demand, the absence of satisfactory information raises doubts about the effectiveness of econometric methods in providing reliable answers.

A cursory review of empirical studies of energy demand shows a startling lack of consensus on price elasticities. The estimates vary considerably from one study to the next, in one case suggesting that price is very important and in the next that it is not; sometimes implying that income is the controlling factor while other times

suggesting price is dominant; or sometimes indicating that interfuel substitution is important and other times that it is not. If policy makers turn to research in this area for guidance, they will be confronted with a range of numbers that is frequently so wide it offers little direction. These disparities can affect the enthusiasm for a given analytical position, or they can be used to support widely disparate positions.

The lack of an apparent consensus among empirical studies may lower the contribution of research to policy decisions. It encourages skepticism about the value of this research in guiding policy and raises questions about the basic economic concepts underlying demand analysis. In the absence of any clear statistical evidence about demand elasticities, policy makers are inclined to rely on intuition or noneconomic criteria. It is not our intention to remove all skepticism about elasticities; on the contrary, a certain amount of skepticism is useful if it leads to judicious use of this concept or to caution in selecting among available policy instruments. The primary purpose of this report is served if it helps the reader to understand the nature of the price effect and the value of information contained in current studies of demand, not only for major energy products, but for other products as well.

A second goal is to examine the importance of a number of empirical problems involved in estimating demand relationships, and to evaluate the effectiveness of econometric methods in dealing with them. These problems are not restricted to energy, but arise in econometric analyses of demand for any commodity. Energy demand provides a unique opportunity to explore them, however, because of the unusually large number of studies undertaken in recent years and the wide variety of econometric methods that have been employed. The literature on energy demand analysis therefore provides a case study of applied econometric analysis that can be useful in addressing the same issues in other applications.

The differences among statistical estimates of price elasticities arise from two basic sources: differences in the economic and institutional conditions reflected in the sample and differences in the procedure applied to the data to derive the estimates. Differences associated with the sample are generally easier to identify and understand. Estimates will vary across studies because the magnitudes and behavior of observed variables are different; the variables included in the model are different; consumer tastes and life styles in the observation period

have changed; the stock of energy-using capital has changed; and institutional factors governing energy markets have changed. Just as these differences among samples may produce variations among estimates, so they will account for errors in forecasting behavior in future periods when the structure of demand has changed from the sample period.

Differences that arise because of estimation procedure are poorly understood and more difficult to identify, and thus are the primary focus of this study. Every econometric study of demand begins with the same basic economic concepts. It is the estimation procedure that produces divergence. A choice has to be made about the type of model to use, the kinds of data that are appropriate, and the estimation technique that fits the model and data. In making these choices, a number of estimation problems are either explicitly or implicitly addressed. These problems are discussed in detail in the next chapter.

This study investigates the relationship between estimation procedures used in studies of energy demand and the statistical results obtained. We wish to determine whether the choice of procedures accounts for the disparities among estimates of price elasticities of demand. To the extent that this accounts for differences, it removes a certain amount of skepticism about these studies.

There still remains the question of which procedures yield the more reliable estimates. To this end, it is necessary to ascertain the empirical importance of several methodological issues. What difference does it make whether a static or dynamic model is used? How important is aggregation bias? Is it useful to attempt to separate supply from demand effects? Are more sophisticated estimation techniques worth the trouble? The theoretical literature on econometric methods demonstrates the conditions under which estimators will be subject to aggregation bias, simultaneous equation bias, and assorted other sources of estimation error. Yet, one cannot deduce from the theoretical arguments the importance of the error or, in some cases, even the direction of the error. These are questions that require empirical verification.

The literature on energy demand is unusually rich in the number of studies that can be compared on the basis of estimation method, model specification, and sample data. It is rare to find such a wide variety of econometric studies investigating the same subject from different angles. What appears to be a confusing array of studies and statistical

results can be used to advantage in exploring the sources of the confusion. Our intention is to use this information to shed light on the reasons for the disparities among empirical results and on the empirical importance of the estimation procedure.

A comparison of demand studies makes it possible to determine how sensitive the estimates are to their particular sets of conditions and methodology. The less sensitive a result is to specific economic conditions, the more confidently it can be used in forecasting exercises, as future conditions will undoubtedly differ from those existing during the sample period. Similarly, the less sensitive the result to estimation method, the less concern one may have for employing less convenient and more expensive approaches.

