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EVALUATING THE COSTS OF REGULATING THE AUTOMOBILE INDUSTRY: AN ECONOMETRIC SYSTEMS MODEL

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ABSTRACT

An econometric model consisting of nineteen equations that describe key relationships in the automobile market/industry is developed to forecast the impact of automobile-related regulations on the industry and the auto-buying public and to provide data that are used to assess the impact on other sectors of the economy. In the development of the model, automobile market behavior (seller-buyer interaction) and output pricing and resource requirement decisions of manufacturers are explored in detail. The process of using the model to forecast the effects of Government regulation on prices, retail sales, production volume, resource requirements, productivity, and other industry variables is described.

The model is used to forecast the effect of Government regulation of automobile noise emissions. The forecast is then used to conduct an input/output analysis of the impact on other industries and to assess the macro-economic effects of the regulation. The study finds that automobile noise regulations (and auto-related regulations, in general):

- Add to the auto industry's unit manufacturing cost
- Cause automakers to increase prices by at least as much as the amount by which costs increase
- Decrease the sales volume of the auto manufacturing industry, supplier industries, and after-market industries
- Increase the capital requirements of the auto industry
- Reduce the productivity of auto industry labor

- Decrease the labor requirements of affected industries, thereby adding to national unemployment
- Add to price inflation

The study also finds that the timing of auto manufacturers' cost-pass-through has a direct effect on their profitability and on the short-term incidence of regulatory costs.

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CHAPTER 1

INTRODUCTION

GOVERNMENT REGULATION OF THE AUTOMOBILE INDUSTRY: THE COSTS

Regulation of the automobile industry has increased considerably over the past decade as the Congress has passed a number of laws authorizing Federal agencies to mandate specific standards for the operating characteristics of new automobiles. Because each new standard has added to the cost of manufacturing new automobiles, a cost whose effects are broadly transmitted, the increase in regulation has been accompanied by an increase in costs which must be borne by the auto industry, the auto-buying public, and the overall economy.

Among the numerous regulatory standards that are now in effect, the most costly are those resulting from legislation aimed at environmental conservation. For example, the Clean Air Act of 1963, along with its amendments that followed, mandated that the Environmental Protection Agency set air quality guidelines including specific standards for acceptable levels of toxic emissions from automobiles. These standards, which required that HC, CO, and NOx emissions from cars be reduced by 90 percent, resulted in a number of effects that were perhaps not fully anticipated at the time the standards were set. We can now see that, because the auto industry had to devote a considerable amount of capital resources to the purchase of plant and equipment needed to manufacture catalytic converters, funds may have been diverted from other, cost-saving investments. We can also see that, because the prices of new automobiles rose as a result of the cost of manufacturing catalytic converters and because most pollution-controlled autos can only use unleaded gas, the cost of owning and operating a car has risen. Moreover, productivity losses resulting from diverted capital funds and higher transportation costs resulting from higher new car and fuel prices have both contributed to inflation.

Another costly piece of environmental legislation, the Energy Policy and Conservation Act of 1975, was prompted by the gas shortage of the previous year. This legislation which mandated that new automobiles meet certain fuel economy standards has, like the Clean Air Act, had a tremendous impact on automakers and auto buyers. To comply with the fuel economy standards set by the Department of Transportation as a result of this act, the auto industry will need to make major modifications in the design of their cars; between 1978 and 1985, the domestic automobile industry will spend $50 billion – more than it cost to put a man on the moon – on the plant, equipment, and tools required to build smaller, lighter, and more fuel-efficient cars.* Consumers will be paying, according to various estimates, between $800 and $1200 more for a new car in 1985 than they would have had the regulation not been enacted. The economy, of course, will bear the burden of the concomitant cost-push inflation.

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* (Irvin, 1977), p. 1.

The mounting cost of regulations placed on automobiles, as characterized in these two examples, is becoming an issue of growing concern to industry and Government officials alike. Industry representatives argue that the impact of regulatory standards should be fully evaluated in Government-sponsored assessment studies before standards are set so that educated cost-benefit determinations can be made. Good estimates of the impact of regulations, they claim, have been lacking in the past. Government officials, particularly those whose job it is to be concerned with achieving national economic objectives, also recognize the need for impact assessment studies and are making their feelings known in Washington. Both groups, it seems, agree that assessing the impact of automobile-related regulations before standards are established is desirable and should be made an integral part of the regulatory process.

If there is such wide-spread agreement concerning the value of regulatory impact assessment, is the Government conducting such studies? The fact is that some Federal agencies now conduct impact assessment studies before they mandate regulatory standards. In those cases where studies are being made, results are used to decide how stringent a standard is warranted on a cost-benefit basis and whether any regulatory standard should be imposed at all; in those cases where studies are still not being made, these types of decisions will continue to be based on insufficient factual information.

PURPOSE OF THIS STUDY

From a policy-making viewpoint, there is little question about the importance and value of impact assessment studies; from a practical viewpoint, however, there is reason to doubt the ease with which thorough impact assessments can be made. The complexity of consumers' car-buying behavior and the auto industry's decision-making behavior which are both important determinants of the ultimate impact of a regulation, rule out the possibility that simple methods can be used; the intricate interrelationships between buyers' and sellers' behavior that must somehow be accounted for, effectively eliminate any piecemeal approach.

Impact assessment studies must be based on an understanding of the behavioral patterns of affected parties if their results are to be meaningful. To account for the many factors involved in the transmittal of a regulation's impact, a detailed, comprehensive approach such as econometric modeling is required. Modeling techniques offer the broad capability to explain the car-buying behavior of consumers, the decision-making behavior of the auto industry, and, in the process, explain the interrelationships between the behavior of these two parties. A model which successfully captures these factors could be used to estimate the primary effects of automobile-related regulations in a consistent, systematic manner. Further, the estimates generated by the resulting econometric model would provide the information required to assess the regulation's impact on a broader, national scale.

This thesis is an attempt to construct an impact assessment econometric model and to demonstrate its use. To fulfill this objective, it will be necessary, as we previously suggested, to become involved in a very detailed study of the behavior of new car buyers and new car makers. Thus, in the process, we will learn a good deal about the new car market and industry.

While this study focuses on the auto industry and related Government regulations, other industries are also subject to similar regulations, and the impacts of these regulations can be estimated by procedures similar to those used in this study. Thus, this study may serve as a general example of policy modeling and methods for evaluating Government regulations.

Let us summarize by stating four distinct purposes of the study:

1. To emphasize the importance and value of assessing the impact of Government regulations
2. To produce an econometric model which can be used to assess the impact of automobile-related regulations
3. To come to a clearer understanding of the workings of the market for new automobiles and the industry which serves it
4. To demonstrate by using the econometric model how the impacts of regulations can be assessed

The remainder of this chapter is devoted to explaining how we will accomplish these desired ends.

THE ECONOMETRIC MODEL: A PLAN

Introduction

A basic rule for planning and building a model is to construct the model to fit the requirements of its intended use by assuring that the boundaries, focus, and detail of the model are defined appropriately. Since our intention is to estimate the effects of automobile-related regulations, the characteristics of the model are tailored to the requirements of this problem.

Focus and Scope of the Model

Cost-Pass-Through

The most direct effect of any Government mandate involving the operating characteristics of automobiles is to increase automakers' manufacturing cost. How an increase in manufacturing cost will affect new car prices depends on how automakers alter prices in response to changes in their costs. Automakers' pricing policies are an important issue that have a direct bearing on the incidence of regulatory costs or in determining where their burden will eventually rest.

The model, therefore, addresses this issue by considering the historical patterns of manufacturers' cost-pass-through policies – the extent to which costs are passed through to price and the speed with which the adjustment is made. To substantiate the statistical findings of the model, qualitative evidence of the automobile industry's pricing practices is presented in the form of testimony from industry executives and experts.

Demand

Once the amount of increase in new car prices is determined, the next important question regards how the price increase will affect the industry's success in selling cars. To answer this question, a statistical explanation of the historical relationship between new car prices and new car sales — a new car demand equation — can be used. By using a demand equation to forecast the magnitude of change in sales resulting from regulation-related changes in price, we are implicitly assuming that consumers' future behavior will be consistent with their past behavior.

A substantial amount of past theoretical and empirical work documented in the consumer durables demand literature has been of great value in our investigation of the price/sales relationship.

Sales-Motivated Price Adjustments

We should also be concerned with the effects, if any, of market demand on market price. If automakers' or auto dealers' pricing practices are sensitive to demand, a slump in demand may cause them to decrease prices in an attempt to stimulate sales. A price increase (caused by regulation-related costs) may cause sales to decrease which, in turn, may cause automakers to decrease price. If this did happen, automakers would shoulder more of the regulation's cost.

A statistical investigation of the possibility of sales-motivated price adjustments has concluded with the finding that prices are only indirectly sensitive to sales. The intermediate variable is what we call "market tightness" and is measured by the level of retail inventory.

Resource Requirements

If a regulation causes the level of automobile sales to decline and with it, automobile production volume, then a notable cost of the regulation is the accompanying decline in the auto industry's employment and capital spending levels. Historical relationships between the level of auto sales, the level of the industry's production output, and the level of the industry's resource use, allow estimates to be made of the magnitude of change in resource requirements resulting from changes in auto sales. These relationships are incorporated in the model in the form of statistical equations.

The decline in the industry's capital and material input requirements resulting from a decline in sales can further be translated into its effect on the demand for supplier industry's output. This can be accomplished by using input/output tables of the economy which detail the input requirements of industries in terms of the output from all other industries. Thus, for example, the tables tell us the dollars of input from all other industries required by the auto industry to produce one dollar's worth of auto output. With this information, the next step — gauging the macro-economic effects of a regulation — is made much easier.

Market Dynamics

Thus far, we have spoken of the impact of Government regulation as though it were static. In fact, the level of impact over time is greatly influenced by the dynamics of the automobile market. Figure 1.1, a causal diagram of the market, helps to clarify this point. By tracing the causal arrows in the diagram, several closed loops can be identified: one, for instance, between "New Auto Sales" and "Stock of Autos"; another between "Retail Inventory" and "Auto Production"; and several others that involve more than two variables. Each of these closed loops represents a feedback mechanism which is important in determining the behavior of the variables that are part of the loop. All of the feedback loops together govern the dynamic behavior of the entire market.

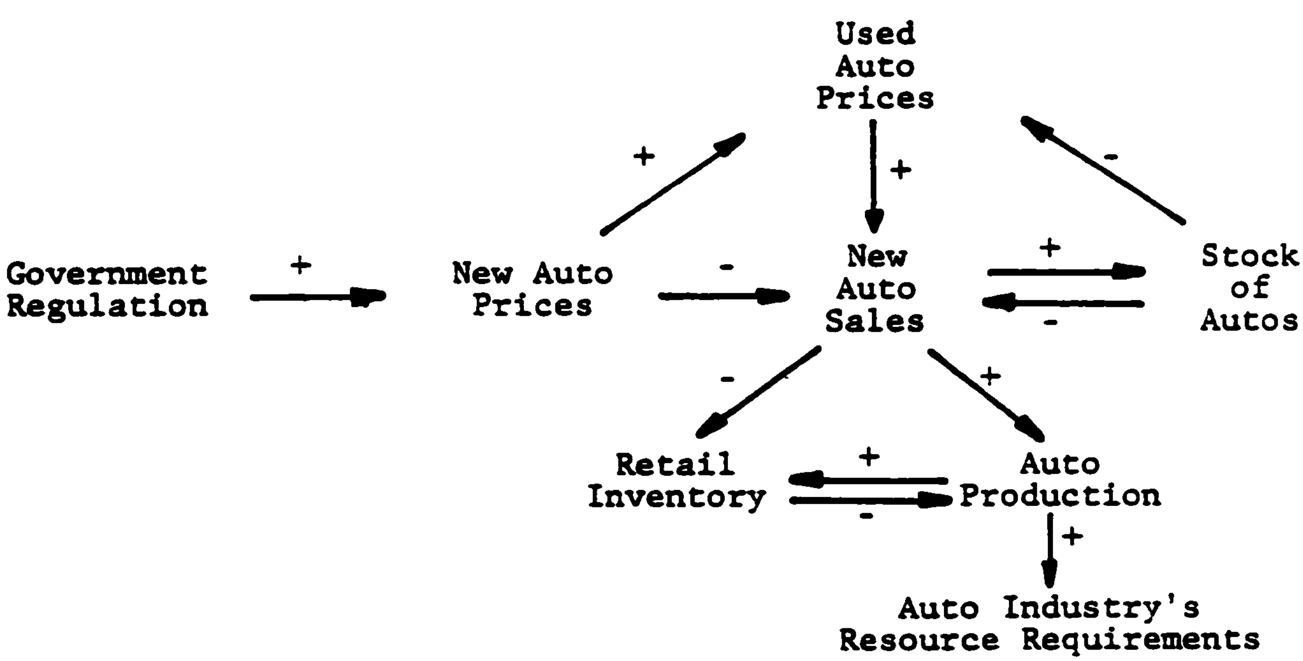

Figure 1.1. Key Market Relationships

The imposition of a Government regulation on the market system, taking the form of an increase in new car prices, may be viewed as an external shock of the system, one whose effects are determined over time by the combined influence of the shock itself and the feedback mechanisms inherent to the system. The feedback mechanisms may amplify the effect of the external shock or dampen it, depending upon whether positive feedback or negative feedback predominates. Without explicitly stating all of the relationships in algebraic form, the only certainty is that the effect of the external shock on the system will vary over time.

This finding underscores the importance of viewing the market in its entirety and of incorporating all of the hypothesized market relationships in our impact assessment model.

Detail of the Model

Selecting the most appropriate level of detail for the model is a decision that involves the trade-off between the size of the study and its manageability. Aggregate data are available and easy to handle, but sometimes errors are introduced in aggregation. Unless these errors are large enough to invalidate empirical work, one is usually forced to accept them. Demand analysis, for instance, is usually carried out with either aggregate time series data or aggregate cross-sectional data. Theoretically, neither of these approaches is correct, but no other practical way of estimating aggregate demand exists.

Automobiles, like consumers, vary in characteristics; they are of different sizes and styles. Aggregating automobiles, like aggregating consumers, produces a tolerably small error in an aggregate demand analysis.* For this reason, we will deal with aggregate levels of new automobiles and not differentiate by size, style, or any other characteristic.

Forecasting Range

"A model designed for forecasting purposes should have as small a standard error as possible, while a model designed to test a specific hypothesis should have high t statistics."** Although many automobile demand equations can be found in the economics literature, all have been developed to test a specific hypothesis concerning consumer demand for automobiles.† None has been developed with the intention of capturing the dynamics of the marketplace, and none has been evaluated on this basis.†

The goal of this study, however, is to develop a model that can be used to forecast. Therefore, an important criterion for evaluating this model is how well it tracks past data. Although following established economic theory is important in the development of the model, developing a new theory of consumer demand is not an aim of this study.

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* Smith (1975) points out that "... consumers have been comparatively indifferent to the engineering and design of their cars; and that style, while important for market share, has had little influence on total demand." p. 26.

** (Pindyck and Rubinfeld, 1976), p. 315.

† See, for example, (Juster and Watchel, 1972), (Kenney, 1972), (Smith, 1975), (Westin, 1976), and (Mishkin, 1978).

While models can be categorized by their intended use as either "theoretical" or "forecasting", forecasting models can also be distinguished by the type of data used in their construction and by the time span of their forecasts. These two related characteristics are also determined by the model's intended use. For example, a model used to forecast the long-run effects of a Government regulation should be founded on theoretical long-run equilibrium relationships and estimated using some combination of cross-sectional and time series data. On the other hand, a model used to forecast the short-to-intermediate term effects of a Government regulation should be based on relationships of variables that determine the market's dynamic response to regulation and should be estimated with time series data.

Whether a long-run or a short-run model is better suited to meet the demands of a forecasting problem depends upon the character of the problem. Forecasting the impact of Government regulations that may have catastrophic long-run effects, for example, certainly requires a long-run model. For those regulations whose effects occur principally in the short-to-intermediate run, a short-run forecasting model that can better trace the dynamic time path of the effects is preferred.

Using this rule, a short-run model is appropriate for forecasting the effects of Government regulations on the auto industry for two reasons:

1. In all previous studies of auto demand, the short-run price elasticity has been found to be many

times greater than the long-run price elasticity.* This suggests that the effect of a price increase instigated by regulatory control will be greatest in the short run.

2. On a present value scale, the short-run effects are those that are most important; long-run effects are discounted. This also suggests that we should focus our attention on the short run.

For these reasons, the model will be developed using data series sampled at quarterly intervals. Use of quarterly data should improve the model's ability to forecast the short-run behavior of the market by assuring that adjustment processes with short cycles are captured. Intuition suggests that there may be many market feedback processes whose average lag is less than a full year.

OUTLINE OF THE DISSERTATION

The remainder of this dissertation is devoted to explaining the development, testing, and use of the proposed model. In Chapter 2, the demand for new automobiles is examined, the theory of demand for consumer durables is reviewed, and important past work is drawn upon to develop a demand model. Institutional information that has influenced the form of the model is also brought out. An important goal of the chapter is to determine how the level of auto price affects the level of demand. Both the static and dynamic characteristics of the price effect are discussed. In its final form, the auto demand model consists of two equations, one explaining the level of total (domestic and import) new car sales and one that relates

* See, for example, Hyman (1970), Juster and Watchel (1972), Smith (1975), Westin (1976), and Wharton EFA (1977).

total sales to the level of new domestic car sales by an exogenous market share variable.

The third chapter is an econometric study of the pricing side of the market. Two equations are developed, one that explains the determination of new car prices and another that explains the determination of used car prices. The first of the two is founded on the model of oligopoly pricing. In developing this equation, Fellner's (1965) and Chamberlin's (1956) works are used and compared with observations of the auto industry's past pricing behavior. An equation is constructed that explains price movements by: (1) the adjustment to a market price that is mutually beneficial to all oligopolists and (2) the influence of the demand side of the market on price determination.

The used car price equation explains the causal flow from the new car market to the used car market. A key question addressed in the construction of this equation is whether changes in new car prices precipitate changes in used car prices. Such a relationship is found and shown to be statistically significant.

The fourth chapter introduces a number of equations that, as a group, are called "the supply side of the model" — "supply" meaning availability. Included in this group are equations that explain how automobile production levels, factory sales, retail inventory, and labor and capital requirements are determined. This set of equations reflects the ties between the auto industry and auto market; it describes how market conditions affect the industry. As such, one may say that these equations model management decisions, decisions such as:

- How much should be produced given specific existing levels of expected demand and retail inventory?
- How much should be shipped and how much should be held in wholesale inventory?
- How many workers are needed to produce the desired level of output?
- How many hours should each employee work per week?
- How much should be spent to build future productive capacity given current expectations for future capacity requirements?

The fifth chapter combines the results of the three preceding chapters. An econometric model comprised of nineteen regression equations and identities is presented and discussed in detail. The structure of the equation system is shown to be dominated by a set of five core equations that "drives" the rest of the model. This set includes equations that determine:

- Retail sales of new cars
- New car prices
- Used car prices
- Production levels
- Factory sales

Thus, the core of the model is "market determination" as explained by the combined decision-making of buyers, dealers, and automakers.

Chapter five also explains the methods required for estimation of the model and the solution of the set of equations. More importantly, it presents the results of historical and ex-post forecasts and the evaluation of these results using the root mean square error, the mean absolute percent error, turning points, and plots of the actual versus forecasted values as evaluation criteria.

The sixth chapter is a case study. In this chapter, the model is used to forecast the effects of a Government regulation which would place limits on automobile noise emissions, a regulation currently being proposed by the U.S. Environmental Protection Agency. Analysis of noise emission regulation begins with a discussion of how automobiles can be made quieter and how much making quieter automobiles would cost manufacturers. Auto companies pricing procedures are examined in detail to establish a basis for estimating price increases resulting from the costs of producing noise control equipment.

The econometric model is then used to generate two forecasts – a baseline, "without regulation" forecast, and a revised, "with regulation" forecast. The only difference between the input assumptions in these two scenarios is that, in the latter, auto prices are made higher to reflect the pass-through of regulation-related costs. The difference between the forecasts generated by the two sets of input assumptions yields estimates of the effect of noise emission regulation on all of the model's variables – retail sales, production volume, labor requirements, and capital spending.

Using this data, the effect on auto-related industries, such as auto industry suppliers and the auto after market, is estimated using input/output analysis. Other macro effects of the regulation, such as its effects on price inflation, unemployment, and productivity, are also evaluated.

In the seventh and final chapter, the key findings of the study are reviewed and those aspects of the auto market and industry which we better understand as a result of the study are discussed. The findings of our case study are reviewed and general observations concerning the effects of Government regulation are made.

CHAPTER 2

AGGREGATE DEMAND FOR NEW AUTOMOBILES

INTRODUCTION

Determining the factors that affect aggregate demand for automobiles has long been a pursuit of applied economists. In 1939, Roos and Von Szeliski were commissioned by General Motors to study the determinants of auto demand and construct a forecasting equation. Since then, many other authors, unsatisfied with previous explanations given, have offered their own interpretation of the auto demand function. Atkinson (1952), Farrell (1954), Boulding (1955), and the famous debate between Brems (1956) and Nerlove (1957) that appeared in the Journal of Marketing are among the commonly referenced early works, but the most widely recognized milestone is Gregory Chow's Demand for Automobiles in the United States: A Study of Consumer Durables published in 1957. Chow's work, a significant step, stimulated interest in auto demand and served as a basis for research to follow.

One year after Chow's work, Daniel Suits (1958) appeared before the Senate Subcommittee on Anti-Trust and Monopoly to offer testimony concerning the price elasticity of demand for new automobiles, a subject about which opinions have always differed greatly. At about the same time, Stone and Rowe (1957, 1960) completed their famous stock adjustment model which, along with Chow's model, influenced most of the time series work on the demand for durable goods that followed.

Notable studies continued to be produced throughout the 1960's by authors such as Huang (1964), Dyckman (1965), Walker (1968), Evans (1969), and Triplett (1969).

During the 1970's, the automobile marketplace has received even more attention than before. Lawrence White wrote The Automobile Industry Since 1945 in 1971 which, although now slightly outdated, is a useful reference to the industry and market. Wyckoff (1970, 1973) studied the depreciation of automobile price. Hymans (1970) and Juster and Watchel (1972) used the University of Michigan Survey Research Center's index of consumer sentiment to measure the influence of consumer attitudes on aggregate new car purchases. Kenney (1972) studied in detail the role of the credit market in demand for consumer durables. Most recently, Smith (1975) modeled consumers' ownership, purchase, and replacement decisions in his work, Consumer Demand for Cars in the USA. Westin (1975) stressed the importance of purchase timing in consumers' demand decisions. In 1977, Loxley and Schink of Wharton Econometric Forecasting Associates used a combined cross-sectional/time-series approach to construct a model of the demand for cars by car category (i.e., subcompact, compact, intermediate, and full size).

Although the results of these previous studies will be drawn upon in this work, a detailed review of past studies will not be undertaken here since the literature on the demand for automobiles has been intensively surveyed elsewhere. See, for instance, Brown and Deaton (1972) and Houthakker and Haldi (1960).

CHARACTERISTICS OF THE DEMAND FOR NEW AUTOMOBILES

The theory of demand indicates that a consumer will purchase those goods and services that he expects will increase his level of satisfaction or utility. Implicit in the theory is the assumption that a good is wholly consumed during the period of its purchase and that, therefore, the utility flow to the consumer is short-lived. The utility flow derived from durable goods such as automobiles is, however, of a special character. Roos and Von Syelski (1939) pointed out that "from the demand standpoint, the outstanding characteristic of passenger automobiles and other durable goods is their durability." Because durables yield service over a protracted period of time and because consumers' utility for durable goods is derived principally from this service flow, the traditional theory of demand with its comparative static utility concept does not adequately explain consumer demand for durable goods.

Recognizing this, past authors have suggested that to explain consumer demand for durables the traditional demand analysis must be modified by somehow accounting for a dynamic component, such as the level of a consumer's auto ownership, in the individual's (or family's) utility function. The buying unit's level of ownership or auto stock may be taken to represent the utility flow from an automobile, and the demand decision may, therefore, be viewed in terms of demand for a certain level of stock. A family's demand for an automobile in any single period, therefore, depends upon their current holding of stock. This viewpoint has been the basis of most efforts in modeling consumer demand for (or investment in) automobiles; the importance of the existing level of stock has been cited in virtually all empirical studies.

A perspective that is commonly invoked for analyzing demand for new automobiles is the stock adjustment framework. This model of consumer investment behavior postulates that the level of purchase over and above replacement demand depends upon the difference between the desired stock of automobiles and the existing stock of automobiles (or the number of automobiles in operation). The desired stock of automobiles is defined as the number of automobiles that consumers, as a group, desire to own at any time. Desired stock would always equal actual stock if consumers had perfect information, made and acted on decisions instantaneously, and if supply was always available. Since this is not the case, desired stock is, one might say, a hypothetical concept. The stock adjustment model, stated symbolically, with S* representing the desired stock of automobiles, S representing actual stock of automobiles, D^E representing expansion demand, and the subscripts t and t-1 representing time periods is:

$$D_t^E = u\ (S_t^* - S_{t-1})$$

$$0 < u < 1$$

The equation specifies that new buyers as a group will respond only partially to the difference between the desired stock of automobiles and the past level of automobile stock. The rate of response depends upon the adjustment coefficient u. (Expansion demand may also be defined in another way as purchases made by those who enter the new automobile market for the first time or buy to increase their family's stock of automobiles.)

The model also posits that desired stock is determined by a number of market, economic, and demographic factors. For example, letting Y represent income and P represent price, we might hypothesize that:

$$S_t^* = \alpha + \beta_o Y_t + \beta_1 P_t$$

or that the desired stock of automobiles is determined by the level of consumers' income and the price of new automobiles.

Total demand, or gross investment, is defined as the sum of expansion demand and replacement demand or:

$$D_t = D_t^E + D_t^R$$

where D represents total demand and D^R the replacement demand. Replacement demand may be defined as purchases made by those who trade in or sell a used auto that they originally purchased new. Replacement is sometimes equated to auto scrappage by assuming that, for every old car scrapped, a new one will be purchased. In other models that emphasize the investment aspects of auto ownership, replacement is equated to depreciation by assuming that owners fully replace depreciated stock each period.

The characteristics of replacement demand and expansion demand are quite different. Replacement demand is not only more volatile than expansion demand, but quantitatively outweighs the latter. The two may also be distinguished by the characteristics of "replacement buyers" and "new buyers" – individuals of the first group are likely to be older and of higher income levels. Economic factors may affect the two groups' buying behavior in different ways, and different factors may be salient in the two types of purchase decisions.

Replacement Demand

The replacement demand market is composed of a somewhat distinct group of buyers. As White (1970) explains, "Not too surprisingly, those who buy new cars display different characteristics from those who own used cars in general; that is, new cars are not bought by a random selection of car owners, but instead tend to be bought by a smaller group who buy new cars comparatively frequently and sell their used cars to the general public to hold."* The average new car buyer has a higher income than the general car-buying public and is more concerned with the reliability and prestige of an automobile.

Consumers who join this elite group usually never leave it; once a consumer buys a new car he may never enter the used car market again unless it is to buy a second or third

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* (White, 1970), p. 96.

car for his family. Because of this, the question that is usually asked of new car buyers is not <u>if</u> they will buy a new car, but <u>when</u> they will buy one. New car buyers do differ in the length of time that they normally keep a car: most use a car for two or three years, but some wait as long as five or six years before they make a replacement.* New car buyers may, therefore, be distinguished according to the length of their normal replacement interval.

During any single period, replacement demand consists of purchases made by a group of buyers that have trade-ins of various ages. The age distribution of cars traded in is a function of new car buyers' replacement intervals which, for the moment, we will assume remain constant over time. If the normal proportion of cars of any given age that will be replaced in each period is also assumed to be constant,** then the number of cars replaced with new cars in any period can be adequately described as:

$$D_t^R = \sum_{v=1}^{T} \alpha_v S_{t-1,v}$$

where D^R is the number of new cars purchased† (i.e., replacement demand); S_v is the number of cars of vintage v existing

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* (Smith, 1975), p. 92.

** Replacements should be distinguished from scrappage. The typical new car buyer replaces a car that is less than five years old. Cars are not usually scrapped until they are much older.

† Typically, time series models use personal consumption expenditures on new automobiles as dependent variables, but cross-sectional studies (see Huang, 1963) have shown that the act of purchasing an automobile is determined by different considerations than the amount of gross expenditure on the automobile once the act of purchase has been decided. Westin (1975) makes this same argument for using units purchased as a dependent variable rather than gross expenditure.

at the end of period t-1; α_v is the proportion of cars of age v that are replaced with new cars; and T is the number of vintages.

This equation, which is similar to those found in (Smith, 1975) and (Westin, 1975), explains normal or average expected replacement demand in terms of new car buyers' normal or average replacement intervals. For many reasons, however, consumers' replacement timing may sometimes vary from the norm. For instance, since replacement buyers typically own fairly new automobiles at the time of purchase, their transportation needs would be satisfactorily met if they decided to delay their purchase. They need not make a decision in haste. In fact, new car buyers exercise a good deal of discretion in the timing of their replacement purchases. They may advance their replacement schedule when economic conditions are good or postpone it when the market seems unattractive.*

Variations in normal replacement timing can be accounted for by adding "discretionary variables" to the equation for replacement demand. Discretionary variables, defined as economic conditions which may influence consumer replacement timing, are added to the equation at concurrent levels to arrive at:

$$D_t^R = \sum_{v=1}^{T} \alpha_v S_{t-1,v} + \beta X_t$$

where X_t is a set of weighted discretionary variables. Smith (1975) and Westin (1975) have found that including lagged

* Hymans (1970), Smith (1975), and Westin (1975) have all made similar arguments.

values of discretionary variables may also aid in the explanation of replacement demand. As Westin explains, "If variations in replacement timing have occurred in previous periods, current demand must also reflect these variations. An adequate procedure for accounting for the previous period's discretionary behavior is to subtract it from current replacement demand by including a lagged discretionary variable."* The coefficient of the lagged discretionary variable should be of opposite sign and of similar magnitude to the coefficient of the current discretionary variable. By accounting for variations in replacement timing in previous periods, the equation becomes:

$$D_t^R = \sum_{v=1}^{T} \alpha_v S_{t-1,v} + \beta X_t - \beta X_{t-1}$$

Thus, the equation explains replacement demand in terms of: 1) the normal frequency of replacement and 2) variations in replacement timing due to buyer discretion.

Various authors have used a number of different economic variables to explain consumer discretion in replacement timing. Income and price are the most common explanatory variables, although they are not always used in this context. Permanent income is usually associated with expansion demand (see Westin, 1975), and transitory income is sometimes viewed a windfall gain that may affect replacement timing. However, in only one of the works cited in this study (Juster and

* (Westin, 1975), p. 386.

Watchel, 1972) has transitory income been found to be a significant determinant of new car demand. The level of new car prices may be a factor to which replacement buyers are sensitive. Buyers may advance their purchases because the relative price of new cars makes buying attractive or because they expect increases in prices. They may postpone their purchases because new car prices are viewed as being too high.

Another frequently used explanatory variable is the unemployment rate. Intuitively, this variable may seem to be unrelated to new car buying since those who would be unemployed and those who generally buy new cars are hardly the same. However, the variable has repeatedly been found to be a strong determinant of new-car-buying behavior.* Its effect has been explained as a dampening of the effective desire for new autos sometimes being likened to an indicator of consumer expectations.

The index of consumer sentiment (ICS) as measured by the University of Michigan Consumer Research Survey Center has also been shown to be highly correlated with purchases of new autos.** Hymans (1970) used the ICS lagged one period in his demand equation so as to avoid the problem of co-determination of the ICS and demand. He attributed the variable's explanatory power to a strong relationship between consumer sentiment and purchase timing. Juster and Watchel

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* See, for example, (Hymans, 1970),(Kenney, 1972), (Juster and Watchel, 1972), (Smith, 1975), and (Westin, 1975).

** See, for example, (Hymans, 1970), (Juster and Watchel, 1972), (Westin, 1975), and (Mishkin, 1978).

(1972) did a detailed study of the influence of consumer sentiment on durable goods demand. They found that when the ICS was filtered, removing all but the most extreme values, it was more highly correlated with demand. Finally, Mishkin (1978) hypothesized that the ICS is a measure of the disposition of household balance sheets. He showed that changes in the ICS can largely be explained by changes in household debt and holdings of financial assets. He went on to show that in a durable goods demand equation the ICS adds little when household balance-sheet variables are already included.

Lastly, the distribution of income may affect secular trends in buyers' replacement intervals. As more buyers have higher real incomes, replacement intervals may be expected to shorten. This has been shown by (Smith, 1975).* The distribution of income is also an important determinant of expansion demand, as will be discussed in the next section.

Expansion Demand

Expansion demand for new automobiles encompasses purchases made by first-time new car buyers and by car owners adding another new car to their personal stock. In the stock adjustment model, expansion demand is determined by the difference between the desired stock of automobiles and the existing stock of automobiles. Algebraically,

$$D_t^E = \mu (S_t^* - S_{t-1})$$

where D_t^E represents expansion demand at time t; S_t^* is the

* See (Smith, 1975), Chapters 5 and 7.

desired stock of automobiles; and S_{t-1} is the actual stock of automobiles at the end of period t-1. In each period, some portion, μ, of the gap between desired stock and actual stock is closed through expansion demand. The adjustment of actual to desired stock in each period is only partial (i.e., $0 < \mu < 1$), because of lags inherent in consumers' decision processes and in purchasing.

The desired stock of automobiles is determined by various economic and demographic variables. Chow (1957) in one of the first stock adjustment studies specified desired stock as a function of deflated price and real disposable personal income. Since then, other authors have used a number of other explanatory variables, the most common types being income variables, price variables, and consumer finance variables.

Income variables in many different forms have been used in auto demand equations. Permanent income, the most widely used form, has been shown to be a significant demand determinant in (Juster and Watchel, 1972), (Kenney, 1972), and (Westin, 1975) among others. Hymans (1970) presents an equation including disposable personal income minus transfer payments. Smith (1975), following Stone and Rowe (1957, 1960), uses the first difference of disposable personal income to explain quarterly sales of new autos. In general, real income, especially permanent income, has proven to be the strongest determinant of new auto sales (or more specifically, the desired stock of autos) in past studies.

The distribution of income among families also has a significant effect on the desired stock of automobiles as demonstrated by several studies of auto ownership by family income level (see Smith, 1975). In (Wharton EFA, 1977), a single variable, the percentage of families with incomes above $15,000 (1970 dollars) was used to explain the desired stock of autos per family. This variable, although not a pure measure of income distribution, was introduced in a cross-sectional model of the desired stock of automobiles to account for the saturation point above which further increases in average family income failed to increase desired stock. On the basis of survey results,* it was hypothesized that "the percentage of families earning $15,000 or more (in 1970 dollars)" should capture this saturation concept, and indeed it did. The variable entered the equation with the expected negative sign, and the estimate of its coefficient was statistically significant at $\alpha = 0.1$. These results suggest that income distribution variables of similar form may be valuable additions to time series explanations of desired stock

The cost of owning an automobile which includes purchase price, maintenance, repair, insurance, fuel, and opportunity loss also may have a significant effect on families' desired ownership levels. Most studies have not considered all of these "price variables" in explaining desired stock because of difficulty in obtaining all of the required data. Although,

* See (Marketing and Mobility, 1976), pgs. 2-19 through 2-32 for a review of these surveys.

Wharton EFA (1977) constructed a variable called the "capitalized cost of ownership" which accounted for all of these factors. When this variable was used in a cross-sectional desired-stock equation, its estimated coefficient had the expected negative sign, but was of very low statistical significance (the parameter estimate was 0.9 times as large as its standard error). From this result it may be inferred, as others have in past studies, that many of the costs of owning a car are viewed by consumers as transportation costs rather than ownership costs. Taking this view, one would expect that these costs would not be perceived by consumers as part of the differential cost of ownership and would, therefore, not have a significant influence on desired stock. For this reason, many past authors have argued that purchase price is the most significant cost component even though it represents only 45 percent of total ownership cost.

The results of using the retail price of new autos relative to all other consumer prices, an appropriate price variable for time series equations, have been mixed and varied. In most studies, the retail price variable has proven to be a significant determinant of auto sales, but in many cases it is not as significant as would be expected a priori. Problems in obtaining good estimates of the price-demand relationship have frequently been attributed to the lack of good price data.* Differences in the statistical significance of new auto price among studies are not as striking as the differences in the estimated price elasticities of demand. Price elasticity estimates made in the 1950's and 1960's seemed to show little consistency from one study to the next. During the past few years, the general consensus is that, in the short-run, auto demand is moderately price elastic, and, in the long run, auto demand is very price inelastic; however, differences of opinion still exist.

Prices of substitute goods may, theoretically, also influence families' desired levels of auto stock. For urban dwellers, use of mass transit systems is a viable substitute for auto transportation and some substitution may occur, but for the majority of families who own autos no acceptable substitutes exist. In the long run, substitution from auto transportation to other modes of transportation may take place if alternatives are made available to more people. However, presently, attempts to quantify such shifts would lack a firm factual foundation.

While it may be reasonable to overlook the substitution between autos and other transporting modes, a more obvious substitution occurs within the auto market itself between

* The two most commonly used price series are the BLS new car price index (a CPI series) and the deflator for personal consumption expenditures on automobiles and parts. The first has been criticized because it is based on only a sampling of models and because it does not adequately adjust for quality change. The second is a conglomerate of new car prices, used car parts, and auto parts prices and, therefore, may be a poor proxy for new car price.

new and used cars. The trade-off between a new car and a used car may be weighed greatest by those who have never before owned a new car and by those families who are in the market for a second or third car. Therefore, it seems that an explanation of the expansion demand for new cars should consider the effect of used car prices.* This market variable would be expected to have a positive influence on demand for new cars for two reasons: the first is the substitution effect and the second is the expansionary effect of the greater trade-in allowances resulting from higher used car prices. However, if the used-car-price-variable is interpreted solely within the stock adjustment framework as a determinant of desired stock, then it could be argued that the variable should have a negative effect on new car demand as a result of its negative effect on the desirability of auto ownership. Clearly, the influence of the variable could be interpreted in either way and only empirical testing can show which effect is stronger or if the opposite effects offset one another.

Consumer credit conditions also influence the desired stock of automobiles and the demand for new automobiles; however, the true relationship between credit conditions and demand for autos has been a subject of controversy among economists. Many studies have been aimed at explaining the relationship, each in a different way. Suits (1958, 1961)

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* This is not a new idea; Farrell (1954) and Wyckoff (1973) both attended to the relationship between new car demand and the prices of substitute used cars.

and Evans (1969), for instance, argued that the average monthly payment on auto installment loans should explain consumers' sensitivity to price as well as credit conditions. Dyckman (1965) suggested that changes in credit conditions cause buyers to enter or avoid the auto market; he constructed a dummy variable indicating periods when credit was tightened or eased and used it to explain the affect of credit on demand. In another study (Hamburger, 1967), AAA bond rates were used as a proxy for finance rates in an auto demand equation. All of these studies viewed the influence of credit on the demand for autos as a price effect since all were concerned with the terms of the credit contract which are components of the discounted cost of purchase.* However, it may also be argued that in the long run the existence of credit has an income effect on demand since financing allows buyers to consume now and save later. Still another viewpoint was expressed in (Kenney, 1972) in which the durable goods and credit markets were viewed as being co-determined and the direct influence of credit on demand was explained in terms of the net flow of credit funds from lenders to households.

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* If all monthly payments in the credit contract are equal, then the average monthly payment adequately explains the discounted cost of purchase. Use of the average monthly payment has been criticized because the monthly payments of many contracts (e.g., balloon paper) are not equal.

One could also argue that a discounted cost of ownership measure should account for the resale value of an auto. This is a factor that no study has considered.

Lastly, the number of buying units should also be included in an explanation of desired stock to account for secular changes in the size of the market. Various measures of the number of buying units or decision-making units could be used (e.g., the number of licensed drivers, the number of households, the number of families); however, the number of families and unrelated individuals seems to be most appropriate.* The demand equation may be standardized and estimated on a per-family-unit basis by dividing all aggregate measures appearing in the equation (e.g., number of cars purchased, auto stock, and income) by the number of family units.

The Empirical Model

The model of total demand, as previously explained, consists of two components: a replacement demand model and an expansion demand model. Recall that the replacement demand model takes the form:

$$D_t^R = \sum_{v=1}^{T} \alpha_v S_{t-1,v} + \beta X_t - \beta X_{t-1}$$

where $S_{t-1,v}$ represents the stock of automobiles of vintage v existing at time t-1, and X represents one or more discretionary variables. The expansion demand model has been simply

* "Family", as defined by the U.S. Bureau of Census, refers to a group of two or more persons related by blood, marriage, or adoption and residing together in a household. "Unrelated individuals" refers to persons (other than inmates of institutions) who are not living with any relatives.

stated as:

$$D_t^E = u\ (S_t^* - S_{t-1})$$

where S* is the desired stock of automobiles.

Because the existing auto stock is central to the formulation of both models, care must be taken in defining this variable. The stock variable in the replacement demand model is already clearly defined as the number of existing cars of various ages; however, T, the age of the oldest existing cars that are traded in, must be found. Survey results* indicate that during the 1960's between 80 and 85 percent of all cars replaced had been owned for less than five years and about 90 percent had been owned for less than six years.** Since estimation results have determined that accounting for auto stock older than five years helps the explanation of demand by little, T will be set to 5.

The stock variable in the expansion demand model, defined as the number of existing cars, can be refined to improve the accuracy of the overall equation. This can be accomplished by categorizing auto stock according to its age or its price range. Chow (1957) and others have shown that in a stock adjustment model all cars should not be considered of equal importance, that auto stock and desired auto stock should not be defined in terms of car units but in terms of new car

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* See (Smith, 1975), p. 92.

** We might also note that replacement intervals became shorter throughout the 1960's, and this trend presumably has continued in the 1970's.

equivalents. In his 1957 study, Chow estimated the average price of cars i years old, found the ratio of this price to the average price of a new car, and weighted the stock of cars i years old by this ratio. Thus, in Chow's measure of total stock, all cars are weighted according to their market value. An alternative means of accomplishing the same end is to enter the level of auto stock of various ages explicitly in the stock adjustment equation and to accord a weight to the stock of each age by the least squares criterion. Although this method requires that additional model parameters be estimated, it is an easy and objective approach.

In this model, as in the replacement-demand model, auto stock will be separated into five age groups ranging < 1, 1-2, ... 4-5. Truncating the auto stock series at five years is expected to result in better focus on the new car market and those who buy new cars.* The expansion-demand model may now be written as:

$$D_t^E = u \left[S_t^* - \left(\sum_{v=1}^{5} W_v S_v \right)_{t-1} \right]$$

where W_v denotes the weight given to an auto that is v years old.

By expressing the expansion demand model in this way, it can be combined with the replacement demand model as follows:

$$D_t = D_t^E + D_t^R$$

* Cars older than five years are assumed to have little or no value to new car buyers or those in similar income groups.

$$D_t = uS_t^* + \beta(X_t - X_{t-1}) + \left[\sum_{v=1}^{5} (\alpha_v - uw_v)S_{v,t-1}\right]$$

With the equation in this form, knowing that S* is defined by a linear combination of variables, we can see that the model is linear and can, therefore, be estimated by a linear regression method. The form of the equation also shows that, without additional information concerning values of the structural parameters, simple linear estimation will leave many unidentified. Estimates of all structural parameters would be interesting from a theoretical standpoint; however, full identification is not necessary to achieve our objective of forecasting.

Recall that a number of economic and demographic factors have been chosen as possible determinants of desired stock, S*, and as possible discretionary variables, X_t's, on the basis of past studies. Of this list of candidate variables, experimentation will determine which among them are the most significant determinants and the most useful predictors of auto demand. Table 2.1 lists the variables that have been tested in this study. Most of the variables listed have proven to be either statistically poor or otherwise problematic.*

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* Certainly any one of these variables would be statistically significant and of the proper sign in an equation including only a carefully selected group of other variables. However, the basic theoretical tenets of the model may be lost in the process of juggling variables. The general rule used in this study is that income and price, the two most important demand determinants, should be retained in the model at the cost of omitting other, intervening variables.

Table 2.1

List of Possible Demand Determinants

Determinants of Desired Stock

- New car prices (relative to CPI)
- Permanent income (constant $)
- Percentage of families earning $15,000 or more (in constant 1976 $)
- Percentage of families earning $25,000 or more (in constant 1976 $)
- Used car prices (relative to CPI)
- Number of drivers per family
- Average monthly payment on consumer installment loans for autos (index)
- Average down payment (percent)
- Average contract maturity (months)
- Automobile credit extensions[a] (constant $)
- Automobile credit repayments[a] (constant $)
- Credit extensions - repayments[a] (constant $)
- Finance rate

Discretionary Variables

- Unemployment rate[b] (percent)
- New car prices[b] (relative to CPI)
- Index of consumer semtiment[c]
- Transitory income (constant $)

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a - Assumed to affect speed of adjustment rather than level of desired stock.

b - Also differenced and lagged version of the variable.

c - Also differenced, lagged, and filtered version of the variable.

Estimation Results

Various forms of the model were statistically tested with quarterly data from the period 1963-1976.* Because seasonally adjusted data were not available for many of the variables in model, unadjusted data were consistently used and dummy variables were included in the estimation equation to correct for seasonality.

In final form, the dependent variables of the estimation equation are the total unit sales of new automobiles divided by the number of family units.** Independent variables include: 1) the existing stock of autos aged 1 to 5; 2) the price of new cars relative to the price of other consumer goods, defined as the ratio of the BLS new car price index to the consumer price index for all items; 3) the price of used cars relative to the price of other consumer goods, measured by the ratio of the BLS used car price index to the CPI; 4) real permanent income† per family unit; 5) the percentage of families earning in excess of $15,000 in 1976 dollar terms, formulated as an "odds ratio"†† to give greater variation; 6) the percentage of

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* Individual data series are described in Appendix A.

** Family units are here used to mean families and unrelated individuals.

† Calculated as a nine-year weighted average of disposable personal income using weights given in (Friedman, 1957), p. 196.

†† An "odds ratio" is a percentage divided by the quantity 100 minus the same percentage, i.e., p/(100-p). This is a standard technique used to magnify changes and thereby aid in estimating relationships.

families earning in excess of $25,000 in 1976 dollar terms, also formulated as an odds ratio; 7) a dummy variable which accounts for supply shortages due to auto labor strikes*

New car prices, used car prices, and new car sales are assumed to be co-determined elements of the market, each variable influencing the determination of the other two. Because these two independent variables bear such a relationship to the dependent variable, both may be expected to be correlated with the equation's residual. Under these circumstances, ordinary least squares estimation produces inconsistent parameter estimates; an instrumental-variable estimation method that corrects for correlation between independent variables and the error term must be used.

The estimation results shown below were obtained by two-stage least squares, a suitable estimation method. Note that the new car price and used car price variables have been replaced by instrumental variables denoted by "hats".

$$D_t = \underset{(1.5)}{.06} - \underset{(-4.6)}{.12}\ \hat{P}_{N,t} + \underset{(3.8)}{.11}\ P_{N,t-4} + \underset{(2.1)}{.02}\ \hat{P}_{u,t}$$

$$+ \underset{(7.3)}{2.0}\ PI_t + \underset{(5.3)}{.12}\ \mathrm{ODDS15+} - \underset{(-2.4)}{.19}\ \mathrm{ODDS25+}$$

$$- \underset{(-4.1)}{.022}\ \mathrm{STRIK} - \underset{(-5.4)}{.03}\ UE_t - \Big[\underset{(5.6)}{.48}\ S_{1,t-1}$$

* The strike variable is coded as +2., Q4-1964; +1., Q4-1967; +4., Q4-1970; +.01, Q4-1973; +.5, Q4-1976. The weights given to strike periods reflect the length of the strike and the amount of production cut-back.

$$+ \underset{(7.4)}{.26} S_{2,t-1} + \underset{(4.6)}{.27} S_{3,t-1} + \underset{(5.9)}{.26} S_{4,t-1}$$

$$+ \underset{(5.3)}{.25} S_{5,t-1} \Big] - \underset{(-3.1)}{.03} D_1 + \underset{(4.7)}{.0042} D_2 - \underset{(-4.5)}{.44} D_3$$

$\bar{R}^2 = .93$ D.W. = 2.2

Standard error = .002 Mean of dependent variable = .04

F (16, 34) = 33.1

where:

D = retail sales of new automobiles per family (units)

P_N = price of new automobiles (index, 1967=100)

P_u = price of used automobiles (index, 1967=100)

PI = permanent income per family (millions of 1967 dollars)

ODD15+ = percentage of families earning more than $15,000 in constant 1976 dollars (odds ratio)

ODD25+ = percentage of families earning more than $25,000 in constant 1976 dollars (odds ratio)

S_i = stock of i year old automobiles per family, i=1, 2, ... 5 (units)

UE = unemployment rate (percent)

STRIK = labor strike dummy variable

D_i = seasonality dummies for first three quarters of year

Here and in subsequent empirical equations, t statistics are shown in parentheses beneath the coefficients; $\bar{R}^2$ is adjusted for degrees of freedom and D.W. denotes the Durbin-Watson statistic.

Standard criteria for evaluating the equation are: 1) the t statistics of parameter estimates; 2) the signs and magnitudes of parameter estimates; 3) the standard error of the residual relative to the mean of the dependent variable; 4) the observed F ratio; 5) the observed R^2; 6) the Durbin-Watson statistic; and 7) time variation of the residuals.

On the basis of all of these criteria, the equation fits the data well.

Particularly telling for an equation that is to be used for prediction is the F ratio. "In order that an equation be regarded as a satisfactory predictor, the range of response values predicted by the equation should be substantial compared with the standard error of the response. The observed F ratio should exceed not merely the selected percentage of the F distribution, but four times the selected percentage."* The critical value of the F distribution (with 15 and 40 degrees of freedom at the 1 percent significance level) is 2.52; the observed F ratio is more than 10 times the critical value, thereby indicating that the equation passes this important test.

The estimation results are, on the whole, quite interesting. The new car price variable, both in the current period and lagged one year, is shown to be a strong determinant of demand. The current value of new car price presumably helps to explain both expansion demand and replacement demand, while the lagged value is picking up the effect of previous shifts in replacement timing. That the absolute magnitudes of the coefficients of the two variables are so close seems to indicate that the main effect of price is to cause advances or delays in replacement timing. It will be shown that, as a result of this, the long-run price elasticity of demand is rather small. The used car price variable is also shown to be a significant

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* (Draper and Smith, 1966), p.

demand determinant, albeit the weakest member of the equation. This variable, remember, is hypothesized to affect families' desired stock of automobiles in two ways: one having a positive effect and the other, a negative effect. The estimation results seem to indicate that used car prices' main effect on new car demand is expansionary and is realized as a result of consumers' incentives to substitute new cars for higher-priced used cars or, alternatively, to trade higher-valued used cars for new cars.

All three income variables are shown to be convincingly significant in explanatory value. Although their estimated coefficients cannot be directly interpreted in terms of new car purchases, since the variables are determinants of desired stock, the signs of their coefficients, particularly the coefficients of the two income distribution variables, tell an interesting story. Recall that the income distribution variables are needed to help explain the relationship between family income and desired stock per family since, as noted previously, survey studies have indicated that this relationship is highly non-linear. A plot of desired family stock versus family income would show desired stock to increase with family income until a certain saturation point beyond which the curve would flatten out, indicating the marginal effect of further income on the level of a family's desired stock to be zero. That the coefficient of ODD25+ is negative and is greater in absolute value than the coefficient of ODD15+ indicates that ODD25+ has captured this saturation effect and that the saturation point is less than $25,000 and more than $15,000 in 1976 dollar terms. That the coefficient of ODD15+ is positive indicates that the slope of the desired stock-income relationship is greater for income levels between $15,000 and $25,000 than it is for income levels below $15,000. This may be explained by the increased desire for second and third cars by families in this income range.

Price Elasticity

The most important aspect of the estimation results is the estimated influence of new car prices on demand since the coefficient of new car price will, to a large extent, determine the main policy implications of the model. To forecast the effects of a Government regulation, for example, differential manufacturing costs would be translated into an expected change in new car prices which would be input to the demand equation to estimate the resulting change in retail sales.

Because the price-demand relationship is so important, examining the estimated relationship in terms of the price elasticity of demand for new automobiles is worthwhile. Calculating the estimated price elasticity, a readily interpretable measure, allows us to judge the reasonableness of the estimated relationship. A priori, we would expect the demand for new cars to be fairly inelastic to price changes because the few substitutes for new cars that do exist (e.g., used cars, mass transit systems) are viewed by most new car buyers as inferior alternatives. However, as was previously noted, increases in new car prices may cause some new car owners to delay their replacement purchases and, therefore, the short-run effect of a price increase may be much greater than the long-run effect. The likelihood of variation in the sensitivity of demand to price changes as the elapsed time after a price change grows longer requires that the dynamic price elasticity of demand be estimated. The dynamic price elasticity of demand which tells how the demand for new cars would change over time in response to a change in price is calculated as:

$$E_p(\tau) = + \frac{P_t}{D_t} \frac{(D_{t+\tau} - D_t)}{\Delta P_t}$$

where P is price, ΔP is the initial change in price, D is quantity demand, t is the base period, and τ is the elapsed time after the change in price.

To calculate the dynamic price elasticity from our estimated equation, we must use the stock identity:

$$S_t = S_{t-1} + D_t - \text{Scrappage}_t$$

to keep track of changes in stock over time. This single equation is actually a simple representation of the way the auto stock of various ages must be updated; we actually need five such stock equations, one for each vintage i, i = 1, 2, ... 5. Scrappage for the first four equations is determined by the probability that a car will be scrapped during the corresponding year of its life* and scrappage

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* Scrappage rates were obtained in (Wharton EFA, 1977).

in the fifth equation also includes all cars that reach five years old. These equations along with an equation for updating the price of used cars* are linked to the demand equation to calculate the dynamic price elasticity.

Figure 2.1 shows a plot of the dynamic price elasticity of demand as calculated from the estimated equation parameters. The plot shows that the main effect of a price increase manifests itself within one year. The elasticity of demand in the first quarter following an increase in price is calculated to be -2.1; in the second, third, and fourth quarters of the first year it becomes increasingly more inelastic and the overall price elasticity for the first year averages out to be -1. Lost sales in the first year are a result of replacement buyers delaying their purchases and of prospective "expansion" new car buyers deciding to buy a used car or other commodities instead of a new car. After one year has elapsed, the elasticity of demand becomes positive. Perhaps to some this result may seem counter-intuitive; however, it does have a good, common sense explanation. Replacement buyers who had delayed their purchases return to the market, the psychic effect of the price increase wearing off and the possibility of further price increases discouraging further delay. This return to the market causes

* This equation is discussed in the next chapter.

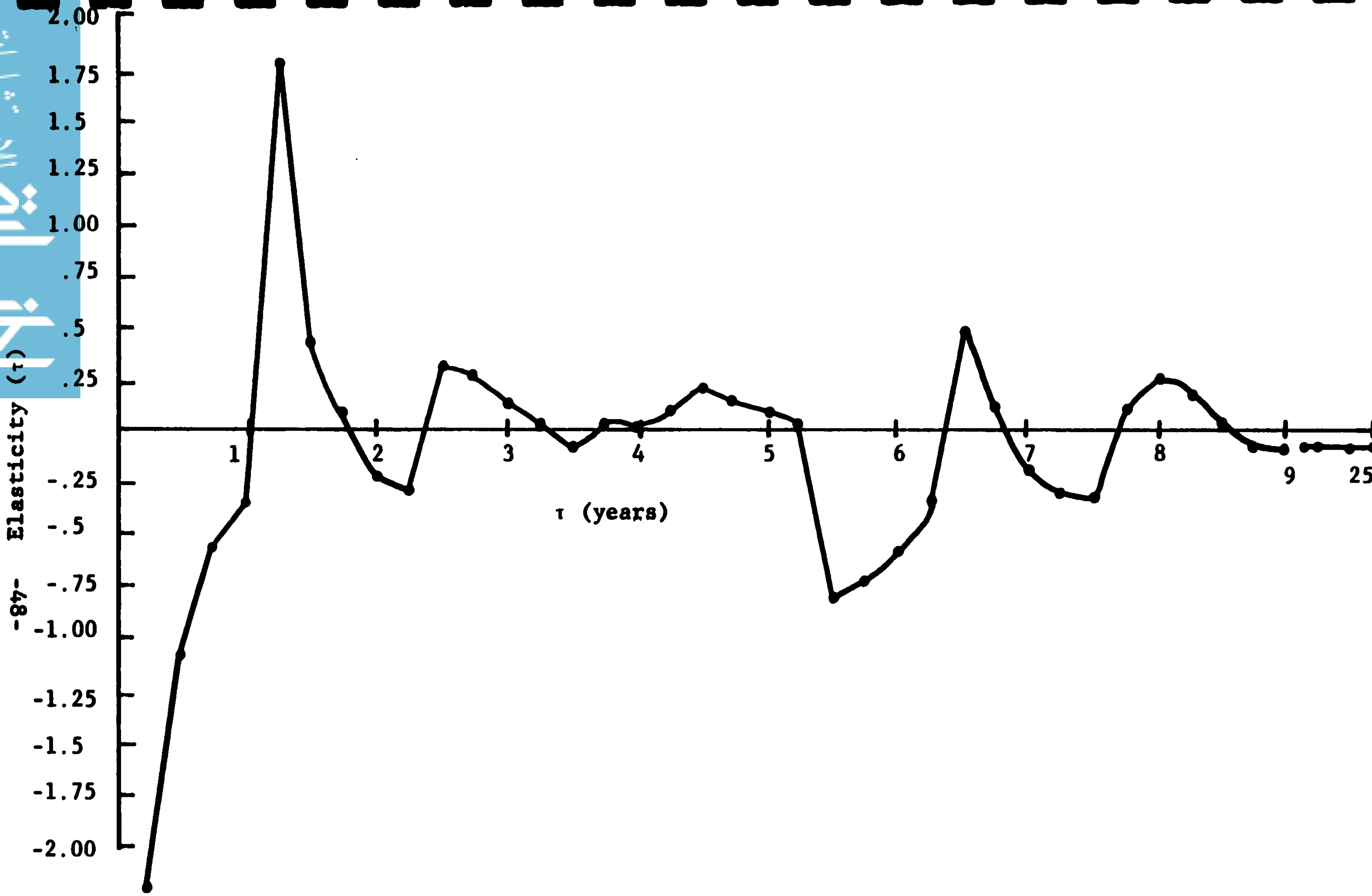

Figure 2.1. Dynamic Price Elasticity of Demand

total sales to be temporarily higher than they otherwise would have been. The expansion market also plays a part in causing demand to bounce back. By the end of one year, the prices of one year old used cars fully reflect the increase in new car prices, and this causes new cars to become comparatively more attractive in buyer choices between new cars and one year old used cars. Oscillations that are shown in the dynamic price elasticity following year two are caused principally by replacement buyers being "off-cycle". The curve dampens as shifts in buyers' replacement buying tend to offset one another and replacement intervals attain a new normalcy. A permanent, long-run price effect does occur, however, as is shown by the price elasticity beyond twenty-five years. The long-run price elasticity, estimated at -.02, is interpreted as a measure of the permanent shift in consumption patterns, a shift that may be a result of decreased expansion demand for new cars or of decreased frequency of new car replacement. In either case, the policy implications of the estimated result are the same. Since the long-run effects of a price increase are so small, the emphasis should be placed on the short-run effects whose present value and absolute value are greatest.*

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* One must add to this conclusion a few words of caution. Both from a statistical and an intuitive point of view, one should be careful making extrapolations based upon sample results. Statistically, the primary concern is whether future values of data will fall within the sample

(Footnote continued on bottom of next page.)

Income Elasticity

The elasticity of demand with respect to changes in disposable personal income per family can be calculated using the estimated coefficients of PI, ODDS15+, and ODDS25+ and knowledge of the functional relationships between disposable personal income and these three variables. Permanent income per family is defined by a distributed lag of personal disposable income over nine years. Thus, changes in personal disposable income can be directly translated into changes in PI. Although the other two income variables, ODDS15+ and ODDS25+, are meant to explain income distribution, by definition they are both influenced by the level of real income per family and must, therefore, be considered in estimating the income elasticity of demand.

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* Continuation of footnote from previous page.

range. In this case, P_N, the price of new cars, is the variable of interest. Because new car prices will likely continue to rise, making extrapolations about the relationship between demand and price at prices higher than those included in our sample is unavoidable. One consolation is that the consumer price index will also continue to rise and, thus, relative new car prices may not change by much. The largest yearly change in price that occurred during the sample period was an 11 percent increase between the fourth quarter of 1973 and the fourth quarter of 1974. Therefore, the model should not be expected to accurately predict the effects of greater than an 11 percent change in the price index.

Intuitively, another caveat concerning assumptions about the constancy of market structure should be voiced. Innovations in the transportation market within the next twenty years are inevitable and such innovations will certainly change the demand for automobile-type transportation. Forecasting events of this type involves a great deal of uncertainty and, thus, all forecasts must be made on a ceteris paribus basis which dooms them to be in error. This, however, is unavoidable.

These variables, the "odds" that a family's income is over \$15,000 and the "odds" that a family's income is over \$25,000, can be statistically explained as a distributed lag of past levels of disposable personal income per family as shown by Wharton EFA (1977). "Past trends in income have a substantial influence on the extreme end of the income distribution which itself has a strong and fairly stable trend."* Using a distributed lag of disposable personal income per family and adding the "change in current period income" and the unemployment rate which each have strong separate effects, two equations have been estimated — one for ODDS15+ and one for ODDS25+ — that can be used in calculating the income elasticity of demand and in projecting future values of the two variables.

1.** $\ell n\ (ODDS15+) = \underset{(10.92)}{22.289} + \underset{(1.73)}{.589}\ \Delta\ \ell n\ (DPI/FAM)$

$+ .6510\ \ell n\ (DPI/FAM)_{-1} + .7936\ \ell n\ (DPI/FAM)_{-2}$

$+ .7312\ \ell n\ (DPI/FAM)_{-3} + .2585\ \ell n\ (DPI/FAM)_{-4}$

$- \underset{(-2.6)}{.1803}\ \ell n\ (UE)_{-1}$

Period of fit: 1964-1977

$\bar{R}^2 = .97$ SEE = .0487 DW = 1.56

2.** $\ell n\ (ODDS25+) = \underset{(14.11)}{26.267} + \underset{(1.56)}{.4146}\ \Delta\ \ell n\ (DPI/FAM)$

$+ .6993\ \ell n\ (DPI/FAM)_{-1} + .8343\ \ell n\ (DPI/FAM)_{-2}$

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* (Wharton EFA, 1977), p. 271.

** Distributed lag on $\ell n\ (DPI/FAM)_{-i}$ for i=1,...4 was estimated using the Almon distributed lag polynomial technique (2nd degree, constrained to zero at i=5).

$$+ .8588 \ln (DPI/FAM)_{-3} + .662 \ln (DPI/FAM)_{-4}$$

$$- .127841 \ln (UE)_{-1}$$

$\bar{R}^2 = .985$ SEE = .0445 DW = 1.6

where:

- FAM = Number of family units defined as the number of families plus the number of unrelated individuals.
- ODDS15+ = The odds of a family earning $15,000 or more (1976 dollars); or (p/1-p) where p is the percentage of total families earning $15,000 or more.
- ODDS25+ = The odds of a family earning $25,000 or more (1976 dollars).
- DPI = Disposable personal income (billions of dollars) divided by the consumer price index (1967 = 100).
- UE = Unemployment rate.

With these two equations, the equation used to construct the permanent income variable, and the estimated demand model, the dynamic elasticity of demand with respect to changes in disposable personal income per family can be computed by simulation. Figure 2.2 shows a plot of the estimated income elasticity at the sample mean. The estimate displays a damped oscillatory behavior, becoming greatest (about 2.7)* at $\tau = 1$ and finally settling to a permanent, long-run value of 1.17, indicating that the long-run substitutability of new cars for other goods and vice versa is virtually negligible.

Comparing the shape of the dynamic income elasticity with that of the dynamic price elasticity, we see that oscillations in the income elasticity are less pronounced and have

* The average income elasticity during the first year is estimated to be about 1.9.

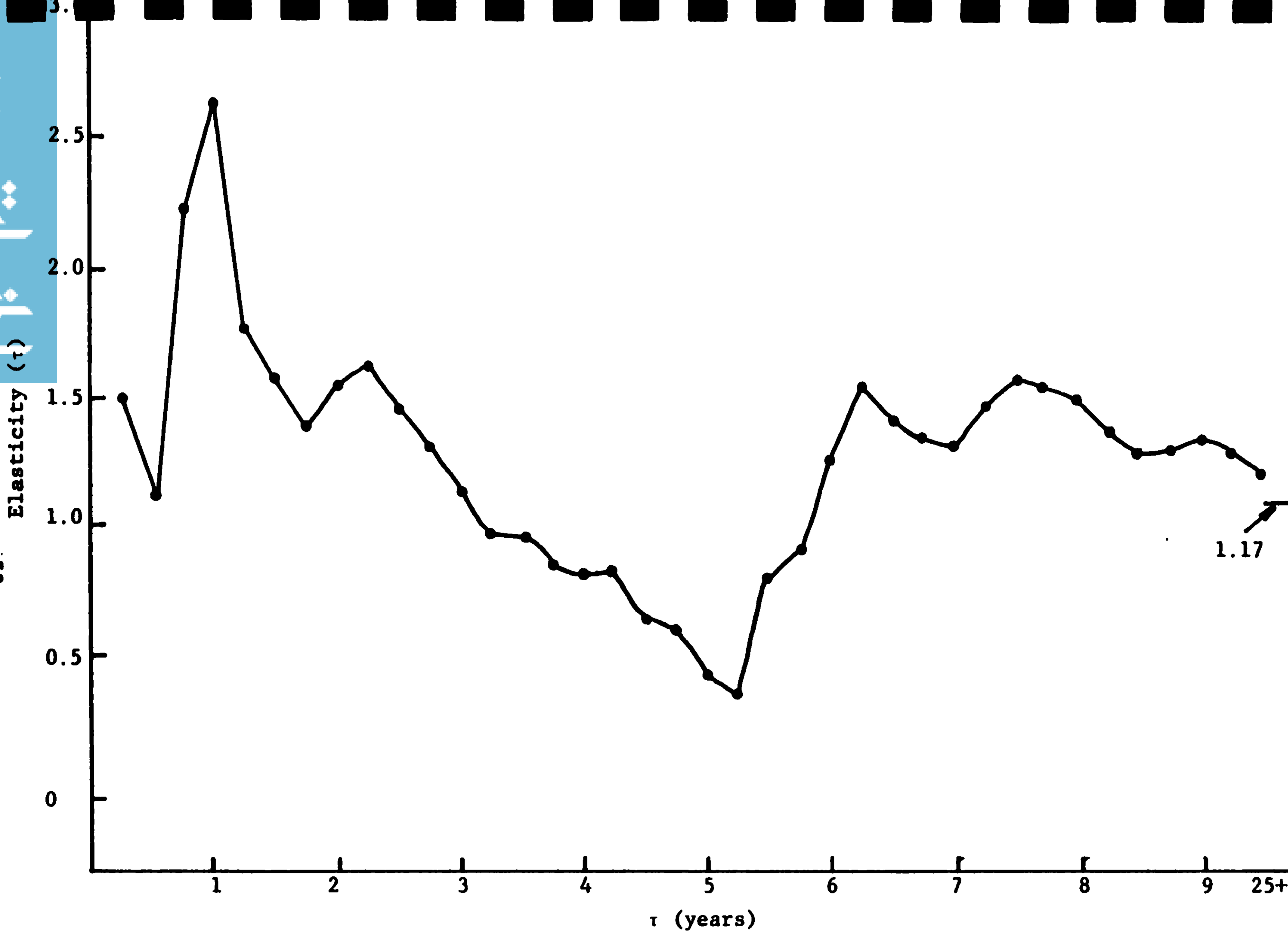

Figure 2.2. Dynamic Income Elasticity of Demand

a longer period. This is a result of the differences in the role that time plays in the functional relationships between disposable personal income and demand and new car price and demand. In the former relationship, demand is influenced by a distributed lag of current and past values of income; the full effect of a permanent change in income level is not realized for nine years, the length of the lag distribution. In the latter relationship, however, demand is influenced primarily by the value of new car prices in the current period and, thus, the full effect of a change in price is immediate. As a matter of interest, recognize that the dynamic elasticity of demand with respect to permanent income would display oscillatory behavior similar to that shown in the price elasticity plot which can be characterized as a dampened series of "overshooting" and "undershooting" the long-run equilibrium level.