A final objective of this exercise is to provide an overall review and evaluation of the econometric literature on energy demand that can be used as a reference. This may assist practitioners in understanding the pitfalls as well as the successes of available estimates, and provide a basis for selecting among the results. The evaluation is intended to highlight the difficult conceptual problems, the progress in overcoming them, and the gaps that remain.

Chapter 2 presents the analytical basis for comparing and evaluating the econometric studies of energy demand. Starting from the economic concepts of demand common to these studies, the discussion focuses on the major methodological issues that arise in translating the theory into testable hypotheses about demand behavior: (1) the method of capturing the dynamics of demand; (2) the choice of the level of aggregation of the data; (3) the separation of supply and demand effects; (4) the choice of equation form and estimation technique; and (5) the identification of separate influences on demand.

The way in which these issues are addressed may be said to characterize a study's procedural approach. For example, one may choose to estimate the demand for a specific fuel directly with a reduced-form model, or indirectly with a model of structural components. The model may be static or dynamic, and may be applied to aggregate consumer behavior or to individual consumers. The model may ignore supply effects or attempt to integrate supply explicitly in an equilibrium relationship. The sample of data may be time-series, cross-section, or both. The choice of variables included may vary, the variables can be measured differently, and they may be

combined in different functional forms. Chapter 2 describes these alternative estimation procedures, and the methodological questions they are intended to address.

Chapters 3 through 6 discuss studies pertaining to electricity, natural gas, petroleum, and coal, according to consuming sector (residential, commercial, industrial, transportation, and electricity generation) and by modeling technique and type of data analyzed. This organization is intended to group the statistical results by common procedure and data in order to highlight their similarities and differences.

The similarities and differences among statistical results are recorded largely in terms of the magnitude of estimated coefficients, their sign, their statistical significance, and their consistency with theory and intuition. These are associated with the estimation procedures and sample characteristics of the studies. Frequently, the associations cannot be sharply delineated. That is, each study embodies a large number of estimation features, some of which are common to other studies and some of which are not. It is not always clear which disparities among results can be identified with which features. Consequently, many conclusions drawn from this exercise follow from broad patterns that show up across a large variety of studies.

As for the range of studies included here, the first criterion is that the study incorporate a price effect on consumption behavior. In addition, consumption must be identified with one of the four energy product categories and with a specific consuming sector (including transportation). This excludes a number of important studies concerned with substitution in production between energy as an aggregate input and other factors of production, or substitution in consumption between energy and other commodity groups. Within the chosen range, an attempt was made to include all prominent studies currently available, but the choices are inherently subjective and some possibly important studies may have been overlooked. Finally, the studies included are not thoroughly or uniformly discussed, because the focus is on information bearing on the estimation issues rather than details about energy demand. Readers are referred to the original works for full details.

The last chapter draws a number of conclusions about the empirical results and estimation methods reviewed. The conclusions about measures of price elasticity focus on the question of reliability and

which measures may be regarded as most defensible. The discussion of empirical methods concentrates on the relative efficacy of alternative estimation techniques and the implications of several estimation problems in measuring elasticities. The chapter closes with a discussion of some limitations of econometric analysis and their implications for users of these analyses.

chapter 2

Estimating the Demand for Energy: Issues and Methodologies

The demand for energy is in principle no different than that for any other commodity, and the statistical analysis is based on the same economic concepts. Estimation of statistical demand relationships for energy products, moreover, will encounter the same range of methodological issues as that for any other commodity, although there are characteristics of energy demand, institutional features of energy markets, and problems of measurement of pertinent variables that require special attention in analyzing energy markets. The choice of analytical approaches and the way these special problems are addressed may influence the outcome of the analysis.

This chapter reviews the major methodological problems of estimation and the options available to deal with them. It begins with a brief discussion of the basic economic concept of demand and then turns to the problems of statistical inference. The major issues discussed here provide the basis for comparing and analyzing the empirical studies in the following chapters.

The Concept of Demand

All studies of demand elasticities are based on the same fundamental economic principles of demand in a competitive market.¹ At the

¹Two venerable references which still warrant reading are Hicks (1939) and Samuelson (1965). Of more recent vintage is Malinvaud (1972).