Comparison with Other Studies

Table 2.2 shows the price and income elasticity estimates resulting from a number of past automobile demand studies. One can see that there is quite a wide range of estimates for both the price and income elasticity of demand. At least part of this dispersion is explainable. The data sets used range from the period 1921 to 1934 to the most recent of 1963 to 1976 used in this study. One would expect that the more recent the data set used the lower (in absolute magnitude) would be the estimates of price and income elasticity of demand. Consumers' attitudes toward automobile transportation

Table 2.2

Studies of the Demand for New Cars: Elasticity Estimates

Author(s)	Date	Dependent Variable	Price Variable & Price Elasticity	Income Variable & Income Elasticity	Other Variables in The Model
Roos & Von Szelski	1920-1938	New car sales	Average unit values of low price 3; -1.5	Disposable personal income less subsistence living expenses; 1.5-2.5	Stock of cars on road; maximum ownership level; replacement pressure
Atkinson	1925-1940	New car sales per 1,000 households	Deflated BLS new car price index; -1.359	Real disposable income per 1,000 households; +2.536	Ratio of current income in previous year's income; average scrapping age of cars
Chow	1921-1953	New car sales per capita	Price index constructed from newspaper ads; -1.2	Real per capita disposable personal income; 3.0	Stock of cars per capita weight by average used car prices
Suits	1929-1956	New car sales	Complex price and credit terms; -0.59	Personal disposable income; 4.16	Stock of cars
Nerlove	1922-1953	New car sales per capita	Chow's newspaper series; short run: -0.9 long run: -1.2	Chow's income series; short run: 2.8 long run: 3.8	Lagged dependent variable
Houthakker & Taylor	1929-1961	Real per capita consumption of new cars	Price deflator for the consumption series; short run: -0.9578 long run: -0.1525	Real per capita consumption of all goods; elasticity not given	Lagged dependent variable
Hamburger	1953-1964 (quarterly)	Consumption of automobiles and parts	Implicit deflator for series; -1.17	Real personal disposable income; 4.32	Interest rates; lagged dependent variable

Table 2.2

Studies of the Demand for New Cars: Elasticity Estimates (Cont'd.)

Author(s)	Date	Dependent Variable	Price Variable & Price Elasticity	Income Variable & Income Elasticity	Other Variables in The Model
Hymans	1954-1968 (quarterly)	Auto expenditures	Permanent income; short run: -0.8 to -1.2; long run: -0.3 to -0.45	short run: 2.55 to 3; long run: 1 ± .05	Unemployment rate, consumer
Ford Motor	(monthly)	New car sales	Cost of ownership; short run: -0.7; long run: -0.35	short run: n.a.; long run: n.a.	Gasoline prices, insurance
Wyckoff	1950-1970	New car sales	short run: ; long run: -0.26	short run: .87; long run: .93	Used car prices
Rand/NAV	1954-1972	New car sales per household	Adjusted BLS index; short run: -1.34; long run: -0.32	Real permanent income; short run: n.a.; long run: n.a.	Used car prices
Chase Econometrics	n.a.	New car, shares	short run: -0.88; long run: -0.41	short run: n.a.; long run: n.a.	Stock annualized purchase price
Interagency Task Force	1960-1973	New car sales	Purchase and operating costs; short run: -1.2; long run: -0.5	Household income; short run: n.a.; long run: n.a.	Fuel price, fuel economy, scrappage
Wharton	1972 (cross-sectional)	New car sales, shares	short run: n.a.; long run: -0.22	short run: n.a.; long run: 0.57	Gasoline price, interest costs, auto taxes, unemployment rate, auto characteristics
Westin	1953-1972	New car sales	Adjusted CPI; short run: -1.3; long run: -0.64	Real permanent income; short run: +0.68; long run +0.52	Unemployment rate, auto stock, consumer sentiment

have changed over time. During the earliest period cited, the real price of new automobiles was quite high and new automobiles were considered luxury goods. During the most recent period, the real price of new automobiles was much lower and a much greater segment of the population owned new automobiles. Today, certain models of automobiles are still considered luxury items, but new automobiles, per se, are not. For non-urban and many urban dwellers who demand reliable transportation, there is presently no acceptable substitute for a new or recent vintage automobile.

Another source of variation in the estimates is the differences in the particular data used. For instance, in some studies, personal consumption expenditures on automobiles and parts divided by the appropriate PCE deflator is used as the dependent variable; this variable accounts for the sale of used cars, auto parts, and new cars. In these studies, the ratio of the deflator for personal consumption expenditures on autos and parts to the deflator for all personal consumption expenditures is used as the price variable. Models constructed on the basis of these data series would be expected to show income and price elasticity estimates that are somewhat different than those found by models using the number of new cars sold as the dependent variable; however, a priori, it is difficult to judge exactly how the estimates would differ. In any case, the estimates from models that use different data are not directly comparable.

Sales of New Domestic Automobiles

For some policy simulations, the change in sales of new autos by domestic manufacturers may be of greater importance than the change in total (domestic plus import) sales. We might want to know, for instance, how the domestic labor market would be affected by a change in auto sales, and this could best be determined by an estimate of the change in sales and production of domestic automobiles.

To determine the number of domestic cars sold from the total number of cars sold, an estimate of the percent market share held by domestic manufacturers is required. Market share is determined by consumers' preferences for domestic or imported cars and their varied characteristics, substantive characteristics such as interior roominess, horsepower, reliability, fuel economy, and appearance, and other characteristics such as model name and market image. Thus, a set of statistical equations explaining the relationships between imported car characteristics and demand for imported cars, and domestic car characteristics and demand for domestic cars could be used, (given information concerning the future characteristics of imported and domestic cars), to forecast market share. The characteristics of future domestic and imported cars, however, cannot be accurately forecasted for more than one or two model years in advance (if that long). A market share forecasting model would, therefore, be much less rigorous than the significant amount of effort required to construct it would justify.

In this study, market share will be treated as an exogenous market factor or as a factor that is determined by forces outside the purview of the model. Forecasts of total car sales will be multiplied by an assumed market share to estimate domestic-type car sales; changes in total car sales will be assumed to be distributed between domestic and imported sales according to market share. This will allow for the flexibility to conduct sensitivity analyses using market share as an adjustable parameter.

SUMMARY

The most significant finding of this chapter is that the elasticity of demand for new cars with regard to purchase price is very low after shifts in replacement buyers' purchase timing are accounted for. Our estimate of the long-run price elasticity, -0.02, indicates that increases in car prices do not effect significant permanent shifts in consumption choices. Quite to the contrary, this result suggests that the main effect of a price increase is to cause buyers to delay their replacement purchases, i.e., lengthen their replacement intervals.

The relationship of purchase timing to price is explained in the demand model by treating price as a "discretionary variable" as was done by Smith (1975). In practical terms, this has meant that both current values of new car prices and lagged values be included in the model as explanatory variables with the lagged price variable accounting for discretionary adjustments that have been made in the past and that will impact the present.

CHAPTER 3

DETERMINATION OF AUTOMOBILE PRICES

INTRODUCTION

In this chapter equations explaining: 1) the determination of new car prices and 2) the determination of used car prices are constructed.

The new car price equation is based on the historical relationship between auto prices and other variables such as auto manufacturing costs and the level of retail inventory. The equation is of importance in this study because: 1) it measures the extent to which auto prices have, in the past, been decreased to stimulate sales and 2) it answers certain questions regarding how auto manufacturing pass through cost increases to price. It will, therefore, help us to determine whether the auto industry will bear regulatory costs and to what extent it will do so.

The used car price equation describes the historical relationship between used car prices and new car prices. Its importance in this study is derived mainly from the role it plays in market feedback. Recall from Figure 1.1 that three variables: 1) new car sales, 2) new car prices, and 3) used car prices, are involved in a feedback chain. The used car price equation is an important link in this chain because without it the chain would be incomplete.

DETERMINATION OF NEW AUTOMOBILE PRICES

Automobile manufacturers, retail dealers, and new auto buyers all play a part in the determination of new automobile prices. Manufacturers set wholesale prices, the prices that dealers pay for automobiles, and list prices, the symbolic "sticker prices". Dealers sell cars at retail prices that lie somewhere between wholesale and list prices, the selling price for any individual car being determined by a bargaining process between dealer and customer. Since this study is concerned with the prices which consumers pay for new cars and the determination of those prices, focus will be placed on retail prices, and wholesale and list prices will be of interest only because of the close relationship they bear to the former.

Auto prices like aggregate prices change for two basic reasons: 1) change in manufacturers' costs (push from the cost side) and 2) unexpected change in market demand (pull from the demand side). Costs are the foundation upon which the secular trend in new auto prices are established since costs are more permanent than market conditions. In the long term, costs determine prices. Market demand, the other force behind price change, effects only temporary aberrations in the basically stable cost-price relationship. Changes in market demand may, for instance, motivate sellers to make short-term adjustments in prices to control inventory levels.

According to the cost-push/demand-pull distinction, dealers and manufacturers change prices for different reasons. Dealers initiate market-motivated price adjustments.* When inventories are low and the market is generally tight, dealers may bargain for higher selling prices; and, when inventories are high and the market is slack, dealers may settle for lower selling prices. Price adjustments made by dealers, however, are typically small in magnitude and last for only short periods of time. Manufacturers, on the other hand, make both cost-motivated and demand-motivated price adjustments to remedy declining profit margins caused by increased operating costs or weak demand. In fact, the best explanation for the increasing historical trend in new car prices (see Figure 3.1) is the increasing trend in the costs of labor and material or, put simply, cost inflation. Manufacturers decrease prices only as a last-resort-marketing maneuver to spur demand and to rescue dealers from the financial hazards of accumulating inventories.**

Until 1978, auto manufacturers changed list prices only at the beginning of a model year; throughout each

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* Dealers also may adjust prices when their operating costs change. However, manufacturers usually know their dealers' operating costs and set list prices relative to wholesale prices so as to allow them an acceptable profit margin. Furthermore, since a large percentage of dealers' operating costs are overhead expenses, their unit costs are largely determined by how many cars they sell.

** Automakers have historically refrained from cutting prices. Increases in manufacturing efficiency (or decreases in costs) are generally passed on to the consumer by adding options (such as radios, automatic transmissions, radial tires, etc.) to standard models at a reduced price, or so it seems.

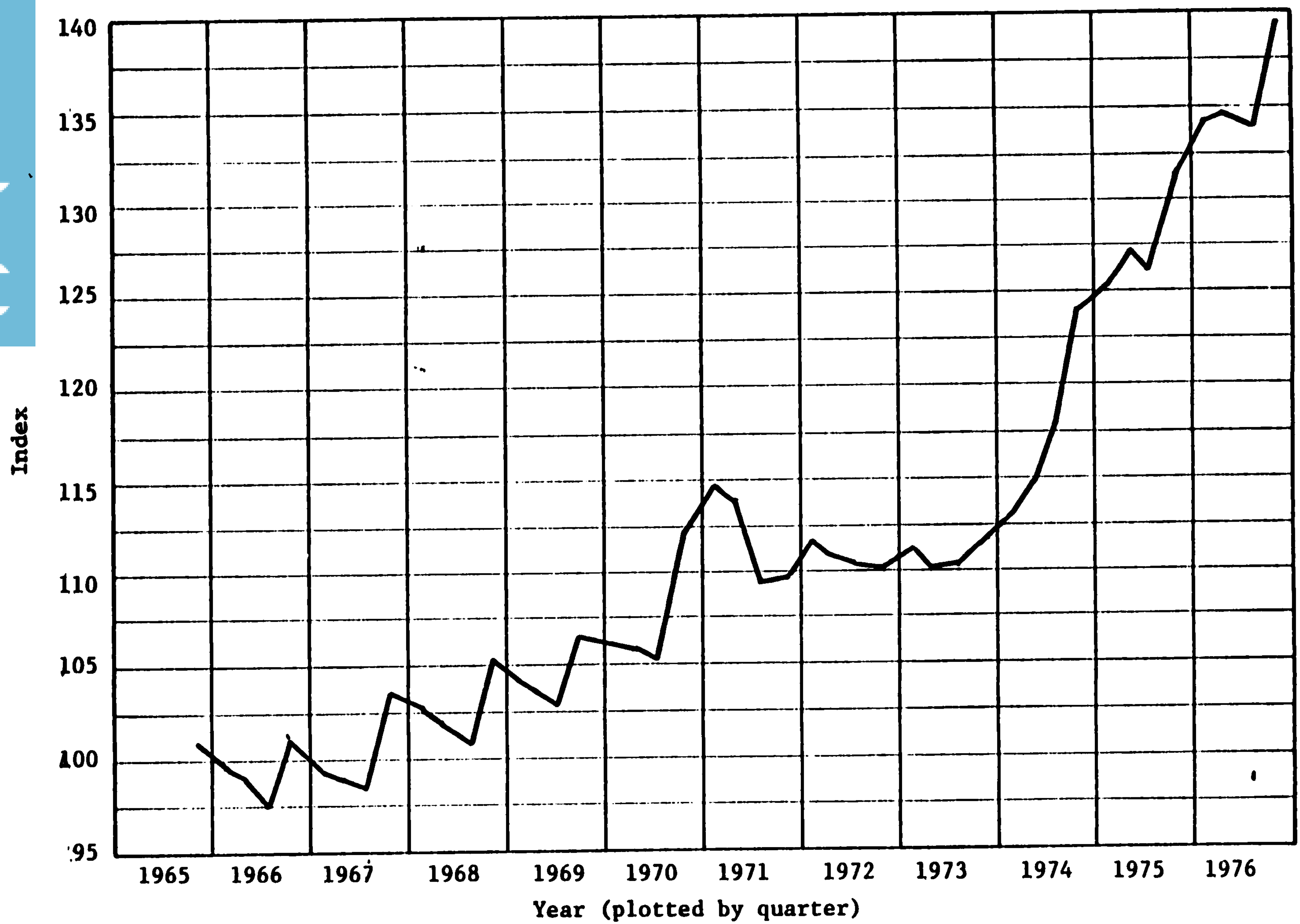

Figure 3.1. New Car Price Index

model year list prices remained fixed. Within-year changes in price consisted of dealers' adjustments and manufacturers' rebate and promotion schemes. As Figure 3.1 shows, because of manufacturers' pricing policies, prices have had a distinct pattern, declining the first three quarters of each year and increasing sharply in the fourth quarter when new models are introduced. This pattern is most evident throughout the period 1965-1970; it disappears from 1971 to 1973 because of price controls during that period, but it re-emerges in 1974.

In May 1978, General Motors announced a pricing strategy which called for refraining from huge price hikes at the start of each model year and, instead, for spreading out price increases in a series of small increments throughout the year.* Although GM spokesmen claimed that the new policy was initiated because of President Carter's anti-inflation campaign, the move may have resulted more directly from GM's concern with growing competition from foreign manufacturers. Importers, unlike domestics, have always maintained a flexible pricing policy and made price adjustments at any time during a model year. Their pricing policies, however, have been dictated by circumstances such as fluctuations in exchange rates that are uncontrollable. GM's decision to initiate a new strategy may have grown out of their realization that pricing flexibility is required as a competitive weapon in the rapidly changing auto market of today.

* (Teahen, 1978).

Indeed, many times in past years, GM and other domestics have found themselves in unenviable competitive positions because of their lack of flexibility.

In early 1978, for instance, when the dollar was devalued relative to the West German and Japanese currencies, the average price of imported cars increased by about $250. Prior to the devaluation, domestic manufacturers had been trying to underprice foreigners to capture market share in the import-held subcompact market; and, according to industry sources, domestics were earning sub-normal profits on their subcompact models. After the devaluation, domestic automakers, whose subcompact prices were now as low as $250 to $300 below imports, chose to hike the prices of their subcompacts by $150 to $200. By doing so, they were able to bolster their meager profit margins but still keep their prices lower than importers'. Because this satisfactory result was owed to pricing flexibility, domestic automakers may be expected to continue to use within-year price adjustments to their best advantage in the future. As of this writing, both Ford and Chrysler have indicated their intention to follow flexible pricing policies similar to GM's.

Relationship Between Costs and Prices for Individual Firms

Cost is an important element of auto firms' pricing decisions. GM's pricing policy, for example, is based on a standard-volume / target-return criterion for each individual car model.* This procedure involves calculating full (direct

* See (National Highway Transportation Safety Administration, Department of Transportation, 1976). Also see Appendix D where GM's pricing policy and the policies of the other three domestic companies are discussed.

plus indirect) unit production costs at a standard planning volume and adding to this cost figure a desired return on investment per unit. The estimate of wholesale price that is derived from this calculation provides the benchmark around which demand-oriented adjustments are finally made. Ford uses a similar pricing procedure, a target return criterion based on a standard planning volume. They too, however, must adjust their cost-based price figures in accordance with expected market conditions. Chrysler and American Motors Corporation (AMC) are in a slightly different position; to remain competitive, they can exercise little control over their return on investment. Although they do estimate their unit costs and plan around expected volume, their prices are determined by the prices set by GM and Ford more than anything else.

Foreign automakers' pricing procedures are somewhat of a mystery in this country, but their pricing strategies are well known. Importers, primarily Volkswagen in the 1960's and the Japanese firms in the 1970's, have priced their small-car models far enough below larger domestic models to attract new buyers and to establish a market niche for the small imported car. Until recently, their job has been easy since they were competing for a segment of the market in which domestic firms had no interest. However, they are now receiving direct competition from domestic firms and are having problems keeping their prices competitive because of the decreasing value of the dollar relative to the yen.

Without their former price advantage, importers are relying more on advertising and merchandizing to retain the twenty percent share of the market that they have had during the past few years.

Table 3.1 shows that, on the average, materials and other direct costs account for about 55 percent of the total cost of manufacturing an automobile, direct labor costs for about 25 percent, and overhead charges for the remaining 20 percent. These are rough estimates and they are based on the production costs of only the "Big Three" auto companies (although the indicated relative sizes of the three cost components may be the same for all manufacturers).

Table 3.1

Estimated Cost Components of an Average "Big Three" Vehicle – Mid-1970's

Cost Component	Percent of Total Cost
Hourly-Rated Labor Cost	25
Materials and Other Direct Costs	55
Subtotal	80
Overhead Cost	20

Source: (A.T. Kearney, Inc., 1977), p. III-37.

Oligopoly Model of Pricing

Given the high degree of concentration in the industry and the high interdependence among its participants, a framework that may be pertinent to automobile pricing is the model of oligopoly behavior. The domestic industry's "Big

Three" — General Motors, Ford, and Chrysler — are a favorite classroom example of oligopoly. White (1972) argues convincingly that the behavior of the Big Three may be explained within the framework of Chamberlin's (1956) or Fellner's (1965) model of oligopoly behavior. Chamberlin asserted that, since oligopolists recognize their interdependence, they are reluctant to engage in price competition that would leave all members of the industry worse off. Instead, according to Chamberlin, oligopolists aim toward a maximization of joint profits and set their prices and output accordingly. As White points out, "There are a large number of important qualifications to this hypothesis — differing cost structures among the oligopolists, differing views of the profit maximizing price, differing views of the proper division of the joint profits, differing views of the likelihood of entry — but its basic idea appears very sound."*

The oligopoly model also suggests that, when costs are stable and are expected to remain so, pricing decisions are straightforward — prices remain unchanged. However, when the costs of labor, materials, or capital increase, firms are faced with uncertainty in their pricing decision.** Each oligopolist wonders how his rivals will change their prices; each wishes to avoid upsetting his fellow oligopolists by increasing prices by too little.

* (White, 1972), p. 110.

** Some would argue that, when the productivity of labor changes, prices will be adjusted. However, changes in labor productivity are not recognized until long after the fact. Further, labor productivity is very difficult to measure and predict; it varies a great deal from year to year.

In the automobile industry, as in other oligopolies, a sort of coordinating institution has evolved that helps alleviate uncertainty in pricing and, hence, helps avoid mutually damaging price competition. Since the end of the Second World War, General Motors has acted as price leader in the industry, and Ford, Chrysler, and the other smaller firms have followed GM's lead in pricing at uncertain times. The pattern of price leadership is not rigid; to be so would certainly invite and attract unfavorable attention. Ford and Chrysler must base their prices on the costs of production; but GM's model prices provide an additional key input to their pricing decisions and determine that point within the "last-minute feasible range" where prices will be set. As long as Ford and Chrysler act as responsible price followers, the outcome should be mutually advantageous to all firms.

Consider the roles of automakers other than the Big Three — AMC and foreign manufacturers. Until recently,* AMC played the role of the weak sister whose financial health was assured by the other members of the oligopoly to avert federal anti-trust litigation. GM and Ford have set their prices with AMC's welfare in mind and have allowed AMC to

* Recently, AMC has joined in agreement with Renault to establish a mutually advantageous relationship. The details of the relationship have not yet been completely disclosed.

The market penetration of imported models has also caused AMC's role to change somewhat. No longer are the other domestic companies as concerned with AMC's welfare as they are with meeting the challenge of foreign competition. AMC's failure may no longer prompt anti-trust litigation since the Federal Trade Commission now considers foreign companies as part of the domestic industry.

underprice their models, especially during the past few years when AMC's financial status has seemed particularly precarious.

Foreign companies were not seen as a real threat by domestics during the 1960's; they were vying for a share in the most unprofitable segment of the market, a part of the market in which domestics expressed little interest. Competition between imports and domestics was slight and price competition was nonexistent. However, in the 1970's, things started to change: imports' share of the total market was growing large and domestics started to feel their presence; domestics started to take an increasing interest in small car markets because of: 1) increasing consumer preference for small cars, 2) rising fuel prices, and 3) federally mandated fuel economy regulations. In the early 1970's, the Big Three increased the promotion of their small cars and imported foreign subcompacts (from their overseas subsidiaries and from independent foreign manufacturers) to be sold at their retail dealerships, but these steps did little to strengthen domestics' positions in the small car market. Meanwhile, AMC discontinued all of its model lines except the compact and subcompact, this leaving them even more vulnerable to foreign competition. In 1974, automakers were told by the Federal Government that passenger automobiles would be subject to fuel economy regulation during the coming decade and thereafter. Domestic companies, realizing that small cars would constitute an important part of their future product mix, began to plan new compact and subcompact models intended to directly compete with imported versions. During the past few years, domestic companies have not been able to reduce foreign companies' market share, even though they can claim some success in the subcompact market. Non-price competition, the rule in an oligopoly, has been the means by which foreign companies have retained their market share despite rising prices caused by disadvantageous exchange rate fluctuations. By changing body styles and marketing the economy, reliability, and durability of their models, foreign companies have successfully weathered competition from domestics.

One may speculate that gradually, as domestic manufacturers gain an equal footing in the subcompact market, competition in this market will be much the same as in other markets – strictly non-price. Since most foreign firms are now establishing manufacturing facilities in the U.S., soon they will no longer be "foreign"; they will not be subject to the vagaries of fluctuations in exchange rates, and they will be required to pay UAW wage rates. Previous cost advantages and disadvantages will no longer be realized. In affect, "foreign" companies will become legitimate members of the auto oligopoly and this, according to theory, means that they and domestic companies will behave correspondingly.

Demand-Pressure Price Changes

"Demand-pressure" price changes arise because manufacturers or dealers perceive the market price to be disadvantageous, given current market demand. The market characteristic that signals such a state is the degree of market tightness which, in the auto market, is measurable in terms of the level of retail inventories, the inventory-sales ratio, or the change in inventory level. Thus, demand-pressure price changes are not caused by demand alone, but by a discrepancy between actual demand and expected demand.

Dealers have a great interest in controlling inventories. For most dealers, inventories constitute a great portion of total net worth and, when inventories build, dealers are financially taxed – some may even be forced out of business. Therefore, dealers are motivated to adjust prices to inventory levels, cutting prices when inventories cumulate and driving harder bargains when inventories are dwindling.

Yearly changes in auto models further force dealers to price according to inventory levels. High inventory levels during the model year are undesirable not only because of the associated holding costs, but also because inventory must be turned over several times during a model year – old stock must be sold to make room for new shipments. Late in the model year, the situation becomes more critical. In the last quarter of the model year, dealers must clear their inventories to make room for new model cars for, if they fail to sell all of their old stock, the remaining portion will decrease in value as soon as new models arrive.

For small dealerships, the franchise quota may also be a consideration. Retail dealerships are established on a franchise basis; the number of franchises is limited by the manufacturer, but, if dealers wish to continue to hold their franchise, they must sell a specified number of cars. Because of this, some dealers may cut prices when the market is particularly slack.

Automobile manufacturers depend on their retail dealers to sell cars and, thereby, to generate revenue; and, because of their reliance on dealers, manufacturers have a vested interest in their dealers' continued existence. When demand is lower than expected, when inventory build-up is prevalent among a manufacturer's dealerships, or when, perhaps, only one model is not selling, the "parent company" takes measures to ease the concomitant burden on its dealers. In similar situations in the past, manufacturers have achieved price reductions by holding sales-incentive contests, giving rebates to dealers, or giving rebates directly to buyers. Now, with manufacturers' new flexible pricing policies, they may also exercise their option to directly reduce wholesale and list prices under such circumstances.

The Empirical Model of New Car Price Determination

The basic premise of the theoretical pricing model is that price is determined by the joint-profit-maximizing behavior of the oligopoly. Assuming that industry production is given by a Cobb-Douglas production function (with Hicks neutral technological change occurring at rate h), we have:

$$X = C_o K^{a_1} L^{a_2} M^{a_3} e^{ht} \quad (3.1)$$

or output in terms of inputs, capital (K), labor (L), and materials (M). For purposes of exposition, we further assume that demand is log-linear in price (p) and income (Y):

$$X = Bp^{-b_1} Y^{b_2} \quad (3.2)$$

The profit function is then given by:

$$\pi = CX^{1-1/b_1} - wL - qK - vM \quad (3.3)$$

where $C = C_o B^{1/b_1} Y^{b_2/b_1}$. By maximizing this function with respect to all inputs, we can find an equation for the profit-maximizing level of output which, after being set equal to demand, will define an equation for the profit-maximizing price level.* If we assume constant returns to scale, the long-run rule for the profit-maximizing price is given by:

$$p = C' e^{-ht} q^{a_1} w^{a_2} v^{a_3} \quad (3.4)$$

where $C' = (1 - 1/b_1)^{-1} a_1^{-a_1} a_2^{-a_2} a_3^{-a_3} C_o$ and q, w, and v represent factor prices as in Equation 3.3. Linearizing Equation 3.4 yields a simpler, approximately optimal pricing rule given by:

$$p = C_o + C_1 q + C_2 w + C_3 v \quad (3.5)$$

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* See (Nordhaus, 1972), p. 28.

Thus, if we assume that auto companies as a group behave in a strictly Chamberlinian fashion, then our pricing equation might be similar in form to Equation 3.4 or, if we were to settle for an approximate model, similar to Equation 3.5.*

As previously discussed, evidence abounds that individual auto companies use cost plus mark-up as a basis for price setting, not "optimality" models. Because of this, one is naturally led to question the relation of the optimal price to the mark-up pricing model.** Cost-plus pricing has been attacked by some as antithetical to profit-maximizing behavior;† indeed, as shown by Nordhaus (1972), mark-up pricing is optimal only under an unrealistically strict set of conditions. However, others have argued that mark-up pricing is consistent with optimizing behavior;†† for example, Simon (1957, 1959) has convincingly disputed the traditional profit-maximizing model on the grounds that, because of uncertainty and time constraints, business use simple, approximate rules-of-thumb (such as cost-plus-mark-up

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* Nordhaus (1972) gives the form of the optimal price equation for other assumptions about the form of the production function.

** The target-return pricing formula is written approximately as:

$$p = \frac{\hat{\pi}\bar{K}}{\bar{X}} + \frac{\bar{L}}{\bar{X}} + \frac{\bar{M}}{\bar{X}}$$

where $\hat{\pi}$ is the target rate of return and bars over variables indicate that the variables are measured at standard levels of operation. See (Eckstein, 1964).

† (Machlup, 1967).

†† (Eckstein, 1964).

pricing) instead of searching for optimal solutions.* In making this observation, Simon identified and explained a major discrepancy between the economic theory of pricing behavior and actual business practice.

In fact, neither the profit-maximizing model nor the mark-up model totally explain price determination in the auto industry, although both seem to explain at least part of the industry's observed behavior. The Chamberlinian model explains the interdependence of auto companies, but it does so in an unrealistic way. The mark-up model explains the pricing behavior of individual firms, but offers no explanation of the outcome of overall industry price.

As a compromise between the two models, we have chosen to characterize industry behavior as approximately optimal and to use Equation 3.5, the "linearized" version of the profit maximization model as a foundation upon which to construct a price determination forecasting equation. This equation requires data that is more accessible and easier to forecast than that required by either of the other two pricing models.** Empirically, the selected model should provide a reasonable approximation to both the neoclassical model and the target return pricing model.

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* Simon (1959) also argues that, "In most psychological theories, the motive to act stems from drives, and action terminates when the drive is satisfied . . . If we seek to explain business behavior in the terms of this theory, we must expect the firm's goals not to be maximizing profit, but attaining a certain level or rate of profit (which changes as aspirations change)."

** Use of the target return pricing model would require that the normal planning volume of output for the industry be "estimated" for each period in the sample range and for each period in the forecasting range.

Pricing Under Uncertainty

One aspect of oligopoly pricing that the model does not account for is the influence of risk on price determination. It has been argued by some that, because the outcome of a price adjustment is uncertain, firms, especially oligopolistic firms, are reluctant to adjust price. The risk of an undesirable outcome causes firms to adjust actual price to their perceived desired price more slowly than they would under conditions of certainty.

Stigler (1961) and others have argued that this so-called "price stickiness" is caused by uncertainty about the form of demand or cost functions faced by the firm. Nordhaus (1972) showed that price setting with uncertainty about the parameters of structural relations would, under risk conditions, lead to greater risk the more price is changed. These findings seem to apply to the auto industry where frequent changes in the characteristics of products must cause uncertainties about consumer reaction.

Others have argued that oligopoly prices are inflexible because of the mutually recognized interdependencies among oligopolists. One old and well known model of oligopoly pricing called the "kinky demand curve" attempted to explain the stickiness of short-run price movements in terms of an individual oligopolists' perceptions of the market.*

* The kinky demand curve theory was originally in (Sweezy, 1939). Sweezy suggested that, if an individual oligopolist were to raise his price without his rivals following suit, he would find himself confronted with a highly elastic sales curve and would fail to gain a larger share of the market. If, on the other hand, he were to reduce his price, only to find (Note continued on bottom of following page.)

The theory, however, was later shown to be dubious by contrary empirical evidence.** Eckstein (1964) hypothesized that the stickiness of price was chiefly due to fear of "rocking the boat". He argued that oligopolists would adjust price only when their return on capital fell outside a certain range as caused by a change in cost that may be experienced by all members of the oligopoly. Eckstein expected that, because of this, price increases would typically occur around the time labor negotiated wage settlements.

Although Eckstein's theory seems an appropriate model of the auto industry's practices in the 1950's and 1960's, it would be difficult to explain industry pricing behavior of the 1970's, statistically at least, using this framework. Price adjustments during the 1970's have been more frequent and have occurred during the model year; a theory based on return on capital would give little insight into these significant short-run movements in price.

As a means of explaining the stickiness in oligopoly price, we have chosen to describe price determination in terms of an adjustment model, one that accounts for the

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* Note continued from previous page.

his rivals doing the same, he would, likewise, gain nothing. Sweezy predicted that, since oligopolists had nothing to gain by adjusting price, prices would tend to remain fixed. He also added that oligopoly price would always be strictly inflexible in the downward direction, that changes, as infrequent as they may be, would always be upward.

** An empirical study of prices in the aluminum industry by Stigler and Kindahl (1970) showed that there was substantial downward flexibility of prices even during contractions. This finding seems to disprove Sweezy's theory.

fact that adjustment to desired price levels is impeded by uncertainty regarding structural relations and rivals' behavior. We postulate an adjustment function given by:

$$P_t - P_{t-1} = \gamma(P_t^* - P_{t-1}) + u_t \qquad 0 < \gamma \leq 1 \tag{3.6}$$

which asserts that during any single period actual price (P_t) will probably move only part of the distance from its position in the last period (P_{t-1}) to its desired position (P_t^*) which is perceived by the oligopoly members as optimal (or at least close to optimal). The closer γ is to unity, the greater is the adjustment made in each period.

The form of this model may be explained algebraically in terms of: 1) the imputed costs of setting price at other than the optimal level and 2) the risk of changing price.* If both costs are assumed to be quadratic, we have a function describing the cost of adjustment which takes the form:

$$C_t = a(P_t - P_t^*)^2 + b(P_t - P_{t-1})^2 \tag{3.7}$$

Minimizing C with respect to changes in P, we get:

$$\frac{\partial C_t}{\partial P_t} = 2a(P_t - P_t^*) + 2b(P_t - P_{t-1}) = 0 \tag{3.8}$$

which yields:

$$P_t - P_{t-1} = \frac{a}{a+b}(P_t^* - P_{t-1}) \tag{3.9}$$

* This idea comes from an analysis of the partial adjustment model by Griliches (1967).

a form equivalent to Equation 3.6. This interpretation tells us that, if the cost of adjustment is zero (i.e., b=0), then actual price will fully adjust to desired price in each period.

Rewriting Equation 3.5 as:

$$P_t^* = C_o + C_1 q_t + C_2 w_t + C_3 v_t$$

and combining with Equation 3.6 gives:

$$P_t = \gamma C_o + (1-\gamma)P_{t-1} + \gamma(C_1 q_r + C_2 w_t + C_3 v_t) + ut$$

an equation explaining price changes in terms of costs and uncertainty.

This model may be improved further by adding a term which explains the influence of demand-pressure on desired price, P*. The classical supply/demand theory suggests that the appropriate descriptor is a measure of excess demand or the difference between demand and supply;* however, such a measure would be better suited to describing demand-pressure in more competitive markets. For the auto market, "the change in the level of retail inventories" or, equivalently, factory sales minus retail sales, is a better variable for explaining demand pressure (i.e., market tightness). Since this variable is the converse of market tightness, it is expected to be negatively related to the desired price level.

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* Eckstein (1972) suggests a demand-pressure variable of the form $\frac{d-s}{c}$ where d is demand, s is short-run supply, and c is capacity.

Data

For empirically testing the model, quarterly data from 1963 through 1976 are used. The Bureau of Labor Statistics (BLS) new automobile price index serves as the dependent variable of the model.* The BLS index allows for discounts by using dealer quotations as the source of price information; it is also adjusted for quality change to some extent. One drawback of the index is that, in the first quarter of each model year, "left-over" models and new models are lumped together; therefore, the price change from one model year to the next is obscured. Another shortcoming of the index is that it does not measure the prices of all new cars, but only a sample of eleven models — nine domestic and two imported.

Next let us turn to specific independent variables used in the price equation.

Labor Costs. The cost of labor input is measured by the "average hourly wage of automobile production workers". This variable is unadjusted for overtime hours (i.e., wages paid for overtime hours are included in the averaging process) and, thus, its value is related to the level of output and to labor productivity. However, its coefficient in the regression model should give an unbiased measure of the influence of labor cost on price since other variables that measure demand pressure are also included in the regression.

* White (1971, pages 121-123) criticizes the BLS index. In defense of the index, Smith (1975, page 19) states that "...the criticisms (of the BLS index) simply reflect the difficulties of constructing a price index for cars..."

Material Costs. The cost of material input is measured by a four-quarter moving average of the wholesale price index for raw materials (goods for further processing) lagged one quarter. This index, compiled by the Bureau of Labor Statistics, measures the prices of a diverse sample of raw materials and is, therefore, not an ideal measure of the prices of materials used in auto production. In statistical jargon, it has a low signal to noise ratio. Taking a moving average of the index solves the problem in part.

Capital Costs. The cost of capital is defined as:

$$q = (d + i)\, p\, (1 - k)\, (1 - uz)/(1 - u)$$

p = price of capital goods

d = depreciation rate

i = discount rate

k = rate of investment tax credit

z = present value of depreciation deduction

u = corporate profits tax rate

This variable was constructed using parameter values taken as averages for domestic auto firms since no data was available for foreign manufacturers. Perhaps because of this the variable proved to be of low statistical significance (the standard error of its estimated coefficient was larger than the coefficient itself), and, therefore, it is not included as part of the final estimated equation.

By omitting the capital cost variable, we have, in effect, produced a short-run pricing equation. According to the theory of the firm, the short-run cost curve (but not changes in this curve) can be determined without knowledge of capital costs. Econometrically speaking, however, if capital costs are assumed to remain fixed or to grow at an autonomous rate, then their omission will cause no forecating error, even in the long run.

Retail Inventories. The change in the level of retail inventories of new domestic cars lagged one quarter is introduced as a measure of demand pressure. Once again, corresponding data for imported cars is not available.

Because former President Nixon's wage and price controls occurred during the sample period (they spanned the period from third quarter 1971 to third quarter 1973), a resulting aberration in the relationship of demand pressure to price could be reflected in the data sample. This hypothesis was tested by including in the regression:
1) a dummy variable indicating each period during which the wage-price controls were in effect by a +1 and according all other periods a zero and 2) a variable constructed by the product of the dummy variable and the demand pressure variable. Neither of these variables proved to be statistically significant, indicating that the relationship of demand-pressure to price was much the same during the

wage-price control period as throughout the rest of the sample period.*

Domestic Share of the Market. The "percent share of the total market held by domestic firms" is introduced to account for the secular decrease in domestic firms' shares of the market over the sample period. This variable is required in the regression because the cost and demand-pressure variables that are used in the equation explain only that part of the price index which measures prices of domestic cars – prices of imported cars must be accounted for by another means. The coefficient of the proposed explanatory variable, by explaining the influence of the size of the market share held by domestics on price, should be positive in sign.

Labor Strikes. A dummy variable indicating the period in which labor strikes occurred, weighted according to the length and severity of strikes, is also included in the explanation of price determination. This variable should explain the influence of strikes on auto dealers' perception of expected market tightness and the influence of their resulting behavior on retail prices.

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* The index of new car prices increased by small amounts during the wage and price control period; however, a plot of the index shows a noticeable break in trend during this period.

Estimation Results

The parameters of the equation are estimated using a technique for estimating simultaneous estimation models with lagged endogenous variables and first-order serially correlated errors.*

$$P_{N,t} = \underset{(.50)}{1.77} + \underset{(14.5)}{.889}\ \hat{P}_{N,t-1} - \underset{(-2.2)}{.003}\ \Delta\ INV_{t-1}$$

$$+ \underset{(1.22)}{1.01}\ W_t + \underset{(1.37)}{.024}\ WPIMA_{t-1} + \underset{(1.26)}{17.39}\ \hat{SHARE}_t$$

$$+ \underset{(2.69)}{.87}\ STRIK - \underset{(-2.12)}{2.3}\ D_1 - \underset{(-2.09)}{2.29}\ D_2 - \underset{(-3.82)}{3.56}\ D_3$$

$\bar{R} - .989$ D.W. = 1.8

SEE = 1.23 $F_{9,42} = 460$

$\hat{\rho} = .24$

where:

P_N	=	BLS new car price index (1967 = 100)
INV	=	Retail inventory of new domestic automobiles at the end of the quarter (thousands of units)
W	=	Hourly wage rate for automobile production workers, including overtime hours (dollars)
WPIMA	=	Four quarter moving average of the wholesale price index for raw materials (1967 = 100)
SHARE	=	Sales of domestic autos divided by sales of domestic and imported autos
STRIK	=	Dummy variable for labor strikes
D_i	=	Seasonality dummies
ˆ		Denotes instrumental variable

* See (Fair, 1970).

Referring to Equation 3.6, we can identify the average speed with which actual price adjusts to desired price as $(1-\gamma)/\gamma$. The estimation results allow us to estimate this quantity since the coefficient of $P_{N,t-1}$ is, according to the model, equal to $1-\gamma$. Using this information, the average lag of adjustment can be estimated at eight quarters, or about two years, a result that seems to substantiate the "theory of price stickiness". More important from the standpoint of this study is that changes in desired price arising from changes in costs or demand would not, according to the model, be fully reflected in actual price until long after they occurred. This finding, however, bears no direct implication of the extent to which costs are passed through to price.

Information concerning cost-pass-through can be gained by estimating the elasticity of price with respect to labor and material costs. The estimated elasticities are:

	Elasticity of Price with Respect to Changes in Cost Variables	
Cost Variable	Short Run	Long Run
Wages	.04	.39
Material Costs	.03	.31

Short-run elasticity estimates measure the instantaneous or first-period elasticity; long-run elasticity estimates measure the elasticity at eventual equilibrium.

Referring to Table 3.1, we can estimate what the wage elasticity of price would be if manufacturers passed on additional wage costs in full. Under such conditions, given that wages account for 25 percent of the cost of manufacture, a 1 percent increase in the wage rate should lead to a 0.25 percent increase in price. Therefore, the wage elasticity would be 0.25. The model produced a somewhat higher estimate of 0.39 which suggests that auto manufacturers pass on more than the full cost of wage increases.*

A similar comparison for the elasticity of price with respect to material costs cannot be made since the percentage breakdown of manufacturing costs given in available reference material does not list material costs as a separate category. However, the estimated elasticity of 0.31 does seem to be of reasonable magnitude.

All in all, the estimation results appear satisfactory – estimated coefficients are of the expected sign and the equation fits the data well.** This estimated equation will later be used in Chapter 6 to determine the effect of price stickiness on the cost of Government regulations to the auto industry.

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* This conclusion is made tentatively because the absence of a cost-of-capital variable from the equation may have biased the coefficient of the wage variable upward in which case the elasticity estimate would also be biased.

** Further tests of the hypothesized auto-regressive equation were performed as suggested by Griliches (1967). The results of these tests gave no indication of misspecification.

DETERMINATION OF USED CAR PRICES*

The new car and used car markets are different both in structure and in behavior. Demand for used cars is composed of purchases made by buyers who are, on the average, younger and of lower income levels than new car buyers. Supply is made available by a diverse group of sellers: new car dealers who sell the used cars they acquire as trade-ins, dealers who sell used cars exclusively, and individual used car owners who, instead of trading in their cars, advertise their cars in newspapers and sell them themselves.

Regarding price determination, the principal difference between the two markets is caused by the lower degree of supplier concentration found in the used car market. Because the average seller has little market power and little influence on overall market price, used car prices are not set, as are prices in the new car market, but they are

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* Used car price determination is of interest in this study because of the substitution effect of used for new cars on the new car market. The elasticity of substitution between used and new cars has been disputed in the automobile demand literature; see, for example, (Smith, 1975, page 20). All must agree nevertheless that there is some substitution; the question is how much? Some authors have argued that the amount of substitution that occurs is so small that it can be ignored. However, empirical tests done for this study show that used car prices are a significant determinant of retail sales of new automobiles. Possibly used car prices and retail sales of new automobiles are correlated for a reason other than the substitution of used for new cars. Used car prices determine the amount that new car buyers will receive for cars traded in, and the trade-in helps finance the purchase of new cars. Regardless of the reason for their importance, we must conclude that used car prices have a significant effect on the new car market.

determined by the combined forces of supply* and demand, as are prices in more competitive markets. This observation suggests that the "model" of used car price determination should be somewhat different in structure than the oligopoly model of new car price determination.

Two previous authors, Suits (1958) and Dyckman (1965), have attempted to model the used car market; both used essentially the same approach. The supply of used cars, according to these authors, is historically determined by previous new car sales. Supply is represented algebraically in their models as a proportion of the previous period's new car sales, the logic being that, for every new car purchased, a used car is traded in and placed on the market for sale. Demand for used cars is determined by used car prices, new car prices, and income. By assuming that the market is cleared in each period, the supply and demand functions are equated and the resulting equation is solved for used car price.

Whereas this supply-demand model seems reasonable, neither Suits nor Dyckman tested the model empirically, so a priori, there is no way of knowing how good an approximation such a model would provide. One apparent shortcoming of the model is its neglect to include used car prices as a determinant of supply. Prices play an important role on

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* "Supply" here is used in a loose sense to mean availability or suppliers' willingness to sell.

the supply side of the market since they determine dealers' scrap-repair decisions: the more a dealer can get for a used car he acquires, the more apt he is to repair it and offer it for sale; the less he can get for it, the more apt he is to scrap it for parts. Thus, price has an important positive effect on supply.

Another questionable assumption made in the Suits-Dyckman model is that the used car market is cleared in each period. A better approach which requires no additional complexity is to assume a continual, but varying, state of disequilibrium. Such a model would be based on the supposition that the rate of change in market price is a function of the disequilibrium between supply and demand at the current market price,* or.

$$\dot{P} = u(D-S) \tag{3.10}$$

where $\dot{P}$ represents the rate of change in used car prices; D the demand for used cars, and S the supply of used cars.

A discrete approximation to Equation 3.10 is given by:

$$P_t - P_{t-1} = u(D_t' - S_t') \tag{3.11}$$

where D_t' is the quantity that would be demanded during period t if the market price remained at P_{t-1} and, similarly, S_t' is the quantity that would be supplied during period t if the market price were P_{t-1}. This model posits that, if the prevailing market price in the previous period would

* Eckstein (1972) and others have used similar models to describe price movements.

serve to clear the market in the current period, then the price will remain unchanged. If, however, excess demand or excess supply would exist under the previous period's market price, then, during the current period, price will adjust upward or downward in proportion to the magnitude of excess demand or supply.

To put Equation 3.11 in a form that can be estimated, demand and supply functions must be specified. As written in Equation 3.12, we assume that the demand for used cars is a linear function of the price of used cars in the previous period* ($P_{u,t-1}$), the price of new cars (P_N), income per family (Y), the price of other consumer goods (CPI), and consumer sentiment (ICS).

$$D_t = \alpha_o + \alpha_1 P_{u,t-1} + \alpha_2 P_{N,t} + \alpha_3 Y_t + \alpha_4 CPI_t + \alpha_5 ICS_t \quad (3.12)$$

Consumer sentiment is considered an important determinant of used car demand because, as an income group, used car buyers are greatly influenced by ebbs and flows in the economy.** Consequently, expectations and attitudes concerning their financial state may be an important element of their buying decisions.

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* The price of used cars appears lagged one period because of assumptions made concerning Equation 3.11.

** For this same reason, one might expect the level of unemployment to be a significant determinant of used car demand; however, empirical tests indicated otherwise. The index of consumer sentiment seems to provide a much better measure of the used car buying publics' attitude toward buying. This variable, however, will help the forecasting accuracy of our used car price equation only inasmuch as it may improve the efficiency of the other parameter estimates.

Supply is written as a linear function of the price of used cars in the previous period, the number of new cars sold per family in the previous period (D^N_{t-1}), and the price of new cars lagged one year.

$$S_t = \beta_o + \beta_1 P_{u,t-1} + \beta_2 D^N_{t-1} + \beta_3 P_{N,t-4}$$

The lagged new car price variable is introduced as a measure of asset cost; assuming the depreciation rate remains constant over time, the original price of a one-year-old car should provide an approximate measure of the owner's valuation of the car and, hence, a measure of what he'd be willing to sell it for.

Substituting Equations 3.12 and 3.13 into Equation 3.11 and combining terms gives:

$$\begin{aligned} P_{u,t} = {} & u(\alpha_o - \beta_o) + (1 + u\alpha_1 - u\beta_1) P_{u,t-1} + u\alpha_2 P_{N,t} \\ & - u\beta_3 P_{N,t-4} - u\beta_2 TS_t + u\alpha_3 Y_t + u\alpha_4 CPI_t \\ & + u\alpha_5 ICS_t + e_t \end{aligned} \qquad (3.14)$$

Using a method that corrects for first-order serial correlation,* the coefficients of Equation 3.14 have been estimated as:**

$$\begin{aligned} P_{u,t} = {} & \underset{(-2.8)}{-58.4} + \underset{(4.7)}{.53} \hat{P}_{u,t-1} + \underset{(1.4)}{.45} P_{n,t} - \underset{(-1.5)}{.42} P_{N,t-4} \\ & \underset{(-1.8)}{-44.7} D^N_{t-1} - \underset{(-2.2)}{4.38} Y_t + \underset{(3.3)}{.41} ICS_{t-1} \\ & + \underset{(3.14)}{1.1} \hat{CPI}_t - \underset{(-1.1)}{1.9} D_1 + \underset{(3.2)}{5.3} D_2 + \underset{(1.9)}{4.3} D_3 \end{aligned}$$

* See (Fair, 1970).

** Although, without prior information, the structural parameters of Equation 3.14 must remain underidentified, for the purposes of this study, the structural parameters are of no particular importance.

$\bar{R}^2 = .98 \quad D.W. = 1.75$

$SEE = 4.04$

$\hat{\rho} = 0$

$F_{9,41} = 248.$

Estimation period: 1964, Q1 - 1976, Q4

where: P_u = used car price index (1967 = 100)

P_N = new car price index (1967 = 100)

D^N = number of new cars sold

Y = disposable personal income per family unit (millions of dollars)

ICS = index of consumer sentiment (1966 = 100)

CPI = consumer price index (1967 = 100)

D_i = seasonality dummies

The model appears to fit the data satisfactorily well — all coefficient estimates are of the proper sign and of acceptable significance levels. Several aspects of the estimation results are of particular interest. Notice, for instance, that the estimated coefficient of income is negative, indicating that used cars are viewed by consumers as inferior goods.* This finding is not all that surprising considering the prestige that is attached to new car ownership. Notice also that the index of consumer sentiment is lagged one period; the lagged version of the variable proved to be stronger in explanatory power than the ICS measurement at the current period.

* When transitory income was substituted for disposable personal income in the equation, its estimated coefficient was positive, but of lower statistical significance than that of DPI.

The estimation results also show that the estimated coefficient of $P_{N,t-4}$ is negative in sign, while, according to our prior expectations, it should be positive. What seems to have happened is that $P_{N,t-4}$ is measuring the price of buying one-year-old used cars rather than the cost of selling them. If this is the case, then we must conclude that $P_{u,t-1}$ does not satisfactorily measure the prices of cars that are less than one year old. We may also guess that at least part of the reason for the strong positive significance of $P_{N,t-4}$ in the new car demand equation is that it is measuring used car prices.*

Let us now address the question concerning the used car market that seems to have arisen most frequently: how closely are new car prices and used car prices related? A partial equilibrium analysis (i.e., disregarding the effect of D^N_{t-1}) indicates that the short-run elasticity of used car price is higher for changes in the CPI (1.1) than for changes in new car prices (0.8). This suggests that in the used car buying income group new cars are not competing as strongly for the consumer's dollar (against used cars) as are other consumer goods. The long-run analysis indicates that the elasticity with respect to changes in the CPI becomes larger (roughly doubling) while the elasticity with respect to changes in new car prices becomes smaller (about one-tenth its original magnitude).

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* This should not significantly affect our ability to forecast the effect of price increases on new car sales, but it does alter somewhat our interpretation of the used car price equation.

These results, especially the long-run elasticity estimates, seem somewhat counterintuitive; intuitively, one would expect used car prices to be more elastic to changes in new car prices. It may be observed that, in isolated cases, used cars sometimes appreciate in value when new car prices are rising — this is especially true of used specialty models such as the Corvette or Datsun 280Z. What may have occurred in the estimation of Equation 3.14 is that, even though the appropriate instrumental variable techniques have been used to avoid such a result, the separate influences of CPI and P_N on P_u have been confounded. If this is the case, then the CPI variable is explaining movement in P_u that should rightfully be attributed to P_N.

To hedge on this possibility, an alternative used car price equation has been estimated, one in which CPI is not included as an explanatory variable. This equation is shown below.

$$\begin{aligned} P_{u,t} = \underset{(-.67)}{-13.8} &+ \underset{(3.5)}{.48}\, \hat{P}_{u,t-1} + \underset{(2.9)}{.91}\, \hat{P}_{N,t} \\ &- \underset{(-1.6)}{.55}\, P_{N,t-4} + \underset{(2.3)}{.04}\, Y_t - \underset{(-1.4)}{.0005}\, STOCK \qquad (3.15) \\ &+ \underset{(1.8)}{.25}\, ICS_{t-1} - \underset{(-.6)}{1.4}\, D_1 + \underset{(3.9)}{10.1}\, D_2 \\ &+ \underset{(2.9)}{7.1}\, D_3 \end{aligned}$$

$\bar{R}^2 = .96 \qquad D.W. = 1.7$

$SEE = 4.3 \qquad \hat{\rho} = .28$

where:

Y = disposable personal income (billions of dollars)
STOCK = total stock of existing used cars (thousands)
All other variables are as previously defined.

Besides its omission of CPI, this equation differs from the previous equation in that: 1) STOCK has replaced D^N and 2) variables that represent levels, such as Y and STOCK, are no longer measured on a per-family basis. These differences have induced two notable changes in the estimation results. One, resulting because of the absence of CPI, is that the estimated coefficient of Y has changed from negative to positive; this occurs because, without CPI in the equation, Y is explaining the effects of inflation.* Another change is that the elasticity of used car prices to changes in new car prices is estimated to be .88 in the short run and .68 in the long run; these estimates seem, intuitively, to be more reasonable than those produced by equation 3.14.

Since it is difficult to determine a priori which of the two used car price equations that have been estimated is preferable, both will be tested for simulation performance (see Chapter 5). Because Equation 3.15 is not adjusted for growth in the number of families, when this equation is used, for the sake of consistency, an alternative new car demand equation (also not adjusted by families) will be used.

* Tests of a used car price equation in which price and income variables were divided by CPI showed that this type of equation produces estimates of the elasticity of used car price with respect to new car price similar to those which resulted from Equation 3.14.

SUMMARY

In reviewing the results of modeling price determination in the new and used car markets, several findings should be emphasized:

1. New car prices, determined by cost and demand factors, are sticky; there is a propensity for prices to remain at current levels despite changes in costs and demand. The estimated average speed of adjustment of actual new car prices to desired new car prices is about two years.

2. Our new car prices equation also suggests that increases in manufacturing costs are, in the long run, fully passed on along with an additional mark-up to new car prices.

3. The rate of change of used car prices is determined by the amount of excess demand or supply in the market. An important aspect of used car price determination is the elasticity of used car prices to changes in new car prices. Because of statistical problems, it is difficult to obtain a single, convincing estimate of this elasticity; we have obtained two estimates:

   a. short run: .8
      long run: .08

   b. short run: .88
      long run: .68

CHAPTER 4

THE SUPPLY SIDE OF THE MARKET

INTRODUCTION

When the sales of an industry's products decrease, a cut-back in their production level must surely follow; and, when production volume is reduced, employee lay-offs are all but a certainty. For the UAW, the most definitive measure of Government regulations' impact on the auto industry is the number of union members laid off. Consequently, because the auto workers' union has enormous political power, this measure of the cost of regulation may carry additional weight in the Government's regulatory decision-making process.

In this chapter, the effect of a decrease in auto sales on industry employment will be explained by statistically describing how the production level is related to the level of sales and how the level of industry employment is related to the production level. The effect of a decrease in sales on capital spending by the industry will also be explained; a measure of this effect may be a good indicator of the secondary impact of automotive regulations on capital goods industries.

PRODUCTION PLANNING

One way to develop a model for forecasting the volume of new automobile production is to reconstruct the decision-making process that automakers use in their production planning. Taking a short-run view and assuming that required capacity is always available, production decisions may be viewed as consisting of essentially two elements: 1) expected sales and 2) existing retail inventory. By fitting an equation consisting of these decision elements to historical production levels, we should have a good statistical explanation of changes in automobile production volume.

To construct such an equation, we must first have a measure of automakers' expected level of sales; consequently, we must estimate how their expectations are formed. It seems reasonable to assume that, barring expected price changes, automakers have no privileged information concerning future sales and that they base their forecasts on the same information that is typically used in constructing econometric equations of auto demand (e.g., income, prices, attitudes, stock). Their expectations of the level of sales in the coming quarter might, therefore, be accurately represented by an instrumental variable constructed by regressing the actual "retail sales of new autos" on appropriate predetermined variables (e.g., lagged values of income, prices, consumer sentiment, stock, sales). Such an "expected retail sales" variable, based upon only that information which would be available to automakers at the beginning of a quarter, should approximate the level of quarterly sales expected at the beginning of each quarter.

As shown in Figure 4.1, "expected retail sales", a variable constructed in the manner described above, closely tracks actual production levels; most turning points are matched and the general trends in the two variables are quite similar. According to our hypothesis, the difference between "expected retail sales" and the level of production should be explainable in terms of retail inventories. For every car held in retail inventory at the beginning of a quarter, logically, manufacturers need produce one less car to meet expected demand. We may go so far as to say that the relationship between the expected sales level and the production level should be a positive one-for-one relationship and that between the level of retail inventory and the production level should be a negative one-for-one relationship.

Numerically, this may not hold exactly because of the seasonality of auto production. Cars produced during any single quarter may not be intended for purchase solely in the same quarter;. this is especially true for the first two quarters of the model year. Car production during the early parts of the model year is heavy, yet the heaviest buying season is spring, when production has already tapered off. In the summer, car production has all but stopped as preparations are made for a new model year; correspondingly, demand is usually weak because buyers wait for new models which start arriving at dealer showrooms by the end of the summer.

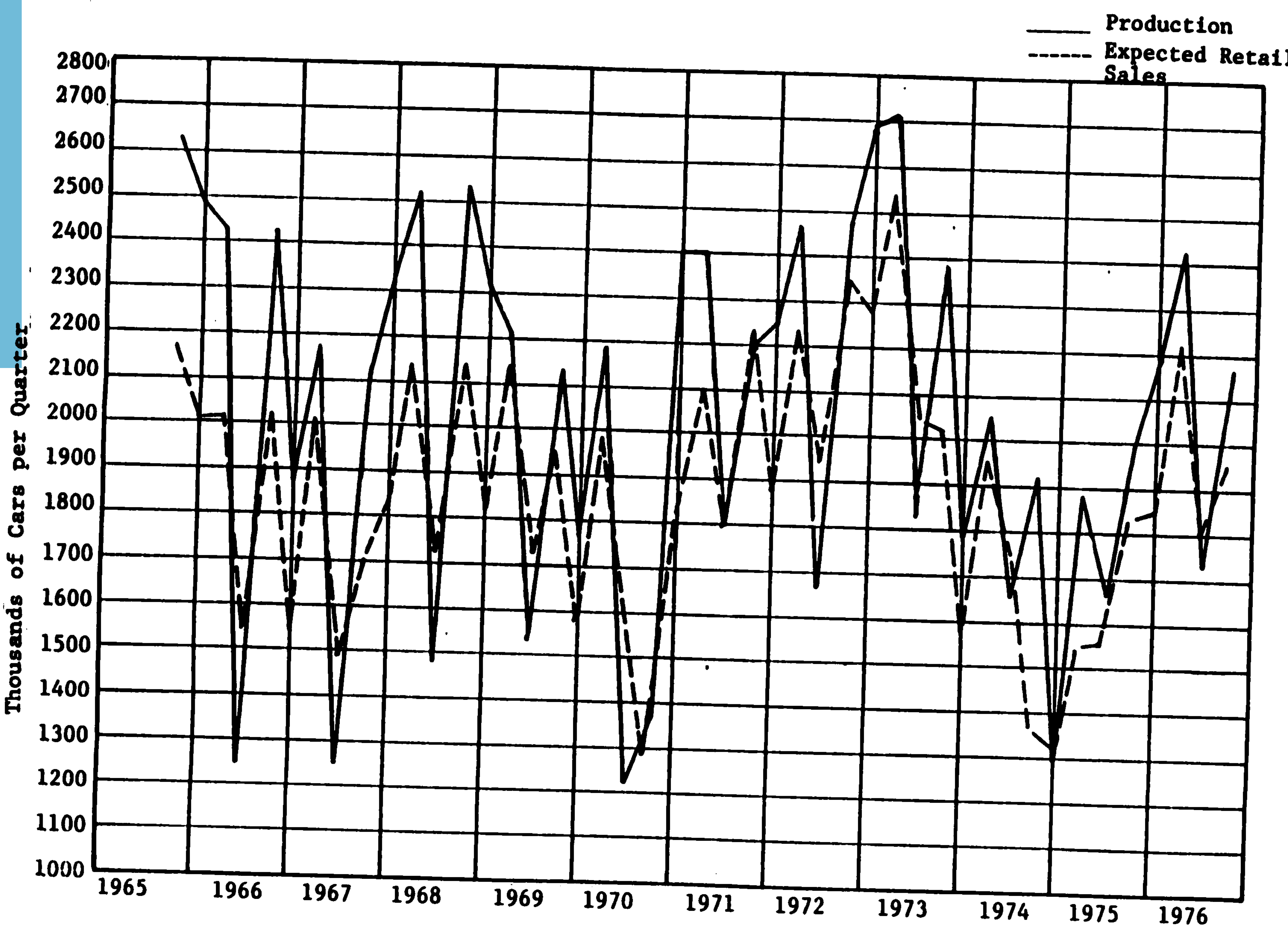

Figure 4.1. Domestic Automobile Production

A great part of this seasonality in the relationship between "expected sales", "retail inventory", and "production" can be statistically removed by seasonal correction of the data.* This can be accomplished by adding the "level of production lagged four quarters" to the right-hand side of the regression equation as shown in Equation 4.1.

$$PRD_t = \alpha_o + \alpha_1 \hat{DS}_t + \alpha_2 INV_{t-1} + \alpha_3 PRD_{t-4} \quad (4.1)$$

where:

- PRD = Production of new domestic automobiles (thousands of units)
- $\hat{DS}$ = Expected retail sales of new domestic automobiles (thousands of units)
- INV_{t-1} = Retail inventory of new domestic automobiles at the beginning of each quarter (thousands of units)
- $\alpha_1 \approx +1$
- $\alpha_2 \approx -1$
- $\alpha_3 > 0$

Notice that Equation 4.1 is meant to explain the production levels of domestic manufacturers only. Although it may be interesting to analyze foreign automakers' production behavior as well, the necessary data is not available.

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* One seasonal factor that cannot be accounted for occurs during the fourth quarter of each calendar year when "retail sales" measures the sales of new model cars as well as the sales of cars left-over from the preceding model year.

** If the data were seasonally adjusted, this variable might not be needed.

By fitting this model to quarterly data from 1963 though 1976 and making necessary corrections for serial correlation, the following parameter estimates result:

$$PRD_t = \underset{(2.45)}{212.3} + \underset{(13.3)}{1.04}\ \hat{DS}_t - \underset{(-7.7)}{.996}\ INV_{t-1}$$

$$- \underset{(-2.8)}{70.6}\ STRIK + \underset{(3.88)}{.20}\ PRD_{t-4} + \underset{(2.76)}{200.7}\ D_1$$

$$+ \underset{(1.19)}{92.8}\ D_2 - \underset{(-.82)}{78.7}\ D_3$$

$\bar{R}^2 = .96$ D.W. 2.14

Standard error = 111.5

Mean of dependent variable = 2200.

$\hat{\rho} = .72$ $F(7,44) = 169$

where:

STRIK = dummy variable for labor strikes

D_i = seasonality dummies, i=1, 2, 3

The results are as anticipated. The sign of expected retail sales is close to +1 and the sign of retail inventory is close to -1. Both coefficients are statistically significant at $\alpha = .01$. The rest of the equation results are equally satisfactory: the lagged production term is statistically significant and of the proper sign, and the dummy variable that accounts for labor strikes also adds to the explanation of production. Overall, the F ratio, which is many times the critical F statistic ($\alpha = .01$) of 3.0, indicates that the model may well be a valuable forecasting tool.

In making forecasts with this equation, values of $\hat{DS}$ will be supplied by the new car demand equation by multiplying an exogenous market share factor by total new car sales to estimate expected sales of domestic cars. Values for the level of retail inventories and lagged production levels will also be endogenously generated.

RETAIL INVENTORY AND ITS COMPONENTS

The importance of the level of retail inventory in the determination of retail prices and production levels has been noted. Inventory control is a fundamental part of automakers and auto dealers short-run behavior, and their efforts in controlling inventory have a significant effect on market determination.

The account for retail inventory of new automobiles includes all new domestic automobiles held by dealers at the end of a quarter. The level of retail inventory changes during a quarter as cars are sold and leave inventory and new shipments arrive and enter inventory. Thus, inventory adjustment from the end of one quarter to the end of the following quarter may be written as an identity:

$$INV_t = INV_{t-1} + \text{NEW SHIPMENTS} - \text{RETAIL SALES}$$

where INV represents the retail inventory of domestic automobiles.

A measure of retail inventories at the end of each quarter is derived from data as reported by members of the Motor Vehicles Manufacturing Association of the United States. This inventory measure accounts for retail inventories of franchised dealers of all domestic new passenger cars in the United States and is compiled by the U.S. Department of Commerce, Bureau of Economic Analysis. Data measuring the retail sales of new domestic passenger cars is available from the same source. To account for new shipments of new domestic passenger cars, two data series are needed — one which measures factory sales of new domestic cars from plants located in the United States and another which measures the number of U.S.-type cars produced in Canada and shipped to dealers in the U.S. The inventory adjustment equation, written in terms of these quarterly time series, is:

$$INV_t = INV_{t-1} + FS_t + CI_t - DS_t \qquad (4.2)$$

where:

- INV = retail inventories of new domestic automobiles (thousands of units)
- FS = factory sales of new domestic automobiles from plants located in the U.S. (thousands of units)
- CI = Canadian imports of new domestic automobiles (thousands of units)
- DS = retail sales of new domestic automobiles (thousands of units)

According to sources at the Bureau of Economic Analysis, this equation will have a small residual "float error" in each period caused by shipments in transit. In other words, since at the time a car leaves the assembly plant it is recorded in factory sales or Canadian imports and since a car is not included in retail inventory until it reaches the dealer, cars in transit will show up in the inventory equation as "float error". Since this float error is small, it causes no significant problem.

Factory Sales

Because a measure of "factory sales" is required to update the level of retail inventory from one period to the next, we must construct an equation for forecasting factory sales.

A simple regression of factory sales (FS) on production level (PRD) indicates that there is little difference between the two variables.

$$FS_t = \underset{(-.85)}{-21.4} + \underset{(130.7)}{.95}\ PRD_t$$

$\bar{R}^2 = .997$

Standard error = 30

Mean of FS = 2050

$\hat{\rho} = .8$

The only difference between the two should be accounted for by the level of wholesale inventory existing at the beginning of the period. The higher wholesale inventories are, the greater factory sales should be. In the absence of a measure of wholesale inventory level, the accumulation of wholesale inventories during the previous period, or $PR_{t-1} - FS_{t-1}$, is used to represent inventory level.

$$FS_t = \underset{(-.87)}{-12.} + \underset{(81.7)}{.97}\ PRD_t + \underset{(2.01)}{.276}\ WI_{t-1} - \underset{(-1.3)}{21.4}\ D_1 - \underset{(-.55)}{8.5}\ D_2 + \underset{(1.3)}{28.7}\ D_3$$

$\bar{R}^2 = .998$ D.W. = 2.07

Standard error = 27.5

Mean of dependent variable = 2050

$\hat{\rho} = .89$ $F(5,46) = 4200$

where:

FS = factory sales of new domestic autos (thousands of units)

PRD = production of new domestic autos (thousands of units)

$WI_{t-1} = PRD_{t-1} - FS_{t-1}$ = accumulation of wholesale inventory (thousands of units)

D_i = seasonality dummies

The wholesale inventory variable is shown to be statistically significant and of the proper sign. Despite the high level of autocorrelation, which apparently is caused by trending in the data, the equation provides a satisfactory basis for forecasting the level of factory sales.

Canadian Imports

As is the case for the factory sales variable, "Canadian imports" must be forecasted so that retail inventories can be updated. Unlike the factory sales variable, "Canadian imports" are rather difficult to predict.

Canada has, since the early 1960's, become an increasingly important source of domestic automobiles sold in the U.S. The Fair Trade Agreements of the early 1960's and the Automotive Products Trade Act of 1965 did much to increase automobile trade between Canada and the U.S. Data for Canadian imports of domestic automobiles in Figure 4.2 show the effects of the changes in national trading policy. The data show that Canadian imports increased throughout the 1960's, but leveled off in the 1970's. To explain changes in Canadian imports econometrically, it is necessary to treat these two periods (the 1960's and 1970's) differently, that is, to assume that the changes in the 1960's are related to unusual, nonrecurrent structural changes.

By making this assumption, changes in Canadian imports are easier to explain statistically. Canadian imports can be shown to vary with factory sales, a reasonable relationship.

$$CI_t = \underset{(4.24)}{96.9} + \underset{(4.82)}{.05}\, FS_t + \underset{(2.6)}{25.3}\, D_1 + \underset{(1.7)}{17.3}\, D_2 - \underset{(-4.6)}{48.24}\, D_3 \qquad (4.3)$$

$\bar{R}^2 = .86 \qquad \hat{\rho} = .1$

Standard error = 19

Mean of CI = 196

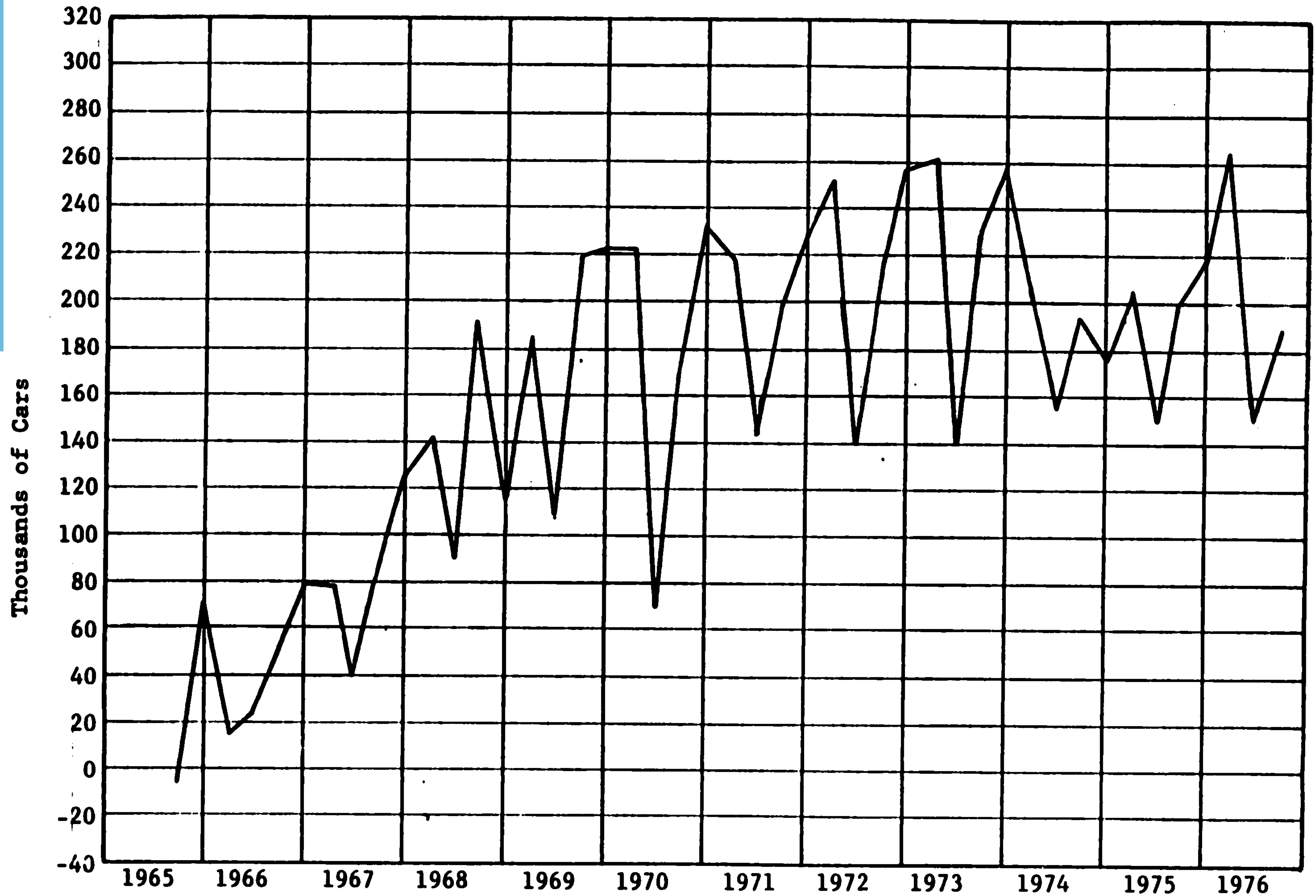

Figure 4.2. Canadian Imports of Domestic Type Automobiles

where:

CI = Canadian imports of new domestic-type cars (thousands of units)

FS = factory sales of new domestic cars (thousands of units)

D_i = seasonality dummies, i=1, 2, 3

However, if the entire data set from 1963 through 1976 is used, the best explanatory equation is less satisfactory. This equation includes two dummy variables, one for the first twelve quarters of the data and another for the following twelve quarters.

$$CI_t = \underset{(4.75)}{132.} + \underset{(1.3)}{.02}\ FS_t - \underset{(12.7)}{145.}\ C_1 - \underset{(-8.2)}{86.7}\ C_2 + \underset{(.56)}{6.9}\ D_1 - \underset{(-.43)}{5.15}\ D_2 - \underset{(-3.1)}{54.7}\ D_3 \tag{4.4}$$

$\bar{R}^2 = .84$ $\rho = .25$

Standard error = 30.8

Mean of CI = 137.2

where:

C_1 = dummy variable for 1963, Q1 - 1965, Q4

C_2 = dummy variable for 1966, Q1 - 1968, Q4

In Equation 4.4, factory sales are not statistically significant* and, since the other explanatory variables are dummies, little is explained. Despite its shortcomings, Equation 4.4 is needed for historical simulations of the overall model. For ex-ante and ex-post simulations, Equation 4.3 will be used.

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* When cross products of the dummies and factory sales are used in the equation to test for shifts in the value of coefficients over time, these variables are nonsignificant also.

LABOR AND CAPITAL REQUIREMENTS

The manufacture of automobiles in quantities of up to 10 million per year requires considerable quantities of labor and capital resources. An evaluation of any change in the automobile market would not be complete without considering the effects on industry employment and capital spending. Since both labor and capital requirements can be directly linked to required capacity, statistical equations can be developed relating labor and capital inputs to production volume.

Labor Requirements

The industry's labor requirements must be analyzed in terms of three separate variables:

1. Average standard weekly hours
2. Average overtime hours per week
3. Number of production workers*

Each of these factors represents a particular and important component of total manhours. For example, if labor requirements of the industry decrease, management may choose to reduce total manhours by using any of three separate ways or by some combination of the three:

1. Shortening the standard work week
2. Reducing overtime
3. Laying off workers

* Only production workers are considered since the number of non-production would not be expected to vary with the level of production in the short-run.

Of the three, the second, reducing overtime, may be preferred by management because it reduces costs by the most. By reducing overtime, management cuts out hours for which workers get paid "time-and-a-half", but retains the same number of workers on the payroll. In the up-down automobile business, retaining workers saves the cost of constantly rehiring and training workers. On the other hand, lay-offs may sometimes be used as a weapon to quiet labor union demands. Whereas adjusting overtime and laying off workers may have advantages, the least preferred measure is shortening the work week since this results in manufacturers paying more overtime wages and may create future requirements for hiring more workers.

It is possible to forecast how auto industry management will adjust manhours in the future (i.e., whether by adjusting the number of employees, overtime, or average work week) econometrically; by building a statistical model that explains how the industry has managed past cut-backs in manhours, we can, assuming they remain true to form, forecast their future behavior.

Manhours

In economic theory, the relationship between production level and total manhours is usually specified with production as the dependent variable. The relationship might be written as:

$$Q = f(K,L)$$

where:

Q = production output

K = utilized capital

L = utilized labor (manhours)

and states that, for given amounts of capital and labor input, a specific level of output can be produced. Theory also suggests that certain restrictions must be placed on the equation. These are:

$$\frac{\partial Q}{\partial L}, \frac{\partial Q}{\partial K} > 0$$

$$\frac{\partial^2 Q}{\partial L^2} \quad \frac{\partial^2 Q}{\partial K^2} < 0$$

$Q \rightarrow M_1$ as $L \rightarrow \infty$ and

$Q \rightarrow M_2$ as $K \rightarrow \infty$

where M_1 and M_2 are finite.

The first restriction requires that the marginal product of both labor and capital be positive, the second provides for a convex production function, and the third specifies that, if either factor of input is increased, the marginal productivity of additional units of that factor will eventually reach zero.

Econometricians have experimented with several alternative functional forms of the production equation (e.g., Cobb-Douglas, CES, VES). The Cobb-Douglas form, simplest and most well known, is written as:

$$Q = A\ L^{\alpha}\ K^{B}\ \mu \qquad (4.5)$$

where A is a coefficient of efficiency, α and B are parameters, and μ is the disturbance term. The parameters are estimated by taking logs of both sides.

$$\log Q = \log A + \alpha \log L + B \log K + \varepsilon \qquad (4.6)$$

With the equation in this form, it can be seen that, if Equation 4.6 is solved for log L, the new equation will relate production to labor input; this equation, the so-called labor requirements function, is shown in Equation 4.7.

$$\log L = \frac{1}{\alpha} \log Q - \frac{1}{\alpha} \log A - \frac{B}{\alpha} \log K + \varepsilon' \qquad (4.7)$$

One way to obtain parameter estimates for Equation 4.7 is to estimate the parameters of Equation 4.6 and then solve for log L. When this procedure is carried out, the parameter estimates are of reasonable magnitude and of proper sign, but the resulting equation tracks historical values of L poorly. This occurs because, by fitting Equation 4.6, one minimizes squared deviations in the log Q direction; deviations in the log L direction may be so large that the equation is of little value when solved for log L. Another way to obtain parameter estimates is to fit Equation 4.7 directly. When this is done, deviations in the log L direction are reduced considerably, but the values of estimated parameters do not conform to theoretical specifications. The main problem is that the estimated coefficient of log K is positive — clearly this term should have a negative sign. Evans (1969) explains why this occurs: "...a rise in Q will lead to a rise in capacity utilization; since L and Q are positively correlated, this often leads to a spurious positive correlation between L and utilized capital, K."* He continues, "If total capital stock is used instead of utilized stock, this problem disappears, but the overall equation is much poorer."**

To avoid the complications that estimation of a labor requirements function involves, one may assume a simpler, more tractable model of production. The fixed proportion model which posits that labor and capital inputs are always in a fixed proportion to one another may be written simply as:

$$Q = aL \qquad (4.8)$$

Capital is not a required variable in the model since, for any labor input, a certain level of capital input is implied.

Equation 4.8 may, in fact, not be that poor an approximation of the auto industry's production function. Over the past fifteen years, the industry's level of utilized capital has grown about 1 percent per year, with total capital stock growing at between 1 and 2 percent per year and real output growing at an average rate of about 1-1/2 percent per year. While labor input varies considerably with the business cycle, so does utilized capital. Thus,

* (Evans, 1969), p. 255.

** Ibid.

the ratio of labor to utilized capital may be fairly steady over time.

Equation 4.9 presents the results of estimating a labor requirements function based on the fixed proportion model of production. The lagged manhours term was introduced as an explanatory variable to account for delays in hiring and laying-off workers. By including this term, we are, in effect, creating a geometrically declining distributed lag relationship between the dependent variable, "manhours", and the independent variable, "the production level". The equation, which also includes a dummy variable for labor strikes and three seasonality dummies, was fit by generalized least squares to correct for autocorrelation of the residuals.

$$\begin{aligned} MHRS_t = & \underset{(4.3)}{4377.} + \underset{(2.6)}{.15} MHRS_{t-1} + \underset{(10.8)}{2.93} PRD_t \\ & - \underset{(-5.6)}{657.} STRK - \underset{(-4.9)}{1294.5} D_1 - \underset{(-4.1)}{835.7} D_2 \\ & + \underset{(1.1)}{385.4} D_3 \end{aligned} \qquad (4.9)$$

$\bar{R}^2 = .9 \qquad \hat{\rho} = .46 \qquad D.W. = 2.0$

Standard error = 459.

Mean of dependent variable = 11200.

where:

MHRS = average production manhours per week (thousands of manhours per week, SIC 3711)

PRD = production of new domestic autos (thousands of units per quarter)

STRK = labor strike dummy variable

D_i = seasonality dummies, i=1, 2, 3

All parameter estimates are statistically significant at $\alpha = .01$ and of the expected sign. The overall fit is satisfactory — the standard error is only four percent of the mean of the dependent variable.

As a means of checking the reasonableness of the parameter estimates, the number of manhours per automobile can be calculated. Since MHRS is measured on a per-week basis and PRD is measured per quarter, the coefficient of PRD, 2.93, must be multiplied by 13, the number of weeks per quarter, to obtain the average labor input required per car, 38.09 hours. This figure may be checked by comparing it with the estimates of typical assembly labor hours required per car which appear in Table 4.1.

Table 4.1

Typical Assembly Labor Hours Per Car

Body Size	Labor Hours
Luxury	50
Standard	27
Intermediate	24
Compact	21
Subcompact	19

Source: Automotive Manufacturing and Maintenance, Part 1, Report of a Panel of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976, pp. 3-28.

As the table shows, the labor hours required to assemble a car vary with the size of the car and the number of options and accessories installed. Luxury models which are typically "loaded" require almost twice as many assembly labor manhours as standard models.

Unfortunately, we will not be able to predict changes in labor requirements that may arise from changes in product mix; however, Equation 4.9 should provide good estimates of changes in labor requirements arising from changes in production volume as the data in Table 4.1 seems to substantiate our average, per-car estimation results.

Overtime

When output increases, the decision of whether to increase total manhours by hiring more employees or by working the existing employees more overtime hours depends largely on the relative costs of each alternative. Increasing or decreasing the number of workers on the payroll involves the costs of hiring, training, and firing. Increasing overtime hours requires that manufacturers pay "time-and-a-half" wages. For small changes in production volume, adjusting overtime hours is easier and less costly than adjusting employment levels; however, large changes in production volume lead to large changes in labor requirements which may necessitate hiring or firing workers as well as adjusting all employees overtime hours. In general, ceteris paribus, we would expect the average number of overtime hours per worker to be positively related to the level of production.

Another important criterion in manufacturers' labor-input decisions is the standard wage rate earned by production workers. Manufacturers will choose to use less overtime hours, ceteris paribus, the higher the standard wage rate is, because the additional cost of extra hours will be relatively more expensive. Laborers may also choose to work less overtime hours the higher their wage rate, since their demand for leisure may increase as their wage rate increases. Thus, overtime hours are likely to be negatively related to the wage rate.

Based upon these hypotheses concerning the relationship of overtime hours to the production level and the standard wage rate, the following equation has been estimated:

$$OT_t = \underset{(2.09)}{10.16} + \underset{(5.73)}{.002}\ PRD_t - \underset{(-2.5)}{2.98}\ SWAG_t$$

$$- \underset{(-2.1)}{.235}\ OT_{t-4} - \underset{(-1.7)}{1.94}\ D_1 - \underset{(-.63)}{.60}\ D_2 + \underset{(4.34)}{6.67}\ D_3$$

$\bar{R}^2 = .65 \qquad \hat{\rho} = .57 \qquad D.W. = 1.83$

Standard error = .99

Mean of dependent variable = 5.6

where.

- OT = average overtime hours per production worker per week (hours)
- PRD = number of automobiles produced (thousands of units)
- SWAG = production workers standard hourly wage/consumer price index (1967 dollars)
- D_i = seasonality dummies, i=1, 2, 3

The parameters were estimated using ordinary least squares, and first generalized differences of all variables were taken as a correction for serial correlation. Estimates of the parameters corresponding to production and wage rate are statistically significant and of the proper sign. "Overtime hours" lagged four quarters were introduced as an explanatory variable to seasonally adjust the data.

The model would predict that, for every 500 additional cars produced in a quarter, the average weekly overtime per production workers will increase by one hour, ceteris paribus. Also, every dollar increase in the wage rate will cause a reduction of about three overtime hours per worker.

Standard Work Week

Data published by the Department of Labor* indicates that the average standard number of hours worked per week by auto production laborers varies seasonally and over time. According to explanatory notes published with the data, this variation results mainly from the changing number of part-time workers carried on auto industry payrolls. The standard hourly week for full-time workers has changed only once in the past fifteen years, that change occurring in September 1976 when the United Automobile Workers (UAW) negotiated successfully to have their standard work week reduced from 40 to 37.5 hours.

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* See Employment and Earnings, U.S. Department of Labor.

** These data were obtained verbally from an employee of the Ford Motor Company plant in Green Island, New York. He said that the standard week for other plants or other companies may have been more or less than 40 hours prior to the 1976 negotiations, but that a 40-hour-week had been the general rule for the industry for quite sometime.

Statistical tests have indicated that the variation in the standard hourly week data is not related to changes in the level of production, nor is it correlated with any production-related variables; the only significant statistical finding is an indication that the average standard hours worked per week is lowest during the summer months when, presumably, part-time workers are hired to fill-in for vacationing full-time workers. Because of the apparent independence of the standard hourly week to other observable variables, the best forecasting model that has been found is a first-order autoregressive equation.

$$(AWWK - OT)_t = \underset{(10.96)}{52.0} - \underset{(-2.5)}{.345}\ (AWWK - OT)_{t-1} - \underset{(-1.24)}{1.33}\ D_1 - \underset{(-1.64)}{1.21}\ D_2 - \underset{(-5.6)}{4.77}\ D_3 \qquad (4.10)$$

$\bar{R}^2 = .69 \quad \hat{\rho} = .575 \quad$ D.W. 2.0

Standard error = .69

Mean of dependent variable = 38.

where:

AWWK = average overtime hours per production worker
AWWK-OT = standard hours per week per production worker
D_i = seasonality dummies, i=1, 2, 3

The parameter estimates of Equation 4.10 were obtained by generalized least squares to correct for serial correlation of the residuals. Equation 4.10 explains about 70 percent of the variation in the dependent variable; fortunately, since all variation of the dependent variable is within a narrow range (37-39.5 hours), the unexplained variation will not pass on large forecasting errors to other equations.

Number of Production Workers

The level of employment in the industry, or the number of production workers on the payroll, is determined by the equation:

$$EMP_t = MHRS_t / AWWK_t$$

where:

EMP = average number of production workers

MHRS = production manhours

AWWK = average hours per week

This equation is integrated with the other three labor equations to enable us to forecast the various aspects of labor requirements.

Fixed Investment Expenditures

To evaluate the long-run effect of Government regulations, their impact on the auto industry's investment behavior must be considered. Regulation may affect the level of industry investment expenditures by: 1) requiring the firms make certain expenditures to comply with standards and 2) causing the costs of production to increase, thereby increasing prices, reducing sales, and reducing the industry's expected future requirements for productive capital.

Capital expenditures made by auto companies to comply with regulations, which may be referred to as "required" investment, are exemplified by the cost of equipment needed to produce catalytic converters, shock-absorbing bumpers, and energy-efficient transmissions and engines. Forecasts of the required investment resulting from a regulation are best made by cost engineers who have experience in and knowledge of the manufacture of the auto parts needed.

Our concern in this chapter is with reductions in capital spending prompted by reductions in sales; theoretically, such changes in so-called "induced" investment can be statistically forecasted on the basis of past investment behavior of the industry. To do so, one must construct an equation relating sales or output to capital expenditures, fit the equation to historical data, and use the resulting estimated equation to predict the decrease in investment expenditure that would result from the expected decrease in sales or output. However, before this can be accomplished, the appropriate relationship between sales and investment must be identified.

The econometrics literature contains a number of studies of corporate and industry investment behavior: (Eisner, 1962, 1967), (Resek, 1966), (Jorgensen, 1966, 1968, 1970, 1971), (Jorgensen and Stephenson, 1967) are a representative sample.* By reviewing this literature, one finds that there is no widely held view concerning

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* See Appendix B for a partial account of this literature.

investment behavior; rather, there are a number of popular investment models, each having its own favorable attributes. One aspect of the modeling of investment behavior that is generally agreed upon is its intractability. Indeed, because there are many factors that influence investment behavior that cannot be adequately explained in a statistical model, good estimation results have seemingly been difficult to obtain.

Perhaps the greatest barrier to constructing a satisfactory model of investment is in appropriately specifying the time structure; that is, the lag between investment appropriations and actual expenditures. Jorgensen (1966), who has offered a solution to this problem, specified the lag as a rational function of two polynomials; the rational distributed lag function, as it is commonly called, is written as:

$$I_t^{NET} = \frac{A(L)}{B(L)} \Delta D_t \qquad (4.11)$$

where:

I^{NET} = net investment

D = retail sales

$A(L) = \alpha_o + \alpha_1 L + \alpha_2 L^2 + \ldots + \alpha_m L^m$

$B(L) = 1 - b_1 L - b_2 L^2 - \ldots b_n L^n$

L = a lag operator, $LZ_t = Z_{t-1}$

This model is based on the supposition that decisions for additions to capital stock (net investment) are made according to expectations for future changes in retail sales, where expectations are formed as a result of past changes in sales. Expressed another way, desired capital stock at any time is proportional to retail sales and changes in actual stock are determined by a distributed lag of past changes in desired capital stock*.

Total investment in the model is the sum of net investment and replacement investment, where replacement investment is determined by depreciation. Symbolically:

$$I_t = I_t^{NET} + I_t^R \tag{4.12}$$

where:

I = total investment

I^R = replacement investment

and $I^R = D$

$= \delta K_{t-1}$

where:

D = depreciation

K_t = capital stock**

δ = depreciation rate = 0.0325 (per quarter)†

Net investment may be expressed as the difference between gross investment and depreciation. Substituting

$$I_t - \delta K_{t-1}$$

for net investment in Equation 4.11 gives:

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* See (Jorgensen and Siebert, 1968).

** Capital stock is updated by the equation $K_t = K_{t-1} + I_t - D_t$.

† This estimate of the depreciation rate is based on information from financial statements of firms in the industry.

$$(I_t - \delta K_{t-1}) = \frac{A(L)}{B(L)} \Delta D_t$$

The parameters of this model (the a_i's and b_j's, for i=0, 1, ... m and j=1, 2, ... n) can be estimated by a maximum likelihood technique developed by Dhrymes, Klein, and Steiglitz (1970).* This method involves, first, finding consistent parameter estimates for lagged values of the dependent variable by using Liviatan-type instrumental variables, and then using an algorithm based on pre-filtering each variable to obtain the maximum likelihood estimates.

Estimation Results

Parameter estimates were obtained for an array of alternative lag distributions. In the set of alternative models tested, the order of the numerator and denominator polynomials was varied; the order of the numerator polynomial ranged from one to seven, and the order of the denominator polynomial was either one or two. After the maximum likelihood estimates of each model were obtained, the model was tested for simulation performance. The model that performed best in simulation tests is given as shown on the following page.

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* An alternative method developed by Maddala and Rao (1971) can also be used, but estimates obtained by either method are approximately the same.

$$(I_t - \delta K_{t-1}) = b_1(I_{t-1} - \delta K_{t-2}) + b_2(I_{t-2} - \delta K_{t-3}) + a_o \Delta D_{t-3} + a_1 \Delta D_{t-4} + a_2 \Delta D_{t-5} + a_3 \Delta D_{t-6} + C_o + C_1 DUM_1 + C_2 DUM_2 + C_3 DUM_3$$

$\delta = 0.0325$	$a_1 = 8E - 5$	$C_1 = -0.12$
$b_1 = 0.57$	$a_2 = 9E - 5$	$C_2 = 0.01$
$b_2 = 0.21$	$a_3 = 5E - 5$	$C_3 = -0.03$
$a_o = 9E - 5$	$C_o = 0.042$	

Standard error = 0.045

$\bar{R}^2 = 0.84$

where:

I = investment in fixed capital deflated by the price index for nonresidential fixed investment (millions of 1967 dollars)

K = capital stock

D = retail sales of new domestic automobiles (thousands)

DUM_i = seasonality dummies

The estimated model would predict that a decrease in quarterly retail sales of 100,000 autos would cause the following adjustment in investment (other things remaining constant):

Quarter After Change in Sales	Decrease in Net Investment (millions of constant dollars)
0	-
1	-
2	-
3	9
4	13.13
5	18.37
6	18.23
7	14.25
8	11.95
9	9.80
10	8.09

Investment would not be affected until three quarters after the change in sales. The impact on investment spending would gradually increase, reaching a peak five quarters after the change in sales and then gradually decrease.

SUMMARY

As a foundation upon which to base forecasts of Government regulations' impact on the economic activity of the auto manufacturing industry, a number of econometric models of relationships inherent to the supply-side of the market have been constructed in this chapter. Among the measures of supply that have been considered are:

1. Production

   By relating expected sales to actual production volume, the "production planning" equation serves to link the demand side of the market to the industry's productive activities.

2. Retail Inventory

   Because short-term market disequilibrium, as measured by the abundance of inventories, affects manufacturers' pricing and output decisions, accounting for the level of retail inventory is a necessary step in constructing the relationship between manufacturers and buyers. In a sense, the level of retail inventory is at the heart of the continual feedback process between manufacturers, price-setters, and consumers, price-discriminators.

To trace changes in retail inventories, we have needed to construct equations for updating the level of factory sales and the level of Canadian imports, two quantities that enter into the retail-inventory adjustment equation.

3. Labor Requirements

Labor input, which is related chiefly to the level of production, is defined according to: a) the number of production workers, b) the standard hourly week for full-time employees, and c) the average number of overtime hours worked per week. By decomposing total man-hours into these components, we will be better able to answer questions regarding the effect of production cut-backs on the industry employment level.

4. Capital Requirements

A model of the auto industry's investment behavior was constructed to provide a basis for forecasting changes in the industry's induced that may occur as an indirect result of Government regulation.

CHAPTER 5

THE MODEL AS A SYSTEM OF EQUATIONS

INTRODUCTION

In this chapter, the equations that have been constructed are assembled together to form a multi-equation model; key relationships that govern the model's simulation behavior are studied; the estimation and solution of the multi-equation model are discussed; and, in the process, a better understanding of the interrelationships between various elements of the auto market and industry is acquired. Lastly, as a means of validation, the model is used to generate a simulation of auto industry behavior over the sample period. Various goodness of fit tests are implemented to measure the accuracy of the model's simulation performance.

KEY RELATIONSHIPS IN THE MODEL

As is generally the rule in econometric model-building, the modeling and estimating of individual equations has been guided by an overall structural model that was hypothesized before modeling began. The initially hypothesized structural model, as outlined in Chapter 1, was, in this case, general in character, consisting most notably of the idea that new car sales, new car prices, and used car prices are simultaneously determined and that once the interrelationships between these three elements of the market are properly specified, market behavior could be related to the industry's productive behavior. This hypothesized model might be called the "a priori model" of the system, since, throughout the modeling process, it has been amended when statistical results proved it to be in error. For the same reason, we may think of our final model as being "a posteriori" and as having improved as a result of the modeling process.

As was previously mentioned, decisions concerning the structure of the model and its equations have been influenced by the ultimate goal of the modeling process — to forecast. Many times throughout the model's construction, decisions were implicitly made to emphasize one aspect of a behavioral equation rather than another for this reason. On the whole, the goal has been to minimize forecasting errors; however, this goal has been compromised frequently when statistical accuracy could be achieved only at the expense of theoretical or intuitive correctness.

We turn now to the structure of the a posteriori model as illustrated in part in Figure 5.1. The flow diagram traces the key relationships found in the core equations of the model, and, as such, it brings out the modeling logic and serves as a check on its soundness. Notice that the equations explaining: (1) income distribution, (2) man-hours, (3) overtime hours, (4) average hourly week, (5) employment level, (6) capital expenditures, and (7) capital stock are not represented in the diagram. These equations are

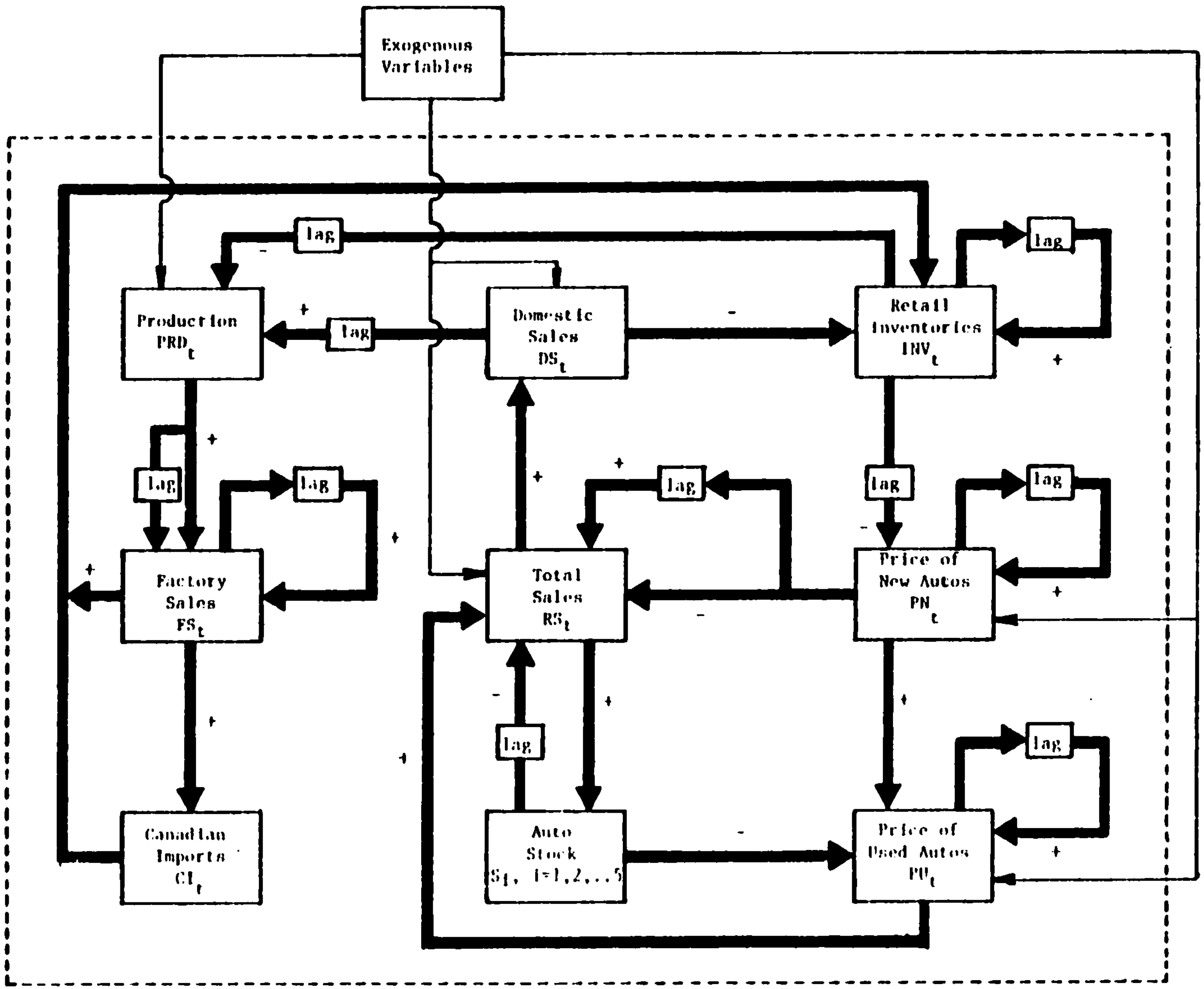

Figure 5.1. Block Diagram of Model

influenced by the core block, but they have no feedback effect; their behavior is totally governed by the equations represented in the diagram.*

Referring to the diagram, the group of equations that explains: (1) total sales, (2) domestic sales, (3) auto stock, (4) new auto prices, and (5) used auto prices should be distinguished as that part of the model which describes the auto marketplace. To trace through the important market relationships, look first at the relationship between the total sales of autos, RS, and the stock of autos aged one to five years, S_i, $i=1, 2, \ldots 5$. The arrow from RS to S indicates that the stock of autos is supplemented as new cars are sold; each car sold automatically becomes part of auto stock. Looking at the arrow that goes in the opposite direction, we see that stock has a negative effect on retail sales: cars that were sold in previous periods will have a depressing effect on future retail sales, an effect that depends upon the age of existing stock. This bi-directional relationship between sales and stock may be called a negative feedback loop. This relationship, and negative feedback systems in general, may be characterized as goal-seeking systems that respond to departures from the system goal. In this case, the goal is the desired stock of automobiles and the negative feedback comes as a result of stock adjustment, or adjustment toward the goal.

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* This is true with the exception of the income distribution equations which may be thought of as exogenous since they are not influenced by the behavior of the system.

This relationship, however, is not a simultaneous one – only stock that exists at the beginning of a period is assumed to influence stock adjustment during that period.

The relationship between total sales, RS, and domestic sales, DS, is given by the identity:

$$DS_t = SH_t * RS_t$$

where SH_t represents the percent share of total sales that are domestic. Total sales and domestic sales are considered endogenous to the model and market share is considered exogenous or determined by variables outside the model.* Both sales variables need be included in the model since each serves a distinct purpose: "total sales" is required to describe the domestic market for new autos since both

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* The demand for domestic and the demand for imported cars, one may argue, are determined by essentially the same factors. And, market share is determined by the relative prices of imports and domestics. Therefore, market share could be made endogenous to the market system merely by specifying two market prices: one for domestics and one for imports.

This argument does not hold because relative market prices explain little of the variation in market share. Surely the low prices of imports encouraged their successful penetration of the domestic market, but consumers bought, and continue to buy, imports for reasons other than price. During the second quarter of 1978, imported subcompacts were priced as high as most domestic intermediates and, yet, Toyota and Honda had record sales. A spokesman for Honda said, "Honda is a way of life. Buyers will continue to purchase Hondas because of their reputation for quality, economy, and high resale value." (See "High Prices Not Hurting Imports," Automotive News, July 3, 1978, p. 1.) The characteristics of different models: their reliability, fuel economy, size, and performance, and the tastes of buyers determine market share. Together, these variables, in a factor analytic sense, constitute a separate dimension of the market, one that is exogenous to the model that has been constructed.

domestic and imported cars satisfy consumer needs and, therefore, both are part of the stock adjustment process; "domestic sales" must be separately distinguished to capture the effect of market changes on the domestic auto industry.

The relationship between total sales and market price, P_N, is complex because of its many components. Because relative prices may cause consumers to substitute other goods for new autos and vice versa, the price of new autos relative to other goods in the current period is negatively related to sales; because consumers may delay their purchases when relative price is high and advance them when relative price is low, the relative price of new autos lagged four quarters is positively related to sales in the current period. Past levels of new car price also affect the current level of new car sales indirectly via their influence on the current level of used car prices. Increases in new car prices cause increases in used car prices which, because of the substitution of new for used cars, have an expansionary effect on new car sales. All things considered, the causal influence of new car prices on new car sales is negative; the higher prices are, the lower sales will be, ceteris paribus.

As can be seen in Figure 5.1, however, a causal flow also exists in the opposite direction – from sales to price. Other things remaining equal, the greater sales are in the current period, the smaller inventories will be in the following period and, thus, the higher prices will be. Following another vein, past levels of sales affect manufacturers' expectations of future levels which determine production volume and, therefore, the availability of new cars. Availability, as measured by retail inventory level, in turn, has a negative effect on price level. Overall, ceteris paribus, the level of sales has a slightly positive (inflationary) effect on price.

Looking now at the relationship between used car prices and new car sales, notice that, as was previously mentioned, increases in used car prices have a positive effect on new car sales. Notice also that used car prices are affected by the level of new car sales; as sales increase, auto stock increases, thereby depressing used car prices (and, we might add, relieving the upward pressure on sales). This relationship is another example of a negative feedback loop contained in the model.

It can be seen by tracing through the relationships between: (1) new car sales, (2) new car prices, and (3) used car sales that, contrary to prior expectations, no simultaneous relationships exist between these variables. A simultaneous relationship would be witnessed in a block diagram such as Figure 5.1 by the presence of two or more blocks joined by a closed loop of unbroken flow lines; as is shown in Figure 5.1, a number of closed loops exist, but all contain intervening lag operators, indicating that the relationships are not simultaneous. That our modeling process did not result in a simultaneous specification does not prove that the true relationship between these market factors is not simultaneous; it may be, for example, that we have produced a recursively structured model which approximates the true, perhaps statistically blurred, simultaneous structure. In any case, this is not a matter of great concern.

Looking now at the production and retail inventory equations, we find another negative feedback mechanism describing auto firms' inventory control practices. Too high levels of production will, indirectly through high levels of factory sales, cause retail inventories to accumulate. When inventories build as a result, the level of production in the following period will be lowered, thereby alleviating the build-up. Conversely, low levels of inventories, indicating a tight market, will tend to stimulate production which, when increased, will cause inventories to build.

To summarize, the structure of the model depicts control-oriented rather than growth-oriented processes. Auto manufacturers' behavior is described as a controlling of inventory levels, production levels, and prices toward desired states; consumers' behavior is described as a controlling of stock holdings toward some desired level. These control mechanisms are important because they govern the models' behavior to exogenous changes; exogenous variables such as consumer income and manufacturing cost determine, to a great extent, the goals toward which the system adjusts and, therefore, the long-run time path of the system.

ZELLNER ESTIMATION

For a number of the equation estimates presented in Chapters Two, Three, and Four, dependent variables that were hypothesized to be correlated with the error term of an equation were replaced by instrumental variables; an instrumental variable method — two-stage least squares — was used to estimate the retail sales, new car price, used car price, and production equations. This procedure was carried out to ensure the consistency of parameter estimates.* The efficiency** of these parameter estimates can be improved by using Zellner or "seemingly unrelated equations" estimation,† a method which accounts for correlation between equations. Actually, Zellner estimation, which, when applied to equations already estimated by two-stage least squares (2SLS), is the third stage of the so-called three-stage least squares (3SLS) estimatiom method, and is simply the application of generalized least-squares estimation to a group of equations.

Zellner estimation has been applied to a group of six equations: (1) the retail sales equation, (2) the new car price equation, (3) the used car price equation, (4) the

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* A consistent estimator approaches its true value (in probability) as the sample size approaches infinity.

** Efficiency refers to the variance of an unbiased estimator.

† See (Zellner, 1962).

factory sales equation, (5) the production equation, and (6) the Canadian imports equation, as a means of accounting for the dynamic interdependence of the corresponding market variables.* As shown in Table 5.1, the correlations between the residuals of these equations are uniformly small with the exception of the 0.4 correlation between the residual series of the retail sales and production equations.

Table 5.1

Residual Correlation Matrix

1	2	3	4	5	6
1.0	-0.14	0.10	-0.02	0.01	-0.01
	1.0	0.03	0.05	0.40	0.01
		1.0	0.04	0.14	-0.12
			1.0	-0.06	-0.34
				1.0	-0.14
					1.0

Key:
1 - Price of Used Autos
2 - Retail Sales
3 - Price of New Autos
4 - Factory Sales
5 - Production
6 - Canadian Imports

Because of these small cross-correlations, we would expect the three-stage least squares estimates of the equations to differ little from their two-stage-least squares counterparts; the 3SLS estimation results presented in Table 5.2 corroborate this: these estimates are very close to the 2SLS estimates.

* The Canadian imports equation has been included because the CI variable is included in the retail inventory identity. Since the retail inventory identity cannot be included in Zellner estimation (it has no residual), all of the right-hand side variables in the identity (retail sales, factory sales, and Canadian imports), have been included.

Table 5.2

Zellner Estimates

5.1 $$D_t = \underset{(1.4)}{.057} - \underset{(-4.6)}{.11}\hat{P}_{N,t} + \underset{(3.9)}{.10}P_{N,t-4} + \underset{(2.0)}{.02}\hat{P}_{u,t}$$

$$+ \underset{(7.2)}{2.1}PI_t + \underset{(5.0)}{.11}ODDS15+ - \underset{(-2.4)}{.20}ODDS25+$$

$$- \underset{(-4.2)}{.023}STRIK - \underset{(-5.4)}{.03}UE_t - [\underset{(5.4)}{.46}S_{1,t-1}$$

$$+ \underset{(7.6)}{.30}S_{2,t-1} + \underset{(4.5)}{.27}S_{3,t-1} + \underset{(5.9)}{.25}S_{4,t-1}$$

$$+ \underset{(5.3)}{.25}S_{5,t-1}] - \underset{(-3.1)}{.03}D_1 + \underset{(4.4)}{.0039}D_2 - \underset{(-4.7)}{.46}D_3$$

$\bar{R}^2 = .925$ D.W. = 2.1

Standard Error = .002 $\hat{\rho} = .1$

5.2 $$P_{N,t} = \underset{(.5)}{1.78} + \underset{(14.5)}{.89}\hat{P}_{N,t-1} - \underset{(-2.2)}{.003}\Delta INV_{t-1}$$

$$\underset{(1.25)}{1.01}W_t + \underset{(1.4)}{.025}WPIMA\text{-}1 + \underset{(1.4)}{17.39}\hat{SHARE}_t$$

$$\underset{(2.69)}{.87}STRIK - \underset{(-2.1)}{2.3}D_1 - \underset{(-2.11)}{2.3}D_2 - \underset{(-3.9)}{4.1}D_3$$

$\bar{R}^2 = .99$ D.W. = 1.9

Standard Error = 1.22 $\hat{\rho} = .22$

5.3 $$P_{u,t} = \underset{(-2.5)}{-56.5} + \underset{(4.8)}{.52}\hat{P}_{u,t-1} + \underset{(1.6)}{.47}\hat{P}_{N,t} - \underset{(-1.6)}{.43}P_{N,t-4}$$

$$- \underset{(-1.9)}{44.5}D^N_{t-1} - \underset{(-2.2)}{4.38}Y_t + \underset{(3.3)}{.40}ICS_{t-1}$$

$$\underset{(2.95)}{.66}CPI_t - \underset{(-.6)}{1.55}D_1 + \underset{(4.5)}{7.2}D_2 + \underset{(2.9)}{4.45}D_3$$

$\bar{R}^2 = .98$ D.W. = 1.8

Standard Error = 4.06 $\hat{\rho} = .1$

5.4

$$PRD_t = \underset{(3.3)}{238.4} + \underset{(12.4)}{1.03}\,\hat{RS}_t - \underset{(-6.4)}{1.0}\,INV_{t-1}$$

$$- \underset{(-1.9)}{71}\,STRIK + \underset{(4.0)}{.21}\,PRD_{t-4} + \underset{(2.9)}{212.7}\,D_1$$

$$+ \underset{(1.05)}{91.6}\,D_2 - \underset{(-1.01)}{73.4}\,D_3$$

$\bar{R}^2 = .96$ D.W. $= 2.11$

Standard Error $= 112$ $\hat{\rho} = .7$

5.5

$$FS_t = \underset{(-.9)}{-12.1} + \underset{(78.2)}{.97}\,\hat{PRD}_t + \underset{(2.1)}{.31}\,WINV_{t-1}$$

$$- \underset{(-1.3)}{25.1}\,D_1 - \underset{(-.7)}{7.8}\,D_2 + \underset{(1.4)}{30.2}\,D_3$$

$\bar{R}^2 = .998$ D.W. $= 2.09$

Standard Error $= 27.6$ $\hat{\rho} = .9$

5.6

$$CI_t = \underset{(3.71)}{88.1} + \underset{(3.0)}{.051}\,FS_t - \underset{(-12.5)}{152}\,C_1$$

$$- \underset{(-9.1)}{83.7}\,C_2 + \underset{(1.6)}{17.1}\,D_1 + \underset{(.91)}{4.53}\,D_2 - \underset{(-2.52)}{35.1}\,D_3$$

$\bar{R}^2 = .85$ D.W. $= 2.05$

Standard Error $= 31$ $\hat{\rho} = .$

SOLUTION OF THE SYSTEM OF EQUATIONS

Recursive Structure

By examining the block diagram presented in Figure 5.1 and tracing through relationships between each of the equations in the model or by examining the equation system in its algebraic form, it can be determined that the model equations can be solved recursively in the following order:

1. New Car Prices
2. Used Car Prices
3. New Car Sales
4. Production
5. Factory Sales
6. Canadian Imports
7. Retail Inventory
8. All Others in no special sequence

Thus, to generate simulations, the model equations are arranged in this order. The new car price equation is solved first, making a $\hat{P}_N$ value available for input to the used car price equation which is solved second, making a $\hat{P}_u$ value available for input to the new car sales equation, and so on.

Notice that the order of solution makes prominent the notion that prices are set on the basis of past information only; current demand, according to the model, is irrelevant. Notice also that, in model simulations, forecasted values of new car sales are input to the production equation in place of the "expected sales" variable used in estimating the equation.

Stability

With the order of equation solution identified, it is usually possible to investigate the stability conditions of an econometric model by substituting one equation into another until a single difference equation containing only one endogenous variable is found. For example, for this model, we can make substitutions until we have a single equation for new car sales with only lagged values of new car sales and exogenous variables on the right-hand side. Typically, with the model expressed as a single difference equation, one can assume constant values for the exogenous variables in the equation and then proceed to find the equation's roots which will impart valuable information concerning the stability, damping, and oscillatory characteristics of the model's time path response. However, in this case, the resulting difference equation in new car sales is of 20th order and this makes infeasible the task of finding its roots.

A "second best" method for investigating the stability conditions of a model is to perform a series of simulations using different time paths for the exogenous variables in the model. Such simulation tests have been run using a broad range of time paths for income, unemployment, wholesale prices, and consumer prices, indicating no apparent instabilities within feasible ranges for these variables. These results have indicated that model instabilities should cause no problems in making extrapolations as far ahead as year 2025 (although this is not recommended).

Restrictions on Forecasting Use

For prudence's sake, several restrictions should be placed on the use of the model. Given that the relationship between the real price of new cars and retail sales is particularly important, special care should be taken that extrapolated values of real price are not far outside the sample range since in such a case little confidence could be placed in the corresponding predicted values of retail sales. Intuitively, the least amount of confidence could be placed in forecasts of sales when the real price variable takes on a value much greater than has occurred in the sample range because, under such conditions, previously nonexistent alternative modes of transportation might become available. In comparison, because the real price of new cars has steadily decreased over the past twenty years, the possibility of producing nonsensical forecasts of retail sales because real price is lower than any previous historical value seems less likely.

Another caveat should be voiced regarding the length of extrapolations: from both a statistical and a pragmatic viewpoint, extrapolations involve a high degree of uncertainty. Statistically, even though our linear model based on sampled observations may seem to explain the real world adequately, in truth this may be because our data sample describes the approximately linear, short-run characteristics of a system that, when observed over a longer time period, exhibits non-linear behavior. Long-range forecasts of the behavior of a non-linear system based on a linear model of the system are likely to be grossly inaccurate. Pragmatically, one must also acknowledge that, because of the likelihood of exogenous discontinuities (e.g., changes in fuel markets, changes in the physical characteristics of automobiles, changes in the availability and desirability of alternative modes of transportation), no one can accurately predict the future very far in advance. Herman Kahn was once quoted as saying something to the effect that, "Forecasting events ten years or more in advance is a form of embezzlement." This statement errs only when the forecaster is not remunerated for his efforts.

For these reasons, it should be noted that the further ahead forecasts are made, the greater the expected forecasting error will be. Forecasts longer than five years may have certain explanatory value, but they may be of no practical value.

Forecasting Equations with First-Order Auto-Correlated Errors

A number of the equations in the model have been estimated by generalized least squares to correct for first-order serial correlation; other equations that include a lagged endogenous variable have been estimated by Fair's (1970) technique developed for the same purpose.* For these equations, forecasting accuracy has been improved by making use of information gained in the estimation procedure.

* See (Pindyck and Rubinfeld, 1976), pp. 170-172.

To illustrate, with a single equation two-variable model,

$$Y_t = \alpha + \beta X + \ell_t$$

$$\ell_t \sim N\ (0,\sigma)$$

The best possible one-period-ahead forecast is:

$$\hat{Y}_{t+1} = \alpha + \beta\hat{X}_{t+1} + \ell_{t+1} \tag{5.7}$$

Having no information concerning ℓ_{t+1}, it is set equal to its expected value of zero. The expected value of Y_{t+1} is, therefore,

$$\hat{Y}_{t+1} = \alpha + \beta\hat{X}_{t+1}$$

Suppose, however, that the error term in the model is known to be first-order auto-correlated:

$$\ell_t = \rho\ \ell_{t-1} + V_t$$

$$|\rho| \leq \quad V_t \sim N(0,\sigma_v)$$

This information can be included in the model to improve forecasting accuracy as in Equation 5.8.

$$\hat{Y}_{t+1} = \alpha + \beta\hat{X}_{t+1} + \rho\ell_t \tag{5.8}$$

or, equivalently,

$$\hat{Y}_{t+1} = \rho Y_t = (1-\rho)\alpha + \beta(\hat{X}_{t+1} - \rho X_t) \tag{5.9}$$

Since in the estimation stage of our model development a number of equations were found to have auto-correlated errors, this information has been used to improve model forecasting. Specifically, equations estimated with a correction for first-order auto-correlated residuals take the form of Equation 5.9 in model forecasts. In accounting for the first-order auto-correlation in forecasting, the error of forecast for $\hat{Y}_{t+1}$ has a smaller variance than would be the case if it were not taken into account.

MODEL VALIDATION

The equations in an econometric model are evaluated individually by a set of statistical tests such as R^2, F ratio, t values, and Durbin-Watson statistics; the reasonableness of estimation results is further judged according to the sign and magnitude of estimated parameters. However, even if every equation in a model fits the data well, this is no guarantee that the model will produce sensible forecasts; the real "acid test" of a model and individual equations in the model is how well the model performs in dynamic simulation experiments.* Performance in simulation experiments must be used as the final criterion in deciding whether an econometric model is performing according to the demands of the problem.

In this section, the results of two different types of simulation experiments are presented. First are the results of an historical simulation, which involves supplying the model with initial conditions that correspond to the beginning of the estimation period and then running a simulation for

* For further information concerning the evaluation of models, see (Dhrymes, et al., 1972).

the entire estimation period. As shown in Figure 5.2, the historical simulation spans the period of second quarter 1965 to the fourth quarter 1976.* Second, the results of an ex-post forecast of the model are presented. An ex-post forecast involves initializing the model to conditions that correspond to the time period directly after the estimation period, and then generating forecasts until the present. As shown in Figure 5.2, the ex-post forecasts are run from the first quarter of 1977 through the fourth quarter.

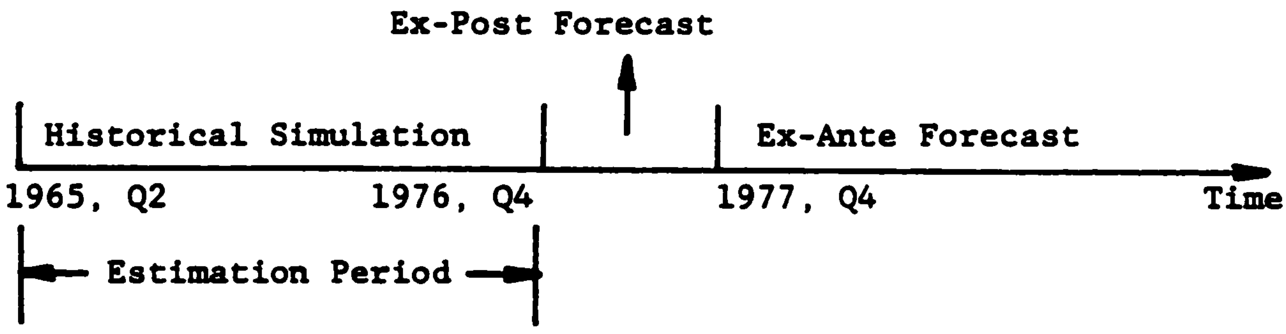

Figure 5.2. Simulation Timeline

A number of possible criteria may be used to evaluate the goodness of fit of an historical or an ex-post simulation. One such criterion is the average error of the forecast which is calculated as:

$$AE = \frac{1}{T} \sum^{T} y_i^s - y_i^a$$

* The model was estimated with data from first quarter 1963 to fourth quarter 1976. The historical simulation begins at second quarter 1965 because the initial conditions of several lagged variables are required to start up the model.

where y^s is the simulated value of y; y^a is the actual value; and T is the number of time periods in the simulation. A shortcoming of this measure of simulation performance is that negative errors offset positive errors and the average error is understated. A better measure is given by the average absolute percent error (AAPE):

$$AAPE = \frac{1}{T} \sum^{T} \frac{|y_i^s - y_i^a|}{Y_i^a}$$

This statistic has the desirable characteristic of being easily interpretable; it is perhaps the most appropriate measure of the average percent error. Its adequacy as a measure of the comparative performance of two or more simulations may be questioned, however, since it gives equal weight to all errors. For comparing the simulation performance of two alternatives, for example, one may want to accord greater penalties to large errors. On this count, another statistic, known as the root mean square percent error (RMSPE) may be recommended.

$$RMSPE = \sqrt{\frac{1}{T} \sum^{T} \left(\frac{Y_i^s - Y_i^a}{Y_i^a}\right)^2}$$

Notice that, since errors are squared in calculating this statistic, great penalties result from large errors. The RMSPE is generally larger than the AAPE, and, therefore, although RMSPE is a good measure of comparative performance, it may not be as readily interpretable a measure of absolute performance as AAPE. Ideally, both measures should be used.

Qualitative criteria may also be useful for judging simulation performance. For instance, a plot of actual versus predicted values shows the closeness of fit and a qualitative "good or bad" judgement can be made on the basis of the plot. One can also see from a plot if turning points are caught or missed; this is another important criterion of model performance. Lastly, simulation performance provides information regarding the stability of a model: if predicted values get increasingly larger or smaller, this may be a sign that the model is unstable; if simulation errors get increasingly larger, the model may either be unstable or perhaps the errors are auto-correlated and equations should be re-estimated using a generalized least squares method.

Historical Simulation

An historical simulation of the model was run starting with 1965, second quarter, and ending with 1976, fourth quarter. The root mean square percent errors (RMSPE) and average absolute percent errors (AAPE) for endogenous variables are shown in Table 5.3. The results indicate that the model tracks actual historical behavior quite closely; the largest error for any single variable is less than ten percent. Notice also that the RMS percent errors are close to the (percent) standard errors of the various equations, indicating that the model is stable and is not accumulating and magnifying errors over time.

Table 5.3

Historical Simulation – Root Mean Square
Percent Errors and Average Absolute Percent Errors

Variable	RMSPE	AAPE
Total Sales	5.26%	4.07%
Domestic Sales	5.26	4.07
New Auto Prices	1.3	.99
Used Auto Prices	3.69	2.82
Production	8.89	7.01
Retail Inventory	8.40	6.19
Man-Hours	6.54	5.13
Average Hourly Week	4.22	3.43
Production Workers	5.71	4.45
Factory Sales	9.25	7.32
Fixed Investment	9.67	7.79
Capital Stock	1.25	.93

$$\text{RMSPE} = \sqrt{\frac{1}{T}\,\Sigma\left(\frac{Y_t^S - Y_t^A}{Y_t^A}\right)^2} \qquad \text{AAPE} = \frac{1}{T}\,\Sigma\,\frac{|y_i^S - t_i^A|}{Y_i^A}$$

The model tracks the most important market variables — sales, new car prices, and used car prices — well. This indicates that the specification of the market mechanism along with its dynamic adjustment properties may be close to the real world. Production, inventory adjustment, labor requirements, and capital requirements are also tracked closely; the RMSPE's and AAPE's are close to the percent standard errors of the respective equations.

What is a satisfactory forecast error? This depends upon the intended use of the model and the sort of real-world system it represents. If the model is to be used strictly for forecasting, then the forecasting error should be as low as possible. Of course, some variables are more difficult to predict than others; quarterly time series variables, for instance, are more difficult to predict than yearly time series variables. The analyst must judge the adequacy of forecast error for each variable on the basis of his understanding of the real world phenomena which the model represents. The lowest possible forecast error for some variables may be over ten percent if unobservable phenomena account for more than ten percent of its variation; for those variables whose determinants are observable, the forecast error may be only a fraction of a percentage point. If the model is to be used as a policy instrument, then the need to produce small forecast errors may be less important. A model's structural relationships may be more critical than its forecast error in correctly forecasting the effect of a policy change. Forecast error is important, however, inasmuch as a small error of forecast indicates that structural relationships are properly specified.

The forecasting errors for all variables in the models are judged to be satisfactorily small. This is true whether the model is considered strictly a policy instrument or whether it is considered a forecasting tool as well.

Another criterion for judging model performance is the model's ability to catch turning points. Table 5.4 presents, for each equation in the model, the number of actual turning points in the simulation period and the number properly forecasted. As the numbers indicate, every equation in the model catches well over fifty percent of its respective variable's turning points. Most of the turning points, however, are seasonal since all variables in the model are highly seasonal. Whether the model catches major cyclical turning points may be more telling. This can be checked by witnessing the plots of actual versus predicted values which appear in Figures 5.3 through 5.9. The plots bear-out that virtually every major turning point for every variable is properly anticipated by the model.

The plots are also useful for making qualitative judgements about model performance. Forecasting errors are shown to be stable throughout the simulation (i.e., they are not becoming increasingly larger), and errors are not systematic, which would indicate misspecification. All in all, the model's historical simulation performance seems to be satisfactory.

Table 5.4

Historical Simulation - Turning Points

Variable	Number of Actual Turning Points	Number of Turning Points Properly Forecasted
Total Sales	31	29
Domestic Sales	31	31
New Auto Prices	19	13
Used Auto Prices	24	18
Production	31	30
Retail Inventory	25	21
Man-Hours	30	25
Average Hourly Week	30	25
Production Workers	30	25
Factory Sales	30	28
Fixed Investment	26	22
Capital Stock	10	9

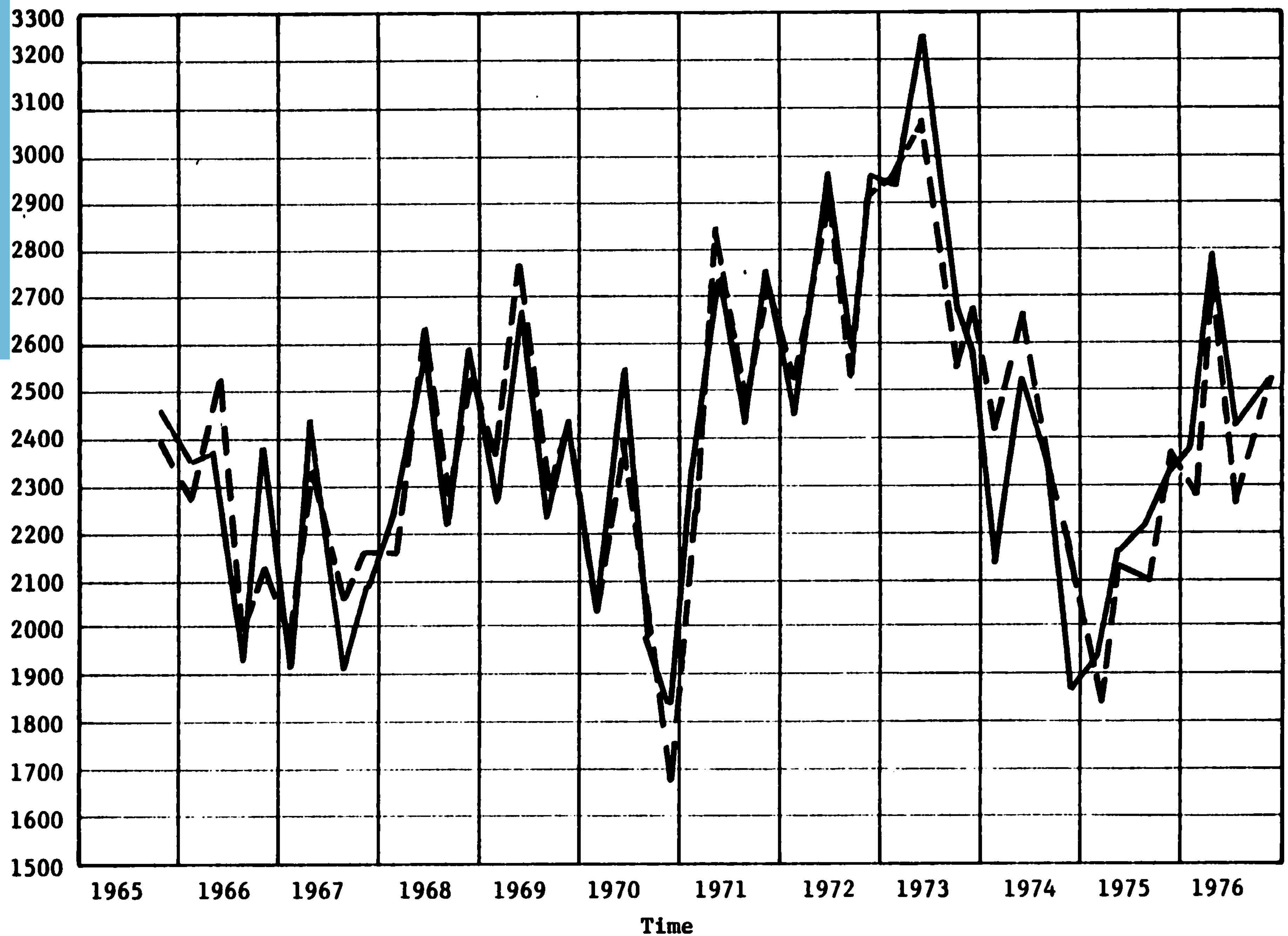

Figure 5.3. Retail Sales of New Automobiles Per Quarter

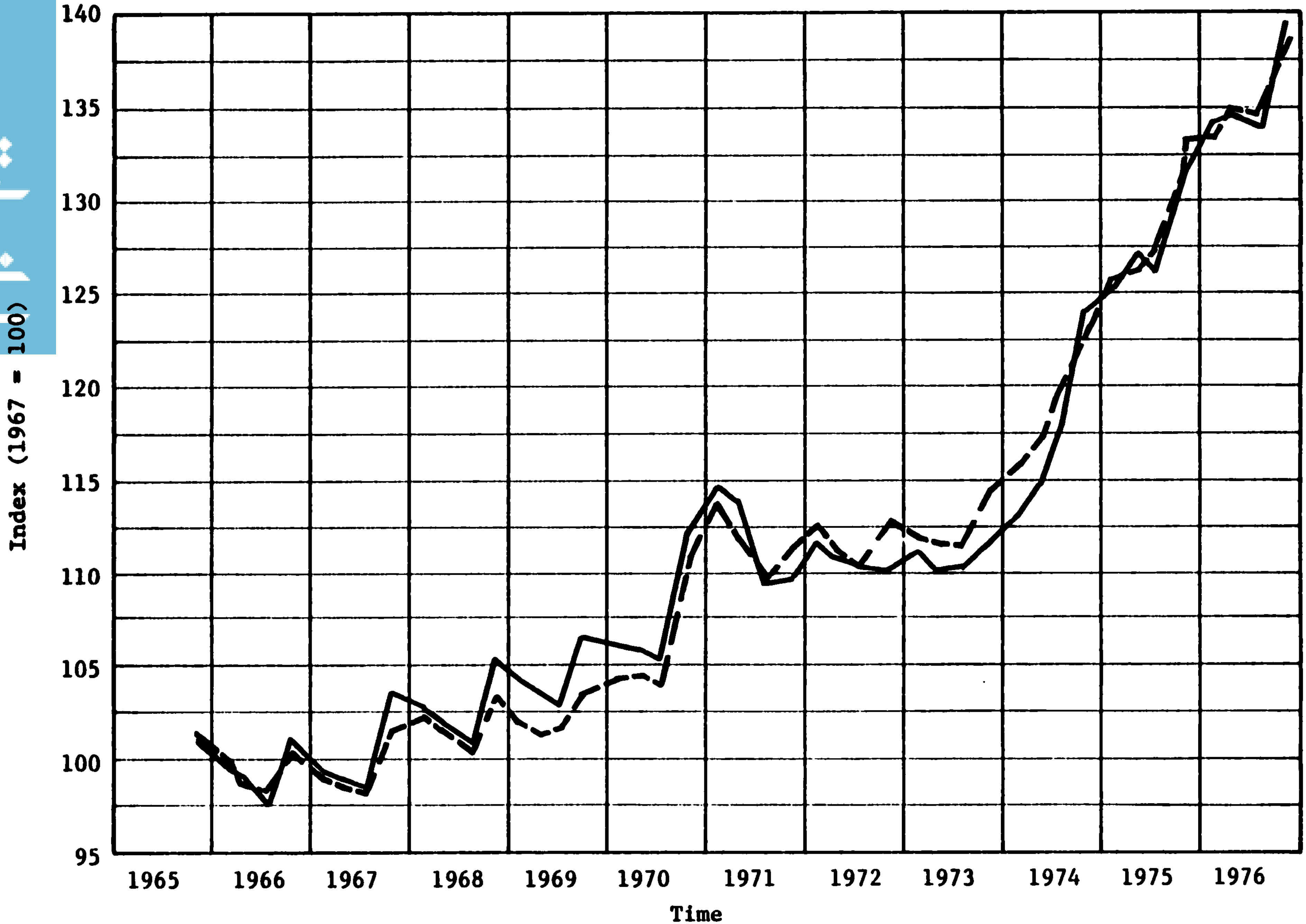

Figure 5.4. New Car Price

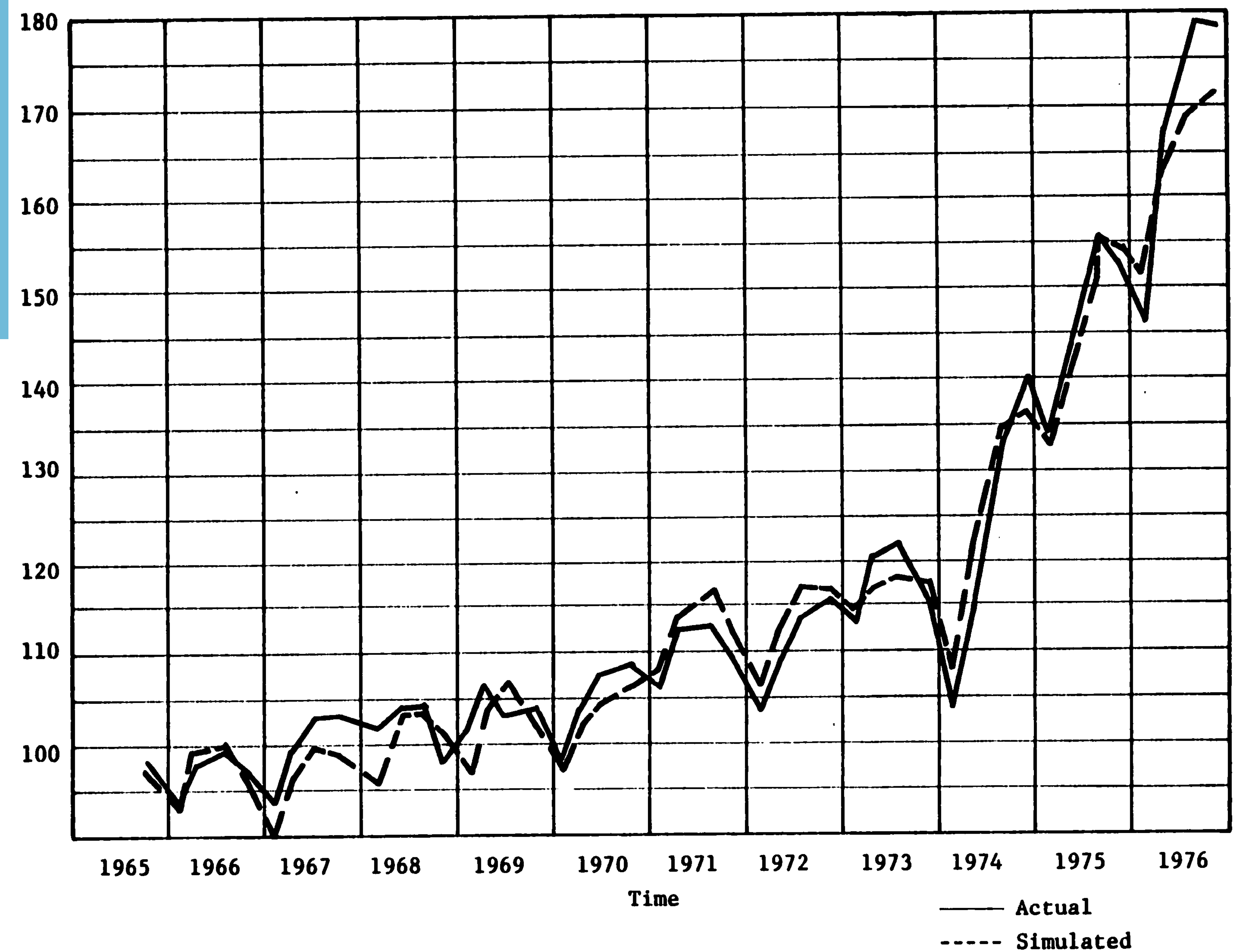

Figure 5.5. Used Car Price

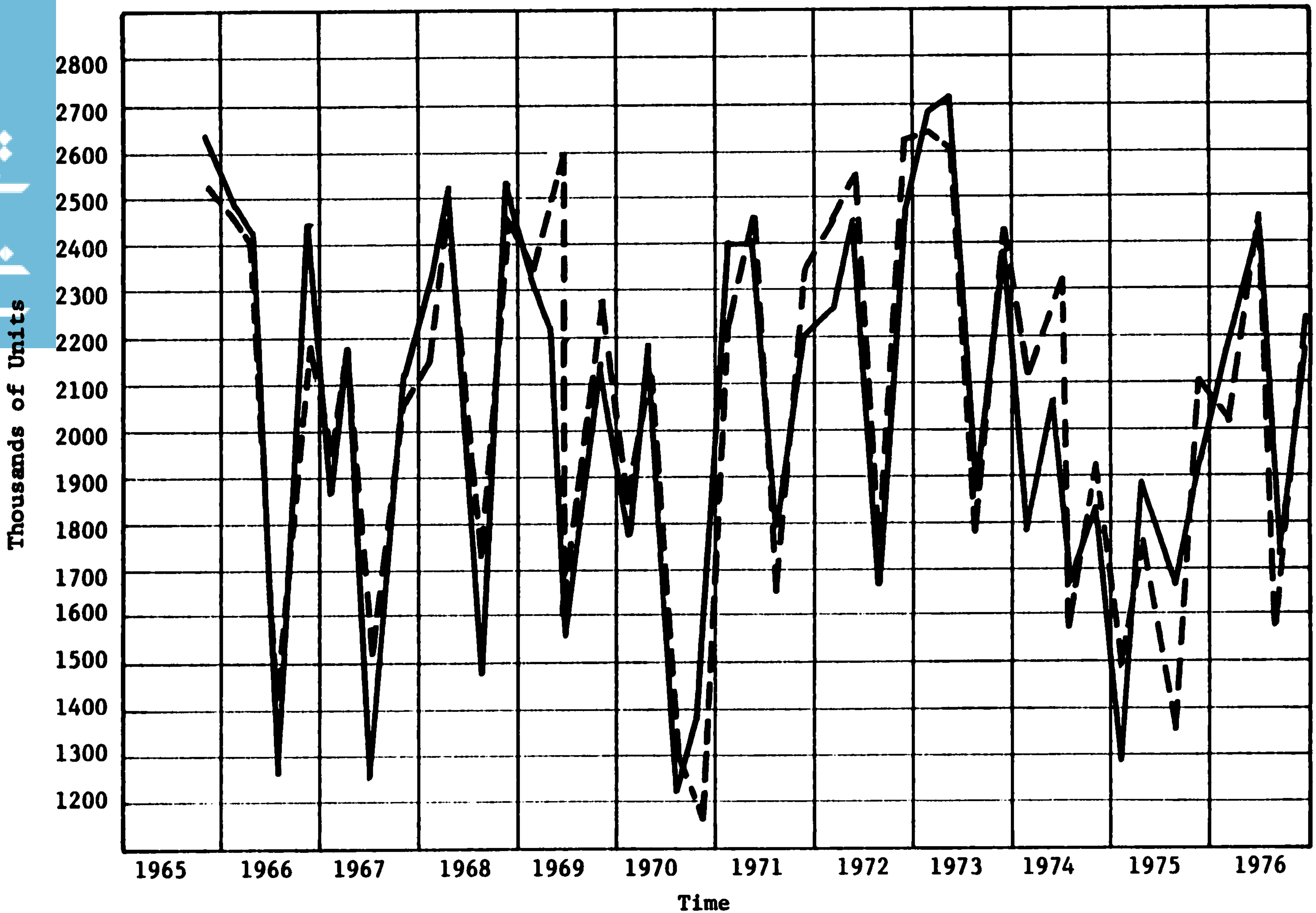

Figure 5.6. Domestic Production Per Quarter

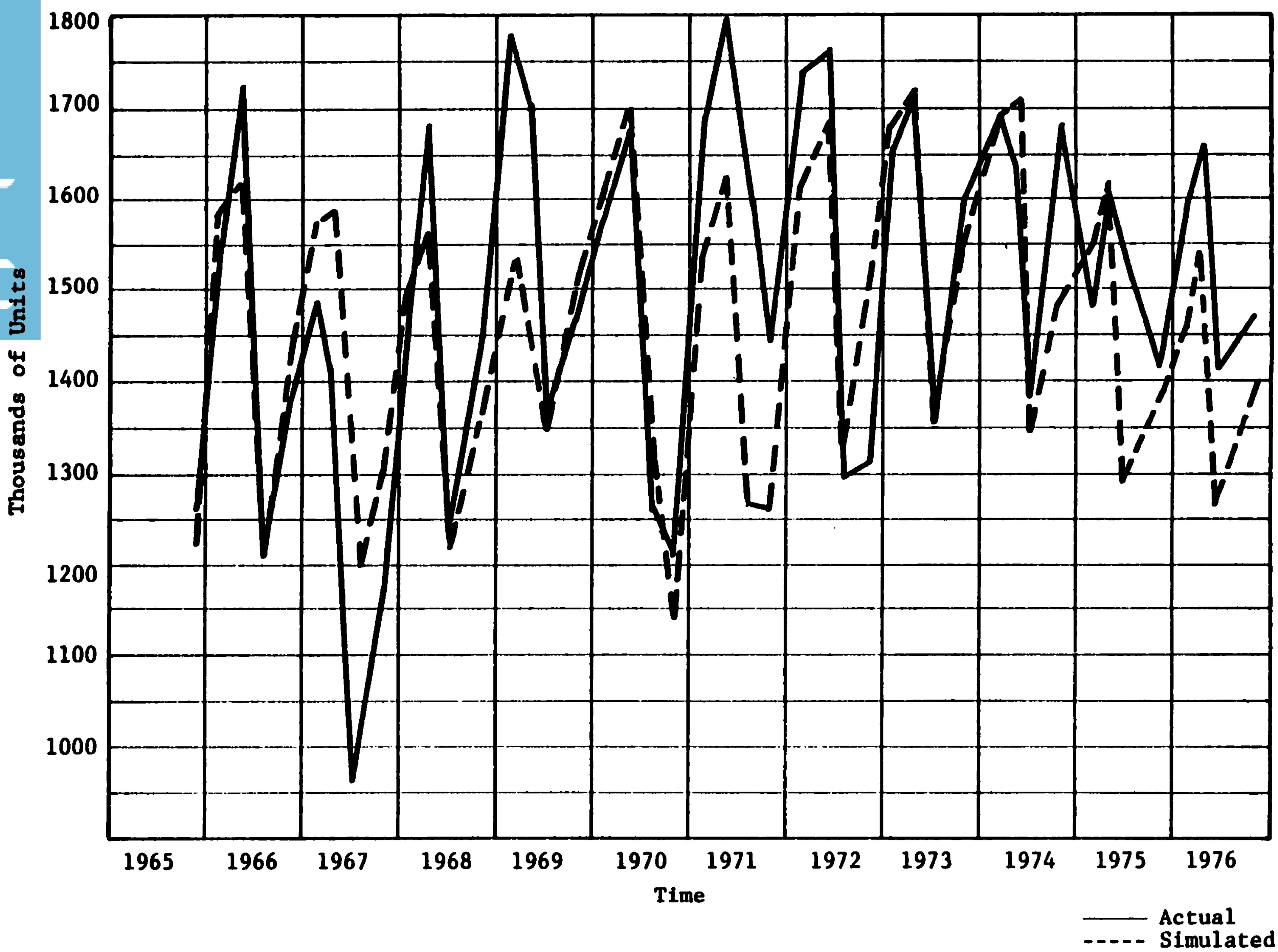

Figure 5.7. Retail Inventories of New Domestic Autos

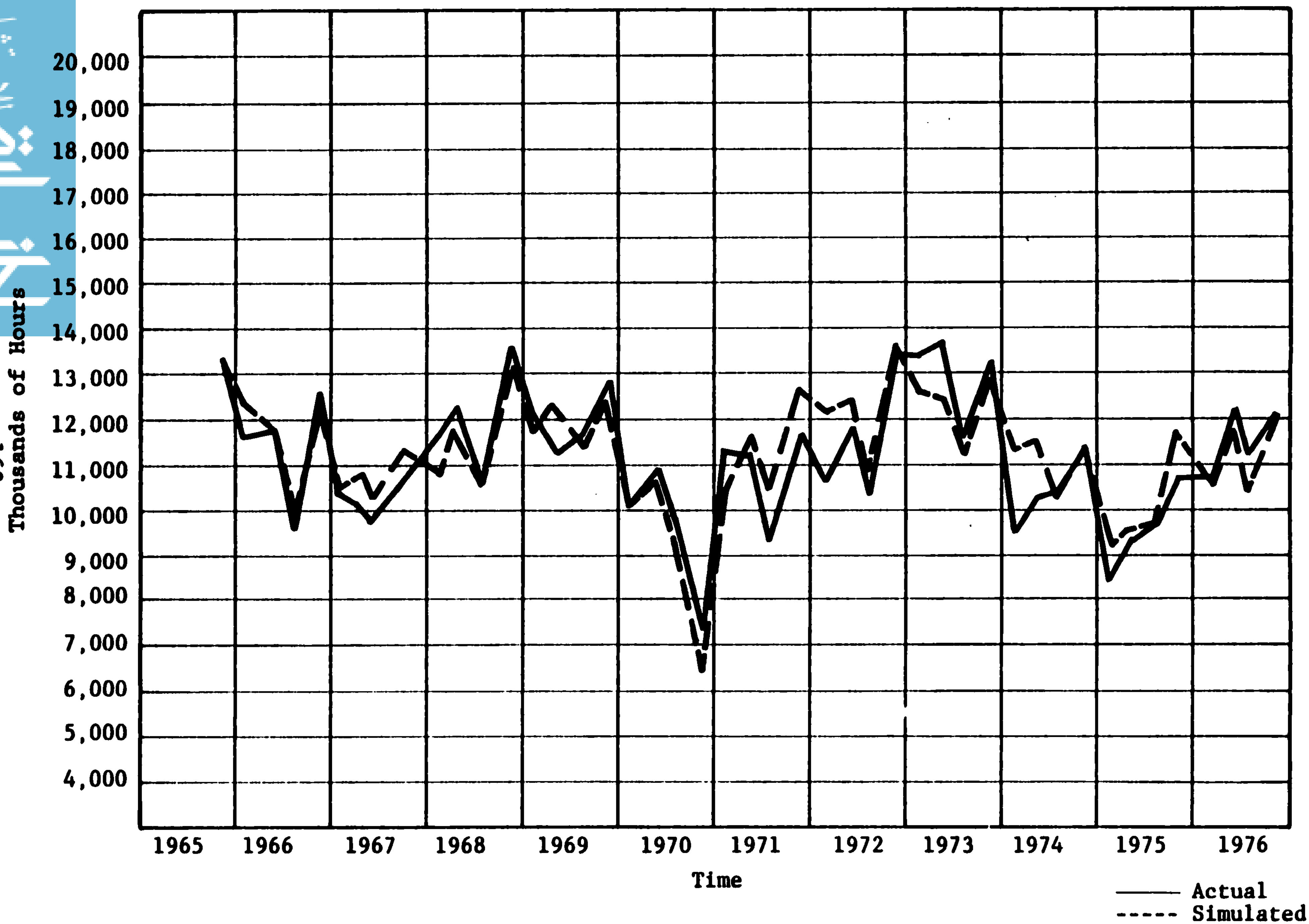

Figure 5.8. Production Labor Hours Per Quarter

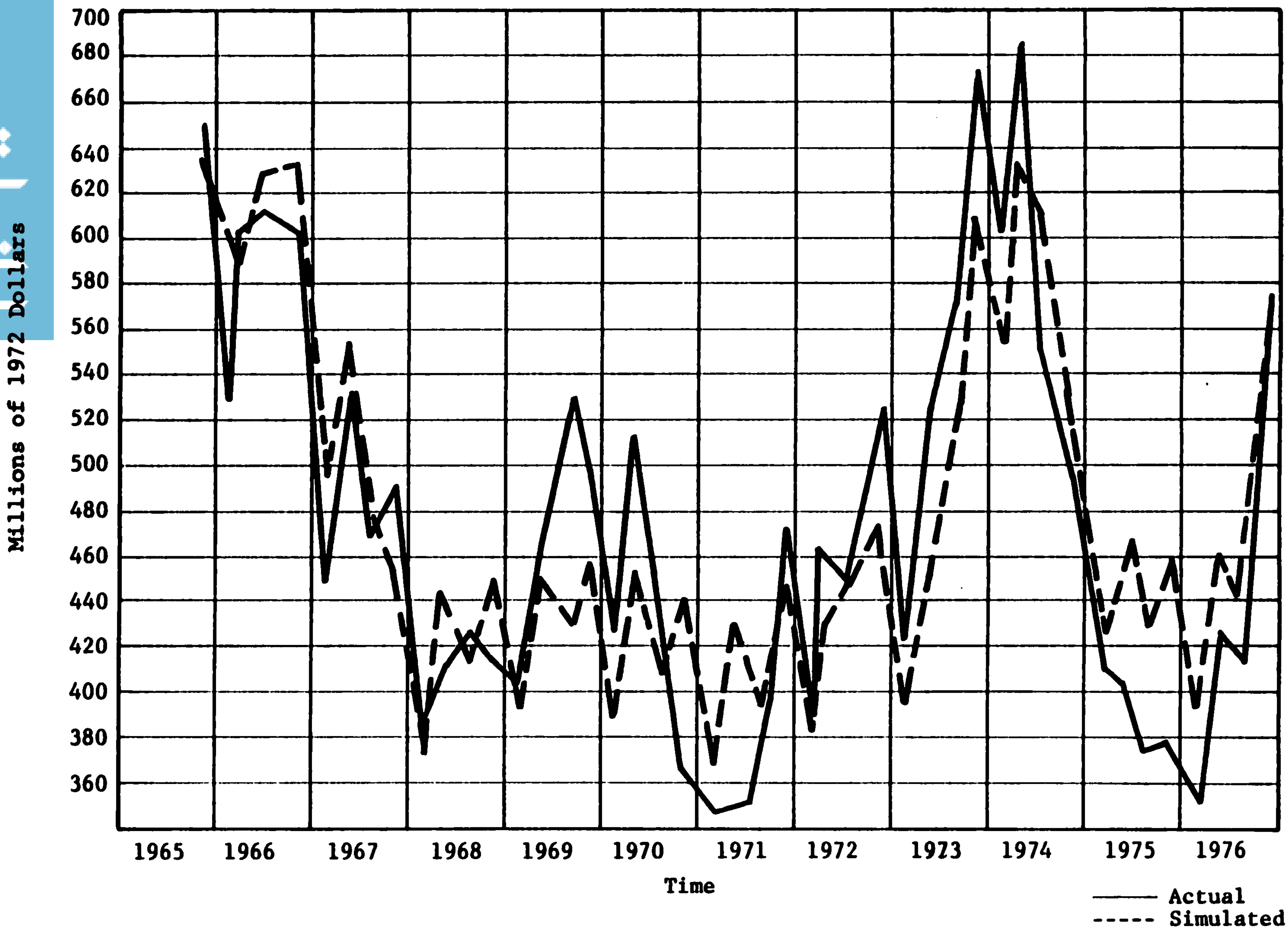

Figure 5.9. Capital Expenditures (Plant and Equipment) Per Quarter

Tuning and Adjusting the Model

The simulation results reported in Tables 5.3 and 5.4 were the best obtained in tests of some 30 to 40 variations of the model. Each variation was created by changing one or more equations — usually by re-estimating slightly different versions — in an attempt to improve simulation performance. The simulation results that have been reported were obtained by modifying the equations for: (1) fixed investment and (2) retail sales.

Investment Equation

Since investment spending is an economic activity that is notoriously difficult to model properly, we could have anticipated troubles with this equation. In the initial simulation runs of the model, the investment equation displayed instability: the combined influence of the investment equation and the capital stock equation caused predicted values of investment to become increasingly larger. A check of the roots of the investment difference equation indicated that one lay outside the unit circle* — a sign of instability.

By examining the historical time series of investment behavior, the reason for this problem became apparent: over the past fifteen years, automobile companies have on three separate occasions — first, during the period 1965-1966,

* See (Griliches, 1967) for a discussion of the stability properties of distributed lag equations.

second, 1973-1974, and, third, 1977-1978 — spent abnormally large amounts of money on fixed capital. These expenditures were not made to expand capacity; rather they were made to obtain the equipment necessary to produce new and different types of auto models. Large expenditures in 1965-1966 were made by domestic manufacturers to develop and market many new subcompact and compact models; the 1973-1974 increase in investment was made to develop and produce air-pollution-abatement equipment; and the recent upsurge in investment spending has been made to acquire the capacity to manufacture downsized, lighter, and more fuel-economical automobiles.

The model of investment spending in its strict accelerator form which explains expenditure level only by the expected need for future capacity, could not and did not explain the occurrence of these high peaks in expenditure levels in terms of capacity requirements. However, since these periods of unusually high expenditure levels were included as part of the estimation sample, they were accorded large weights in the estimation process and, therefore, biased the estimates of the true accelerator model. One way to eliminate this source of bias and yet still account for the occurrence of occasional periods of high investment spending is to denote periods of high spending in the statistical equation by dummy variables. Equation 5.10 presents the results of estimating (by maximum likelihood) a revised investment equation, one that includes a dummy variable (DUM) which takes on the value +1 during the already identified periods of high investment spending and a value of 0 otherwise.

$$
\begin{aligned}
I_t - \delta K_{t-1} = .02 &+ .54\,(I_{t-1} - \delta K_{t-2}) \\
&- .11\,(I_{t-2} - \delta K_{t-3}) + .00003\ \Delta DS_{t-3} \\
&+ .00001\ \Delta DS_{t-4} + .00001\ \Delta DS_{t-5} \qquad (5.10) \\
&+ .00004\ \Delta DS_{t-6} - .07\ D_1 + .03\ D_2 \\
&- .04\ D_3 + .09\ DUM
\end{aligned}
$$

where: $\delta = .0325$

$\bar{R}^2 = .91$

The simulation performance of Equation 5.10 is far better than that of the previous investment equation which did not include DUM. By some simple algebraic calculations, one can verify that Equation 5.10 is stable, that both roots lie within the unit circle.

It should be noted that, in forecasts with the model, DUM will take on a value of +1 until 1985 to account for the large amounts of investment dollars that automakers are expected to devote to the fuel-economizing of their fleets.

Retail Sales Equation

In Chapter 3, where the used car price equation was discussed, two alternative equations — 3.14 and 3.15 — were presented. Recall that Equation 3.15 was claimed to define the relationship between new car prices and used car prices in a more realistic manner than Equation 3.14 and was, therefore, viewed as being a more appropriate equation for simulating the effect of a change in new car prices on used car prices. Recall also that a principal difference between the two used car price equations is that "level" variables in Equation 3.14 are standardized by the number of family units and the same variables in Equation 3.15 are not. Because of this, to attain consistency, whenever Equation 3.15 is used to explain used car price determination, an alternative, unstandardized retail sales equation should be used in conjunction. Equation 5.11 is the unstandardized version of the retail sales equation:

$$D_t = \underset{(.71)}{2424.} - \underset{(-5.1)}{7350}\,\hat{P}_{N,t} + \underset{(3.3)}{5551}\,P_{N,t-4} + \underset{(2.7)}{1480}\,\hat{P}_{u,t}$$
$$+ \underset{(7.0)}{1795}\,PI_t + \underset{(5.8)}{.005}\,INC15+ - \underset{(-2.9)}{.035}\,INC25+$$
$$- \underset{(-4.0)}{105}\,STRIK - \underset{(-4.5)}{164.7}\,UE_t - \Big[\underset{(5.5)}{.52}\,S_{1,t} \qquad (5.11)$$
$$+ \underset{(5.9)}{.43}\,S_{2,t} + \underset{(4.6)}{.39}\,S_{3,t} + \underset{(6.1)}{.34}\,S_{4,t} + \underset{(5.2)}{.36}\,S_{5,t}\Big]$$
$$- \underset{(-2.6)}{118}\,D_1 + \underset{(4.1)}{198}\,D_2 - \underset{(-3.9)}{236}\,D_3$$

$\bar{R}^2 = .93$ D.W. = 1.98

SEE = 104 F(16,34) = 33

where: D = retail sales of new automobiles (thousands of units)

PI = permanent income (millions of 1967 dollars)

INC15+ = number of family units earning more than \$15,000 in constant 1976 dollars (thousands of units)

INC25+ = number of family units earning more than \$25,000 in constant 1976 dollars (thousands of units)

S_i = stock of i year old automobiles (thousands of units)

All other variables as previously defined.

The price and income elasticities calculated from Equation 5.11 are similar to those presented in Chapter 2; therefore, substituting this equation for the previously presented retail sales equation does not significantly alter any of the observations and conclusions that were made in Chapter 2. The simulation performance of the overall model is the same whether the standardized retail sales and used car price equations are used or the unstandardized versions of these equations. It is believed, however, that the unstandardized version (which will henceforth be referred to as Model #2), will provide more realistic forecasts of the affect of price increases than will the standardized version (Model #1).*

Ex-Post Simulation

An ex-post simulation of the model was run starting with the first quarter of 1977 and ending with the last quarter.** The performance of the model in this test should serve as a check on whether the model can accurately forecast outside of its estimation period. The results of this experiment, as measured by the RMSPE and AAPE for each endogenous variable in the model, are presented in Table 5.5.†

* Note that Model #2 is estimated by two-stage least squares; Zellner estimation has not been applied to this version of the model.

** At the time the simulation was run, the fourth quarter of 1977 was the latest period for which a complete set of data was available.

† The results presented describe the accuracy of forecasts made with Model #2; however, forecasts made with Model #1 yielded identical results.

As can be seen by comparing the statistics shown in Table 5.5 with those in Table 5.3, the model performs roughly the same in ex-post forecasts as it does in historical simulations. This is a significant and encouraging result since the RMSPE's and AAPE's of the ex-post forecasts are better estimates of the model's ability to forecast than are the statistics of historical simulations. This result indicates that the model performed almost as well during this short excursion outside its estimation range as it did, on the average, throughout its entire estimation period; it suggests that RMSPE's and AAPE's of similar magnitude may be expected for ex-ante forecasts of the same duration.

Once again, however, a word of caution: because of Government's and automakers' efforts to improve the average fuel economy of new automobiles, major changes in the physical characteristics of automobiles and perhaps in the characteristics of automobile demand may occur during the next five to ten years. Such changes would undoubtedly affect the accuracy of the model's forecasts. Admittedly, simulating the 1977 auto market was a good test of the model, since many new downsized models were introduced during 1977 and the concomitant macro effects described in the market data seemed to indicate consumer acceptance of downsized models and little departure of the market from its historical pattern. However, because of the high degree of uncertainty surrounding the future of the auto market, an ample amount of skepticism should be maintained regarding the model's forecasting accuracy.

Table 5.5

Ex-Post Simulation Performance

Variable	RMSPE	AAPE
Retail Sales	6.3	5.4
New Car Prices	1.6	1.2
Used Car Prices	3.6	3.2
Production	12.6	11.9
Retail Inventory	12.2	10.0
Man-Hours	5.7	4.8
Average Hourly Week	8.9	8.2
Production Workers	6.4	6.0
Factory Sales	12.2	10.8
Fixed Investment	8.6	7.8
Capital Stock	0.9	0.7

SUMMARY

Since all models are only approximations of the real world phenomena which they describe, before a model is used to forecast, its approximations should be understood. This chapter has presented tests and evaluations that aid in understanding: the accuracy of the model's simulations and forecasts has been measured; the shortcomings and limitations of the model have been identified; and the uncertainties inherent to forecasting have been noted. This background will enable us to use better judgement in making and in evaluating model forecasts.

CHAPTER 6

REGULATION OF AUTOMOBILE NOISE EMISSIONS – A CASE STUDY

INTRODUCTION

Since the focus of the model is on the structure and dynamics of the relationship between new car prices and new car sales, it can best be used to simulate the effects of policies that involve or can be translated into changes in price. These may be policies such as Government regulations placed on new automobiles (e.g., environmental or safety standards), excise taxes, labor union policies, raw material price increases, or process energy price increases. The model can be used for two different types of policy simulations: (1) ex-post and (2) ex-ante. Ex-post policy simulations involve simulating the effects of policies that could have occurred in the past, but did not. These types of simulations answer the question, "What would have happened if such and such were the conditions?" They are basically exercises in learning about and understanding the real world system. Ex-ante policy simulations are actual forecasts. The model is used to project the effects of a certain policy change by generating two forecasts: (1) a baseline forecast and (2) a revised, or policy, forecast. The baseline case is the most likely forecast, a projection of the system without the proposed policy. Baseline projections are usually conservative because great changes in exogenous variables are rarely considered "most likely".

The policy forecast is made by introducing a change in the model parameters that represent the exogenous effect of the policy. All other parameters and conditions are kept the same as in the baseline forecast. The model is then run under these revised conditions to generate the policy projection. The effect of the policy change is determined by finding the difference between the policy forecast and the baseline forecast.

ABATEMENT OF AUTOMOBILE NOISE EMISSIONS

Background

Automobiles and the automobile industry are rapidly changing, chiefly as a result of Government regulations. During the past five years, the Government has mandated that new automobiles meet specified standards of safety, fuel economy, and air emissions. As previously mentioned, these regulations have had a tremendous impact on auto companies, one that can be measured by their increased cost of operations and their decreased profitability. They have also affected consumers who must pay for at least a part of manufacturers' increased costs; supplier industries whose level of productive activity depends largely on demand for new automobiles; and laborers whose jobs depend on the level of auto output.

A new Governmental regulation which has been enacted but which has not yet been enforced calls for a limit to be placed on the level of noise emitted by new automobiles. The history of this regulation begins with the Noise Control Act of 1972* in which Congress declared "that it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare."** To this end, Congress stated, the Act is "to establish a means for effective coordination of Federal research and activities in noise control and to authorize the establishment of Federal noise emission standards for products distributed in commerce..."† The Environmental Protection Agency (EPA) "shall, after consultation with appropriate Federal agencies, compile and publish a report or series of reports... identifying products which in EPA's judgement are major sources of noise."†† The Act also requires that EPA publish proposed regulations for each product that is identified as a major source of noise.

EPA has not yet publicly identified passenger autos as major sources of environmental noise; however, they plan to do so within the next two or three years. At that time, EPA will publish a regulatory statement which will establish a standard or an acceptable level of automobile noise and will

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* 86 Stat. 1234.

** Section 1, Art. 1, 1972.

† Section 2.

†† Section 5.

detail an incentive system designed to encourage automaker's compliance with the standard. The incentive system may take the form of a penalty system which would levy fees on automakers who fail to comply; for example, if the Government finds that all Chevy Chevettes produced in 1983 are too noisy, GM may have to pay a fine for every Chevette produced or, alternatively, they may be forced to recall all models and change some parts to make the cars quieter. The exact form of the incentive system and its enforcement has not yet been made public.

Answering the Policy Question

Before the Government enforces noise standards for automobiles, they must, in the interest of the economy and the country, determine the undesirable side effects that may result from the regulation. If the cost of the regulation to any specific group is too great, EPA may decide to compromise the stringency of their standards or to cancel the proposed program altogether. To make such decisions, the Government sponsors research programs aimed at estimating the impact of proposed regulations on the economy and on specific economic groups such as (in this case) auto companies, consumers, supplier industries, and labor groups.

The research program designed by EPA to estimate the major impacts of controlling automobile noise emissions consists of a number of tasks such as those listed below.*

* The information in this chapter is based on the experiences of the author in participating in a research contract funded by EPA. While a majority of the information is totally accurate, much has been omitted or suitably massaged to protect EPA's proprietary rights. References to source documents are omitted for the same reason.

1. Determine how automobiles can be quieted cost-effectively; what physical changes are required and how they will affect the functioning of other parts of the auto.

2. Determine which types of automobiles need to be quieted to meet a certain noise standard.

3. Estimate the cost of manufacturing noise control components for autos, the cost of any additional changes in the auto that need to be made to accommodate the noise components, and the costs of installation.

4. Estimate the magnitude of price increases that will occur as a result of manufacturing cost increases and determine how the automaker will allocate these costs across his model lines.

5. Estimate consumer's response to possible increases in the price of new cars.

6. Estimate the effect of possible decreases in the sales of new autos on the auto industry, its resource requirements, and related industries.

7. Estimate the overall economic effect of the regulation on the economy.

In the remainder of this chapter, we will trace through each of these steps. Although the focus of this case study will be on use of the econometric model, the results of all of the work tasks listed above will be dealt with at least briefly.

Quieting Automobiles

There are two major sources of automobile noise – the engine while in operation and the friction of tires and pavement – but this study deals specifically with the problem of quieting engine noise. Automotive engineers and noise experts have determined (by measuring the ambient noise level of unmodified cars, by making various noise-reducing modifications, and then by measuring the resulting reduction in ambient noise level),that the noise emitted from an auto engine can be reduced by muffling engine exhaust and by enclosing the exposed areas of the engine. They have found that by equipping cars with larger mufflers and with under-side engine enclosures or "belly pans" that the level of ambient noise is reduced considerably.

One problem they have found is that, when the engine compartment of a car is enclosed, because of reduced heat loss through convection while the car is idling, and restricted air flow while the car is in motion, the ambient temperature of the engine compartment becomes too high. To alleviate this problem, automotive engineers have determined that larger radiators and higher capacity fans would also be needed on those cars that require enclosed engine compartments.

Thus, one way that has been found to reduce the engine noise of a car and yet not affect its performance otherwise is to install a better muffler, a belly pan, a larger radiator, and a higher capacity fan. This is one way, but not the only way and, perhaps, not even the best way. However, for the purposes of this study, we will assume that automakers will choose to meet Government noise standards by making similar modifications to the cars that they produce.

Autos Requiring Noise Reduction

Using a noise-measuring device to record the level of noise emitted by various types of automobiles at different speeds and rates of acceleration, it has been found that the level of noise emitted by an auto depends chiefly upon the size and type of its engine. The smaller the engine, other things remaining equal, the noisier it is likely to be; four cylinder engines are noisier than six cylinder engines which are noisier than eight cylinder engines. Studies have also shown that diesel engines are much noisier than the more common spark ignition engines; an eight-cylinder diesel generates more noise than a four-cylinder spark ignition.

The noise regulation currently proposed by EPA would require that only the major offenders — diesel-engined and four-cylinder autos — be quieted; conventional six- and eight-cylinder vehicles would meet the proposed standard without modification. Thus, to comply with noise-level regulation, automakers would be required to equip only their diesel and four-cylinder models with the noise-abating hardware described above.

Costs of Modification

Cost engineering studies were conducted to determine the per-vehicle cost of manufacturing the specified noise control components. With detailed specifications of the size, shape, and material of the components, a research team with experience in the manufacture of automotive components has been able to estimate the: (1) direct labor, (2) direct materials, (3) overhead expense, (4) general and administrative expense, (5) research and development expense,

(6) tooling expense, and (7) expenditures on plant and equipment that would be required to manufacture these components. While we will not go into the details of these cost estimates, a summary table is provided below.

Cost Estimates – Summary

Manufacturing Cost Per Vehicle (Direct and Indirect)	$120.
Investment in Plant and Equipment (Amortized per vehicle)	2.
Total Modification Cost Per Vehicle	$122.

These, it should be observed, are average figures; the cost of noise control modifications would vary somewhat by vehicle according to the area that the engine enclosure would need to cover, the size of the muffler that would be required, etc. However, the between-vehicle difference in modification costs are slight and are, therefore, of minor importance.

We should also note that these cost estimates are based on an assumed production volume of economic proportions, one which could easily be achieved by any of the major auto manufacturers. The estimates are pessimistic in that possible learning curve effects which would tend to decrease manufacturing costs over time have not been considered in their derivation. We shall not attempt to correct for possible efficiencies realized through learning because doing so may, in fact, be somewhat presumptuous and, for the sake of conservatism, we would rather over-estimate than underestimate the costs of the regulation.

Note also that we are implicitly assuming that automakers will manufacture the required noise hardware themselves rather than purchase it from independent suppliers. This will undoubtedly be true of GM and Ford, who manufacture most of the parts that go into their autos themselves, but, perhaps, not true of Chrysler, AMC, and many of the foreign manufacturers who contract for much of their parts manufacturing. The upshot is that GM and Ford may be able to equip their cars with noise components for a lower cost than the other manufacturers* and will, thus, be able to obtain a slight competitive cost advantage. This, however, will have little effect on the validity of our cost estimates since historically private industry, especially the auto industry, has been able to meet Government regulations for much less than the Government initially expects. We know that our cost estimates are much higher than the actual costs to auto manufacturers will be.

Translating Modification Costs Into Price Increases

Using economic theory as a guide, one might try to predict the amount by which market price would increase as a result of an increase in manufacturing cost by a comparative static analysis in which the marginal cost curve of the oligopolist is shown to increase, the oligopolist is shown to produce a new output volume given by the volume at which

* Foreign manufacturers will be paying for cheaper labor hours, however, so they may be able to obtain these parts for less than GM and Ford can, regardless of whether they manufacture them in-house.

marginal cost and marginal revenue intersect, and the oligopolist then charges a new market price which is given by the point on the demand curve corresponding to the new production volume. Theoretically, nothing may be wrong with such an analysis, but practically, it is fraught with well known difficulties.

A more practical approach will be used here, one that requires that we take the following steps:

1. Collect historical information regarding automakers' pricing policies.
2. Use this information to construct a "normal" pricing rule relating cost to price.
3. Input the expected increase in cost to the pricing formula to determine an expected increase in normal price.

A presentation of historical information regarding automakers' pricing procedures can be found in Appendix D. This information tells a fairly consistent story of how automakers set their prices. We know, for instance, that normally the price of each model is set at the sum of direct cost per unit, an allocation of indirect costs (representing the proper absorption of burden at standard volume), and a profit margin determined by the target return on capital. (Here "target return" refers to a long-range target return.) We also know that the prices of models are adjusted in accordance with the prices of competing models and that manufacturers may try to balance out such adjustments across model lines by matching competitively motivated decreases in the price of a slow-selling model with increases in the price of a fast-selling model or one for which demand is less sensitive to price. Profits on "stripped" models may be sacrificed only to be recouped on "loaded" models.

In essence, we have found that the normal pricing rule is standard-volume, cost-plus-target return pricing. A formula that approximates this pricing rule is given by:

$$P_N = (1 + DM) * (GR * CI + FC) \tag{6.1}$$

where: P_N = average normal retail price
DM = average dealers margin
GR = the gross rate of return on capital investment
CI = capital investment per produced unit
FC = full cost per unit (direct labor and material costs plus allocated indirect costs and fixed expenses, all per unit)

By writing this formula in differenced form as:

$$\Delta P_N = (1 + DM)\ (GR * \Delta CI + \Delta FC) \tag{6.2}$$

the relationship between changes in costs and capital and changes in retail prices is seen; for any ΔCI and ΔFC, a ΔP_N can be predicted.

Since the cost increase that we are concerned with will affect only some of the models which are sold, we need to correct for this by weighting ΔP_N as follows:

$$\Delta P = W_N * \Delta P'_N \tag{6.3}$$

where: W_N = the fraction of new cars requiring noise abatement devices
P'_N = the normal average price of cars that require noise reduction
P = the normal average retail price of all new domestic autos

In this way, the average price increase for all new automobiles can be estimated.

To use Equations 6.2 and 6.3, we need estimates of: (1) GR, the industry's gross rate of return on capital investment, (2) DM, dealers' average mark-ups over wholesale price, and (3) W_N, the fraction of the total number of cars that will require noise reduction.

Gross Rate of Return on Capital

Table 6.1 shows the percent earned on total capital for each of the four domestic automakers for the years 1968-1977. These figures are for after-tax return on capital; to get the gross rate of return on capital, divide by one minus the tax rate, which is 48 percent. The figures show that return on capital varies considerably for all manufacturers: in the low demand years of 1970, 1974, and 1975, manufacturers' returns are also low; similarly, in years when demand was high, economic return is shown to be high.

To estimate manufacturers' desired returns on capital, one may take an average of the historical rates of return that were achieved during high years. The following figures may approximate the four manufacturers' desired gross rates of return:

GM	30%
Ford	23%
Chrysler	15%
AMC	12%

Thus, the sales-weighted average for the industry* is a desired gross rate of return of about 25 percent.

* Foreign manufacturers are assumed to desire a return of 23 percent, similar to Ford. This is factored into the weighted average.

Table 6.1

Percent Earned on Total Capital (After Taxes)

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
American Motors	1.7	2.5	-	2.7	6.1	11.4	6.6	-	-	2.5
Chrysler	11.7	3.9	5.0	3.5	7.6	7.7	-	-	9.6	6.0
Ford	12.0	10.2	9.0	10.7	13.0	12.8	5.3	3.7	12.3	18.0
General Motors	17.4	16.7	6.2	17.3	17.7	18.4	7.4	9.2	19.2	20.0

Source: Value Line, 1978.

Dealers' Mark-Ups Over Wholesale Price

White (1972) estimated that manufacturers set dealer margins at 26 percent of list price (minus excise tax and dealer preparation charge) for luxury cars, 22 percent for full size cars, 19 percent for intermediates and compacts, and 17 percent for subcompacts. He made no estimates of dealers' mark-ups over wholesale price. The only such estimate to be found in the literature was made by the U.S. Department of Transportation.* They estimated that the average mark-up of retail price over wholesale price is about 18 percent. Although they did not indicate how this estimate was derived, it seems reasonable.

Fraction of Cars Requiring Noise Reduction

In the same Department of Transportation study, projections of future product mix were made. Cars were classified according to engine type (e.g., four-, six-, or eight-cylinder or diesel) and, thus, the fraction of diesel-engined and four-cylinder models can be taken from these projections. The projections estimated that diesel-engined and four-cylinder cars (i.e., noise-controlled cars) will constitute 66 percent of the product mix by 1985. They will gradually increase in popularity from their current 25 percent share of the market at the rate of about five percent per year. Hence, the fraction

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* (USDOT, 1977), Document 1.

of cars that will require noise reduction will grow each year.*

Increases in Retail Price Resulting from the Costs of Automotive Noise Reduction

Using these available data and Equations 6.2 and 6.3, price increases can be calculated. The pricing formula may be written with $\Delta P'_N$ as the left-hand-side variable:

$$\Delta P'_N = (1 + DM)\ (GR * \Delta CI_N + \Delta FC_N)$$

where: $\Delta P'_N$ = change in the average retail price of those models that require noise control devices

ΔCI_N = change in the capital investment required to produce the average noise-controlled car

ΔFC_N = change in the full costs of manufacturing the average noise-controlled car

Let: $DM = .18$

$GR = .25$

$\Delta CI_N = 2$

$\Delta FC_N = 120$

Under this set of conditions, $\Delta P'_N$ is estimated to be about \$142. In other words, the "normal" price of diesel-engined and four-cylinder cars will increase by \$142.

Now, assume that the future market share of diesel-engined and four-cylinder cars is as given below.

* This projection is discussed in further detail in Appendix E. Notice that we are assuming that the introduction of noise control costs will not affect the validity of these projections; this issue is also addressed in Appendix E.

Year	Market Share of Noise-Controlled Cars (W_N)
1978	30
1979	35
1980	40
1981	45
1982	50
1983	55
1984	60
1985	66
1985+	66

Using Equation 6.3,

$$\Delta P = W_N * P'_N$$

we find that, if noise regulations are introduced in 1980, the average price of new automobiles will be changed as follows:

Year	Increase in the Average Price of New Autos (ΔP) (Constant 1977 Dollars)	Cumulative Increase (Constant 1977 Dollars)
1980	56.80	56.80
1981	7.10	63.90
1982	7.10	71.00
1983	7.10	78.10
1984	7.10	85.20
1985	8.52	93.72
1985+	0/year	93.72

Recall that these estimates represent the amounts by which the average price of all new automobiles will increase. This average price increase may be a result of an increase in the prices of all models that require noise reduction modification but it need not be. As previously mentioned, auto manufacturers may decide to distribute the cost of noise control modifications across the prices of a variety of models, some of which may not require noise reduction components. The issue of how manufacturers will distribute noise control costs across model prices is discussed in detail in Appendix E.

Translating Dollar Price Changes Into Index Price Changes

The next step is to take these dollar changes in new car price and convert them to changes in the consumer price index for new cars. This must be done because the consumer price index for new cars is the price variable used in the econometric model's demand equation.

On the average, new autos in 1977 retailed for about $5,000. The consumer price index for new cars in 1977 was 143 (1967=100). Changes in average dollar prices can be translated to changes in the CPI on a percentage change basis, i.e., by assuming that a certain percentage change in dollar price will correspond to a similar percentage change in CPI. Thus, for every one dollar change in average retail price (measured in 1978 dollars), the CPI changes by .0286.

CONSUMERS' RESPONSES TO PRICE INCREASES RESULTING FROM NOISE REGULATIONS

Car buyers' responses to these price increases can be estimated by:

1. Generating a baseline or most likely forecast which does not include the price increases

2. Generating a revised, policy forecast which includes the price increases
3. Finding the difference between the two forecasts – this difference being the estimated effect of the price increases

The Baseline Forecast

The ex-ante baseline forecast is a simulation of the model forward in time, from first quarter 1978 to fourth quarter 1986. To run ex-ante forecasts, several steps must be taken.

First, the parameters of all equations in the model must be re-estimated, this time including all available observations in the sample period. The parameters had previously been estimated using data from 1963 through 1976 to generate historical and ex-post forecasts. The accuracy of ex-ante forecasts can be improved by making full use of the latest information, i.e., by including 1977 data in the estimation sample. Since 1977 was a volatile year for the automobile market – new and used auto prices both increased sharply – adding 1977 data to the estimation period should improve forecasts. Including these more recent observations in the estimation will decrease the variance of the forecasting error and, beyond that, add to the "experience" of the model.

Second, a time horizon for forecasting (e.g., one year, five years, or ten years in the future), must be identified. Actually, the appropriate forecasting horizon for a model is identified even before it is constructed; forecasting models should be tailored to fulfill forecasting requirements – not the other way around. Even though our model is most suitable for short-to-intermediate term forecasting (perhaps ideally for four to five year forecasts),* it will be used here to forecast nine years forward in time. Projections beyond the five-year limit should be viewed with an appropriately large measure of skepticism.

Third, since ex-ante forecasts are conditional upon exogenous input assumptions, a set of input assumptions, or a scenario, must be selected. The exogenous variables in the model include permanent income, the consumer price index, the wholesale price index, the unemployment rate, the number of family units, production worker's hourly wage, domestic market share, the index of consumer sentiment, and labor union strikes. Future values for each of these variables must be assumed and supplied to the model as input.

Because the future values of exogenous variables are uncertain, it is wise to construct more than one scenario and to generate a forecast from the set of input assumptions contained in each. In this way, a forecasting band is generated whose limits are defined by the two most extreme projections. Table 6.2 shows the assumptions contained in three scenarios that have been designed for this purpose. Scenario 1 consists of input assumptions that will result in a high projection of new automobile sales; scenario 3, a low projection; and,

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* The variance of the forecast error is greater, the longer the forecast is. We are suggesting here that, after five years, the variance of the model's forecast error may be unacceptably large.

scenario 2, a projection of new automobile sales that will lie between those produced under scenarios 1 and 3. Since scenario 2 is the least extreme of the three, it will be used as the baseline case.

Table 6.2

Forecasting Scenarios 1978-1986

Exogenous Variable	1	2	3
	Annual Growth Rates (percent)*		
Consumer Price Index	8	8.5	8.5
Disposable Personal Income (Current Dollars)	11	10	9
Wholesale Price Index	7	7.5	8
Production Worker's Hourly Wage (Nominal)	8	10	11
		Constants**	
Unemployment Rate	5.5	6	6.5
Domestic Market Share	.8	.8	.8
Consumer Sentiment	80	80	80

* The number of family units grows at a decreasing rate, growing 1978-79 at a rate of 1.17 percent and 1985-86 at a rate of 1.13 percent.

** Labor union strikes occur in all three scenarios at 1979, Q4; 1982, Q4; and 1985, Q4.

With these three sets of input assumptions and with updated estimates of the model's parameters, the model was used to generate three forecasts. The resulting projections of total auto sales are plotted on a yearly basis along with the historical levels of yearly auto sales in Figure 6.1. The projections are presented in this way to allow for a proper historical interpretation.

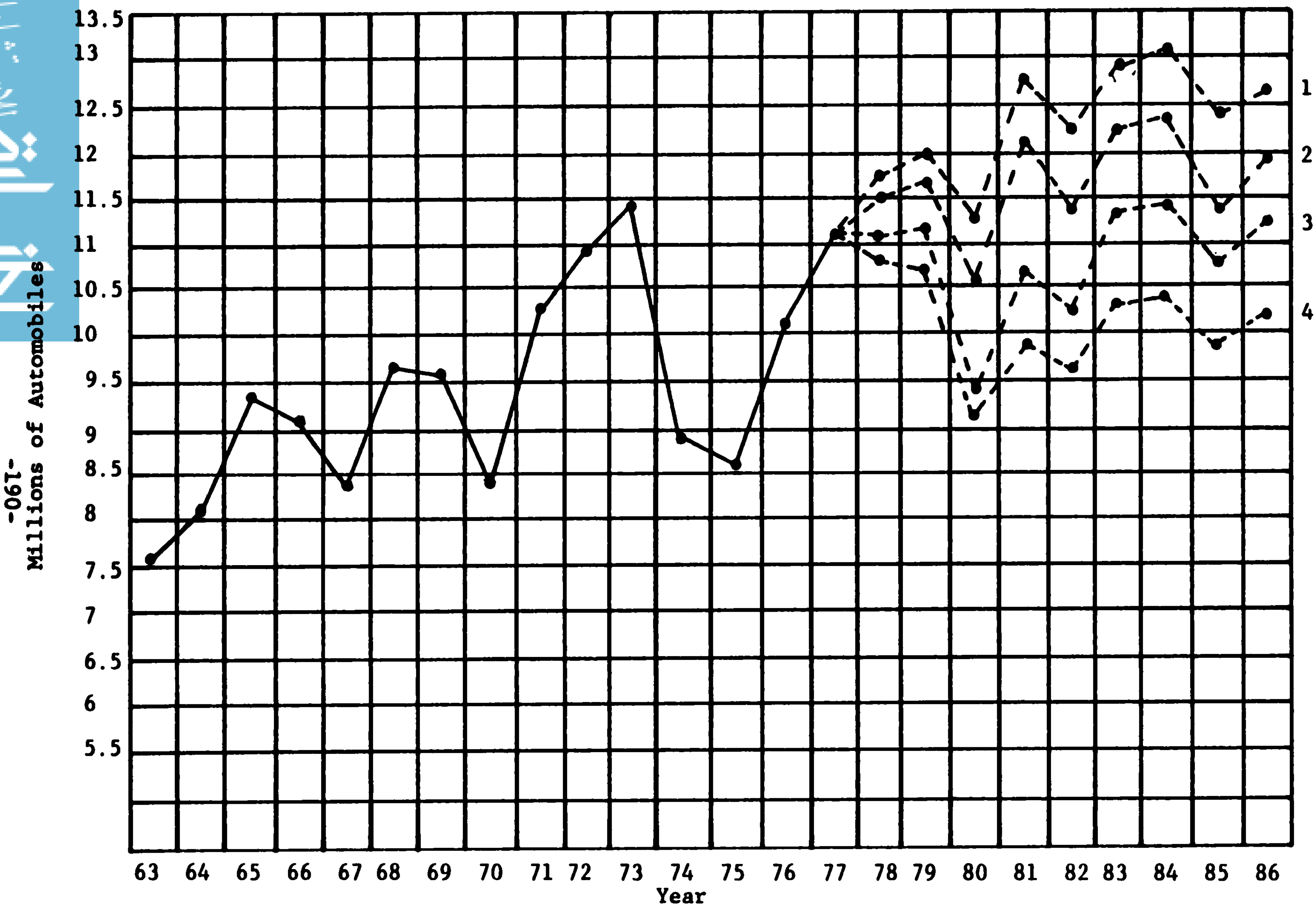

Figure 6.1. Projections of Yearly Auto Sales 1978-86

Reviewing the plot, we notice that all three forecasts are fairly optimistic, i.e., even the lowest forecast predicts that the level of auto sales will not fall to the recent historical lows of 1974 and 1975. The optimism of the projections may be attributed to the optimism of the input assumptions which include in all three scenarios, for example, the assumption that the national unemployment rate will remain constant at six percent. The input assumptions are optimistic in this instance and in other instances because, without the guidance of national economic projections from a model such as Wharton, Data Resources, or Chase, it is difficult to formulate consistent macro-economic scenarios, especially when it comes to variables such as the unemployment rate. The safest assumption to make for these types of variables is that they will remain at their most recent levels, but, by making this assumption, the resulting projections are somewhat inflexible. To hedge on the possibility that the three scenarios are consistently overly optimistic because of this, a fourth projection has been plotted in Figure 6.1 which should adequately cover the most abysmal of all possible scenarios.

The three forecasts generated by the model show a similar pattern: peaks in sales occur in 1979, 1981, and 1984; low points occur in 1980, 1982, and 1985. Notice that historically this has generally been the case – a peak is followed by a trough. This occurs, you may recall, because of the stock adjustment effect: troughs are most likely to occur after peaks or sustained advances because, under such circumstances, the gap between desired stock and actual stock is most likely to be small. The same logic can be applied conversely to explain why large advances usually occur shortly after the market plummets.

The Revised or Policy Forecast

The next step in the analysis is to generate a forecast that incorporates the effect of noise regulation price increases. The input assumptions of this revised scenario are the same as those of the baseline case, except here, increases in the new car price variable, representing the noise control costs passed through to price, will be exogenously imposed on the system of equations. There are two different ways to do this as described in the following paragraphs.

One way is to add the specified price increments as constant values to the right-hand-side of the new car price equation at the appropriate time periods and then run the model, letting the model solve for new car price. Using this method, the full magnitude of the scheduled price increases is, according to the specifications of the new car price equation,* gradually introduced in a series of small increments. (See Figure 6.2a.)

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* Recall that in Chapter 3 we observed the "sticky price" characteristic of the new car price equation. Briefly, we showed that prices adjusted according to the difference between some desired level, P*, and the actual level, P, by:

$$\Delta P = \gamma(P^* - P)$$

If we wish to exogenously impose upon this model the condition that "normal" price increases by "a" units, we can do so by adding γa to the right-hand-side. Since $0<\gamma<1$, the effect will be that P will gradually adjust to the new P* as shown in Figure 6.2a.

Increases in New Car Price Due to Noise Regulation

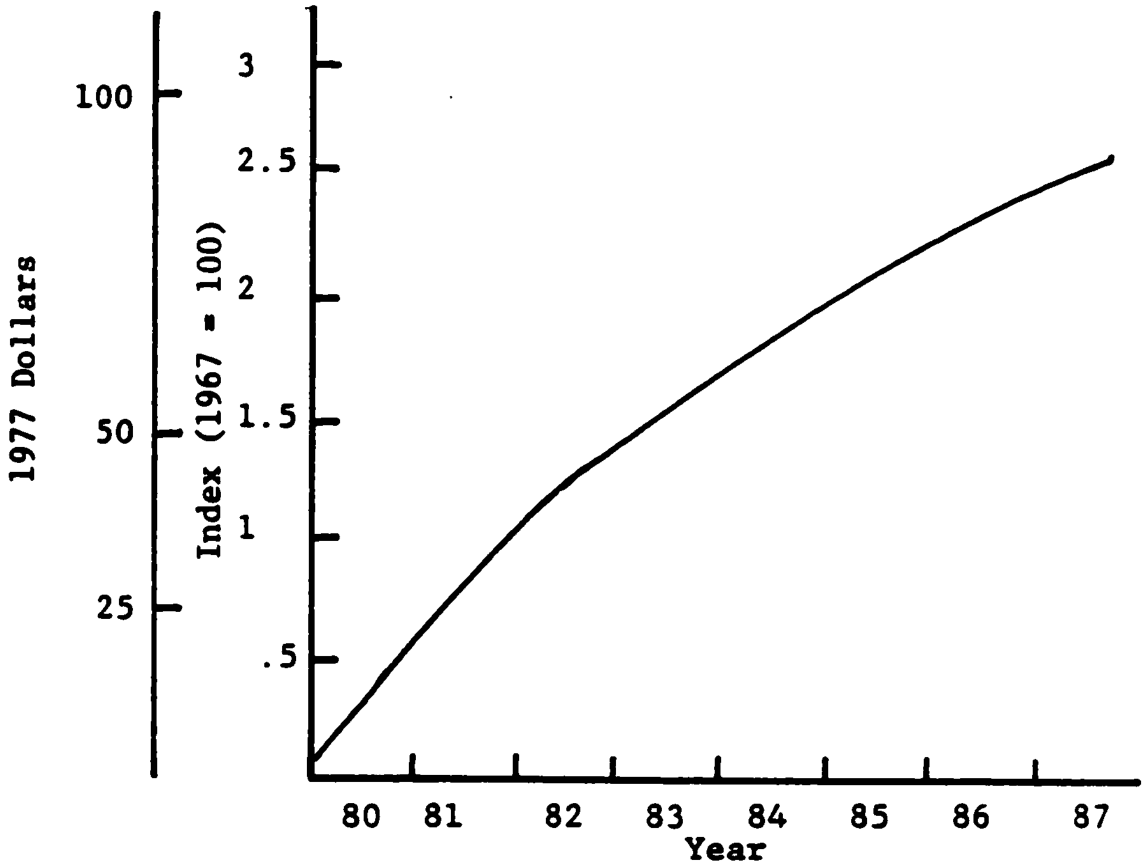

Figure 6.2a. New Car Price Endogenous

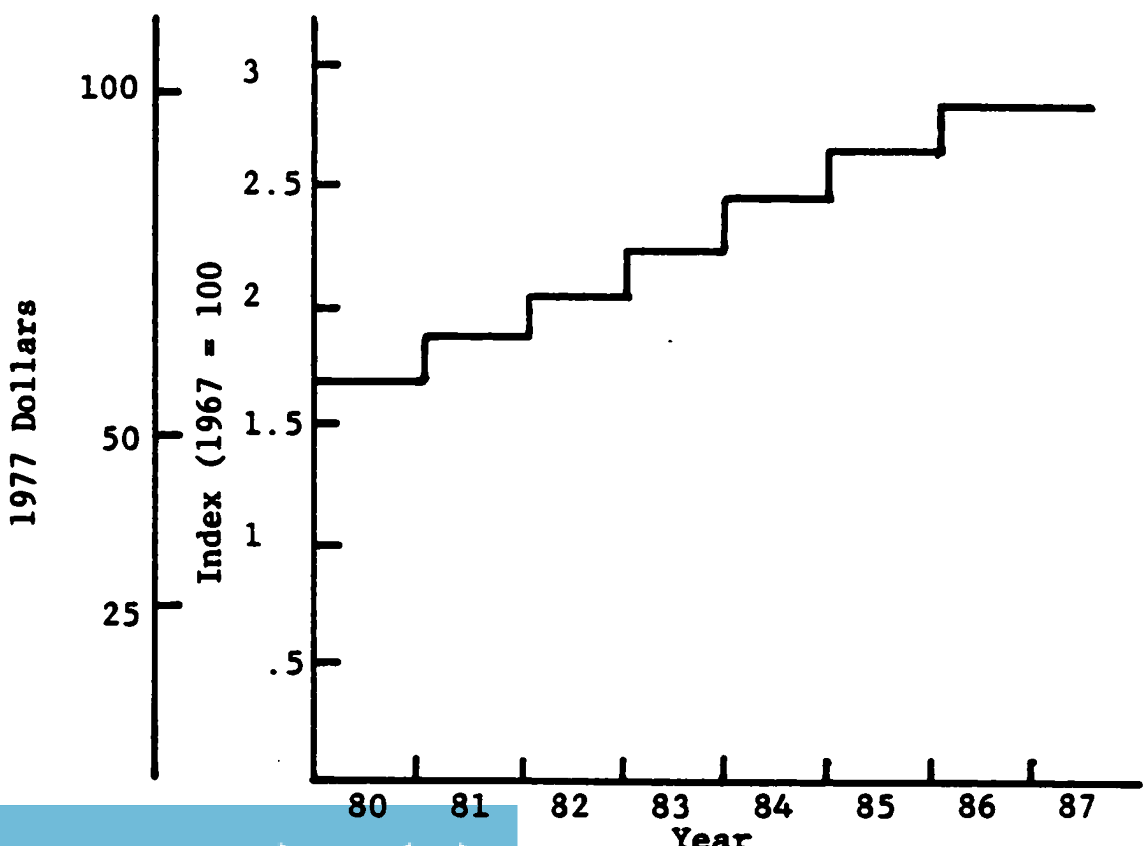

Figure 6.2b. New Car Price Exogenous

The solution of market price, as shown in the figures, is influenced by feedback from other equations in the model. This solution represents, according to the model, how actual market price would change in the real world if "normal" price changed as it is expected to change because of noise abatement regulations.

Another, quite different way to impose price increases on the system of equations is to treat "new car price" as an exogenous variable by removing the new car price equation from the model. Values of new car prices are calculated independently as the sum of: (a) the values of new car price forecasted in the baseline scenario and (b) the specified increases in "normal" price resulting from noise abatement regulations. These values are then exogenously supplied to the model, period by period; other equations in the model, therefore, have no influence on market price. The increases in new car price that result from using this method are shown in Figure 6.2b. Note that by using this method the output of the model will provide a direct answer to the question of what would happen if increases in market price were of the same amounts and timing as increases in normal price.*

The Projected Change in Sales

Since both of these approaches (the "price endogenous" approach and the "price exogenous" approach) have certain advantages, both have been used in assessing the impact of the regulation. Figures 6.3 through 6.8 each depict the

* In Appendix F, a general dynamic multiplier analysis of exogenous changes in new car price is given.

forecasted impact using both approaches. Figure 6.3a, for example, shows the projected change in total sales for the price-endogenous case, and Figure 6.3b, the price-exogenous case.

Notice the marked difference between the two forecasts: the price-endogenous case shows price increases having only a slight effect on sales concentrated mostly in 1980; the price-exogenous case, in contrast, indicates a larger effect whose most pronounced characteristic is a 60,000 car decrease in sales in 1980. Both projections share an oscillatory nature, although the former case is somewhat more damped than the latter. These oscillations are an important trait of the forecasts and can be explained in terms of the mechanics of the model: an increase in price, no matter how large or small, will initially cause a drag on retail sales which will reduce the rate of stock accumulation. Since auto stock has a negative effect on retail sales, less stock means more sales. The depletion of stock stimulates sales and the "change in sales" function (as shown in Figure 6.3) bounces back to become positive. Once again, however, the function overshoots its mark, causing stock to over-accumulate. This causes the function to turn down once more. The feedback relationship cycles back and forth accounting for a part of the oscillation which appears in the plots.

The used car price equation also plays a role in causing the oscillations. When new car prices increase, ceteris paribus, used car prices will also increase, thereby partially offsetting the concomitant drag on new car sales. However, more importantly, used car prices are negatively related to

Total Sales: Projected Change Due to Noise-Control Price Increases

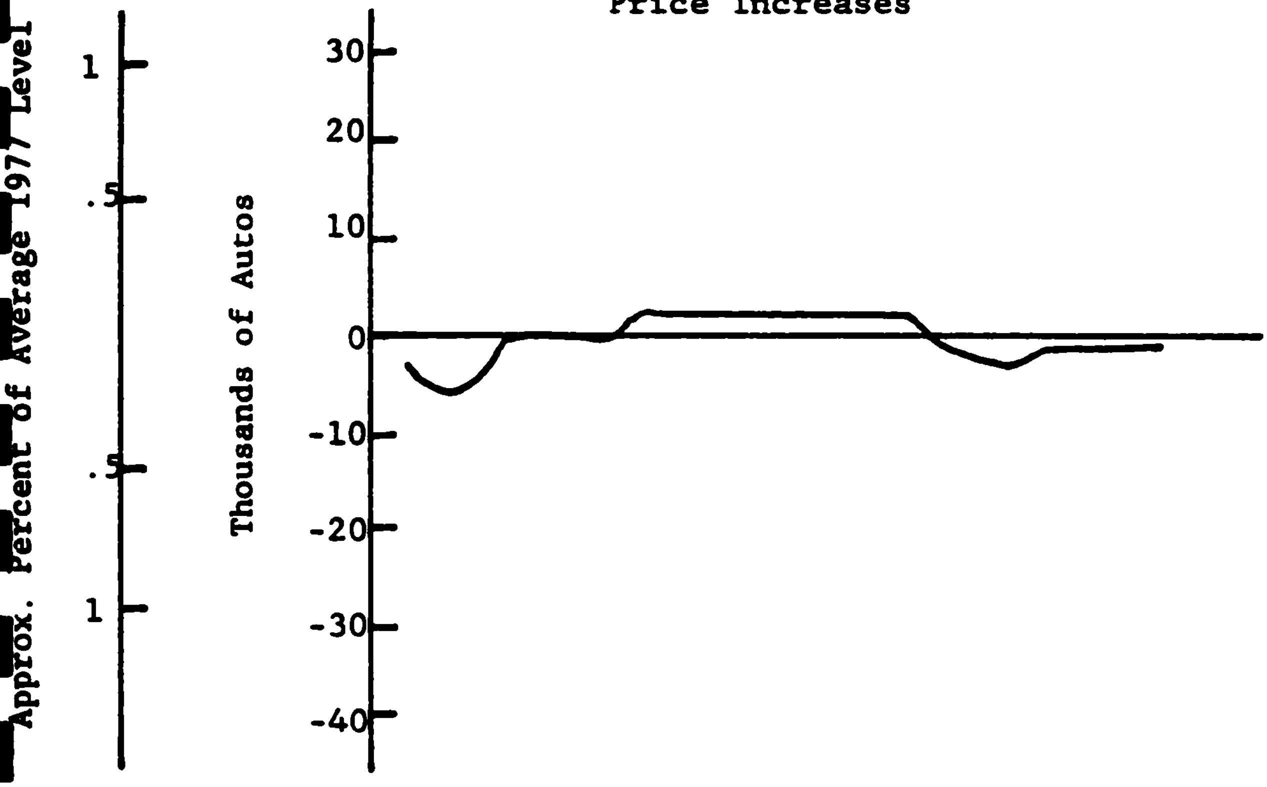

Figure 6.3a. New Car Price Endogenous

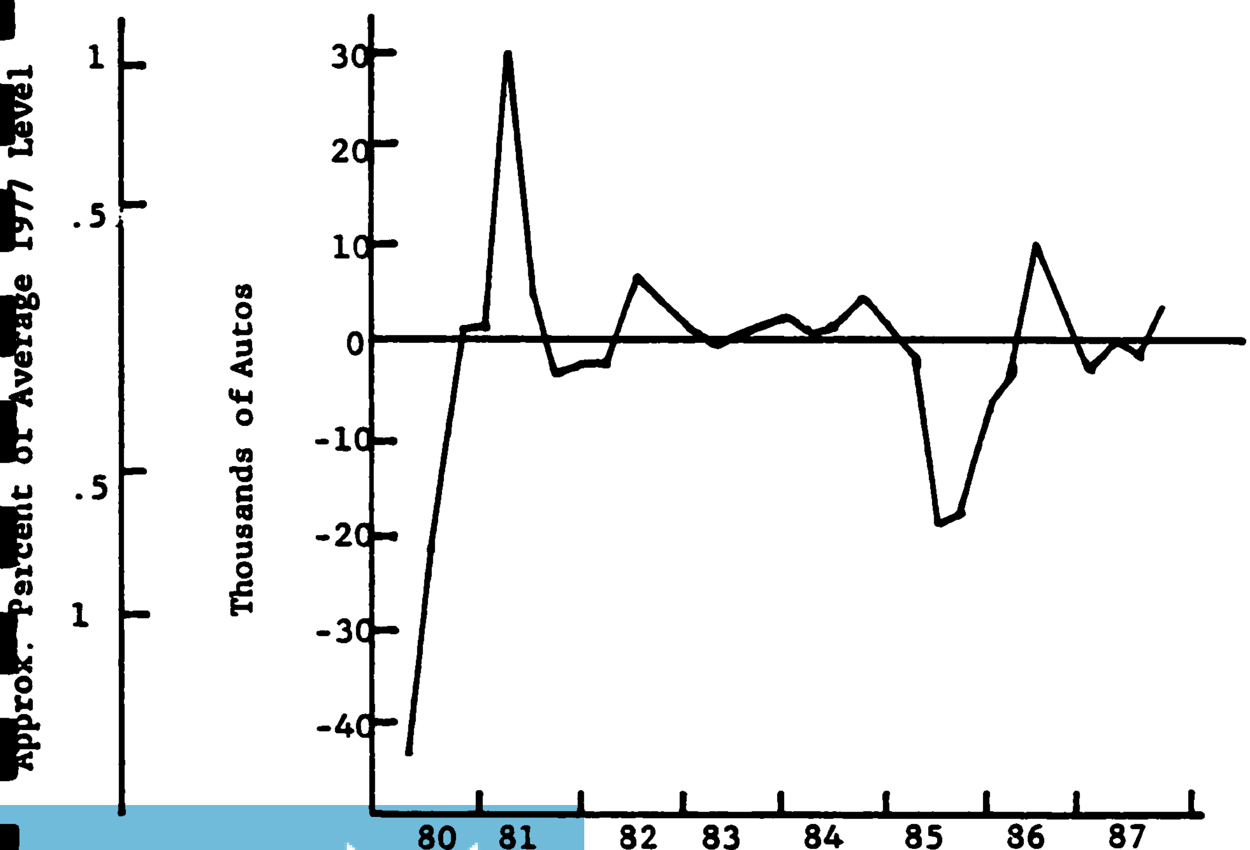

Figure 6.3b. New Car Price Exogenous

the level of auto stock, so, as the level of stock becomes depleted, used car prices will rise, thereby stimulating new car sales.

That the oscillations in the price-exogenous case are of greater amplitude than those in the price-endogenous case is due partly to the damping effect of the new car price equation. When the market is slack, when sales are lower than expected, and inventories are high, price is adjusted downward; when the opposite conditions exist, price is adjusted upward. This tendency has an equilibriating effect on the system, one which results in the price-endogenous projection damping rapidly.*

At this point, it may be useful to pose the question of which of the two cases is more realistic. Answering this question requires that we retrace our path and take a broader perspective of what we have done. An implicit assumption we have made regarding consumers' valuations of reduced noise levels seems quite pertinent. We have assumed in our analysis that consumers place zero market value on reductions in the exterior noise level of their autos. Therefore, all increases in market price that may result from noise reduction modification have been included in the corresponding increases in the quality-adjusted index of new car price which is used in the demand equation. If consumers do, in fact, value and agreeably

* Of course, another reason why the price-endogenous case damps-out more rapidly is that the price increases imposed in this scenario are not as abrupt or as large as those which characterize the price-exogenous case.

accept paying for quieter cars, then both of the projections in Figure 6.3 may be over-estimates. The chances that this is the case, however, seem slight.

Another pertinent assumption regards the manner in which manufacturers will pass through the costs of regulation.* While the price-endogenous case assumes the sticky-price model and the price-exogenous case assumes that all increases in normal price will be fully and immediately reflected in market price, a third case which cannot be simulated with our model is a possibility. To explain, suppose that manufacturers increased market prices in the same manner as assumed in the price-exogenous case, but distributed a significant share of the required mark-up to options and accessories for which demand is highly inelastic to price. In this case, aggregate demand for new autos would probably be affected by less than is indicated in Figure 6.3b, but perhaps still more than is projected in Figure 6.4b.

It seems distinctly possible that a variety of cost-pass-through strategies such as the one described may be used. Because of the huge capital demands of current Government regulations, automakers are encountering cash flow problems; and, because of the accompanying financial strain, they are becoming less cautious in their pricing. Under these conditions, departures from the traditional "sticky-price" strategy are to be expected — automakers will be worrying more about themselves and less about their fellow oligopolists.

* This issue is addressed in Appendix E.

Used Car Prices: Projected Change Due to Noise-Control Price Increases

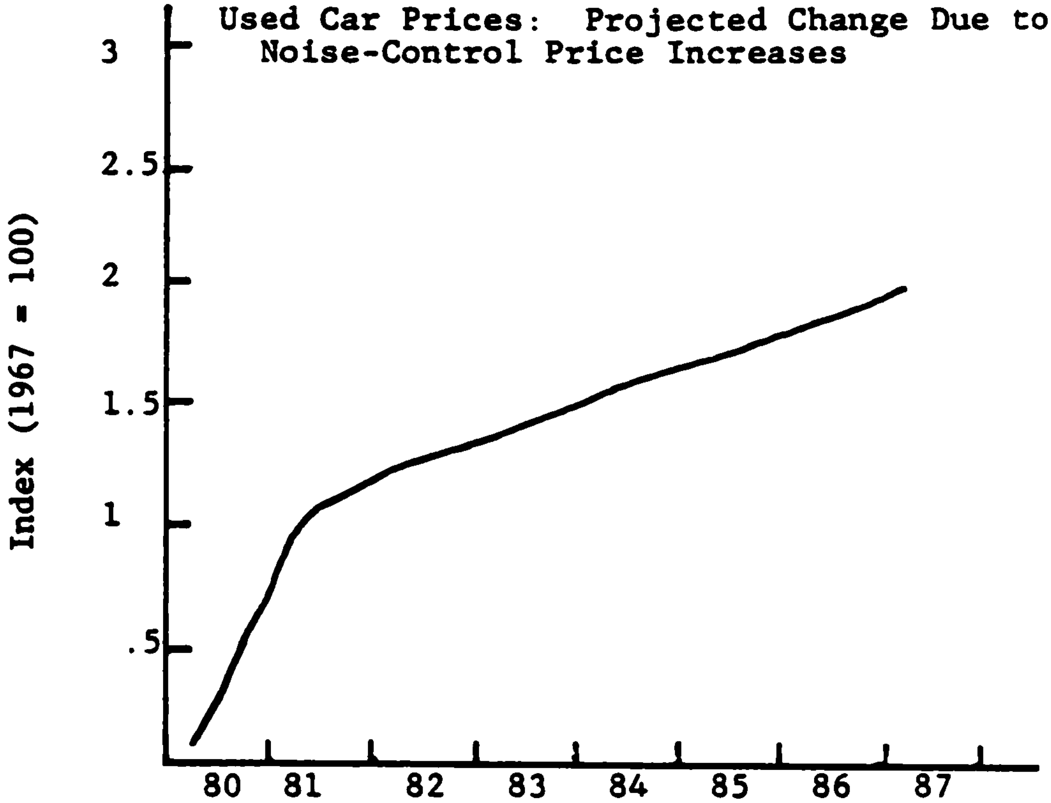

Figure 6.4a. New Car Price Endogenous

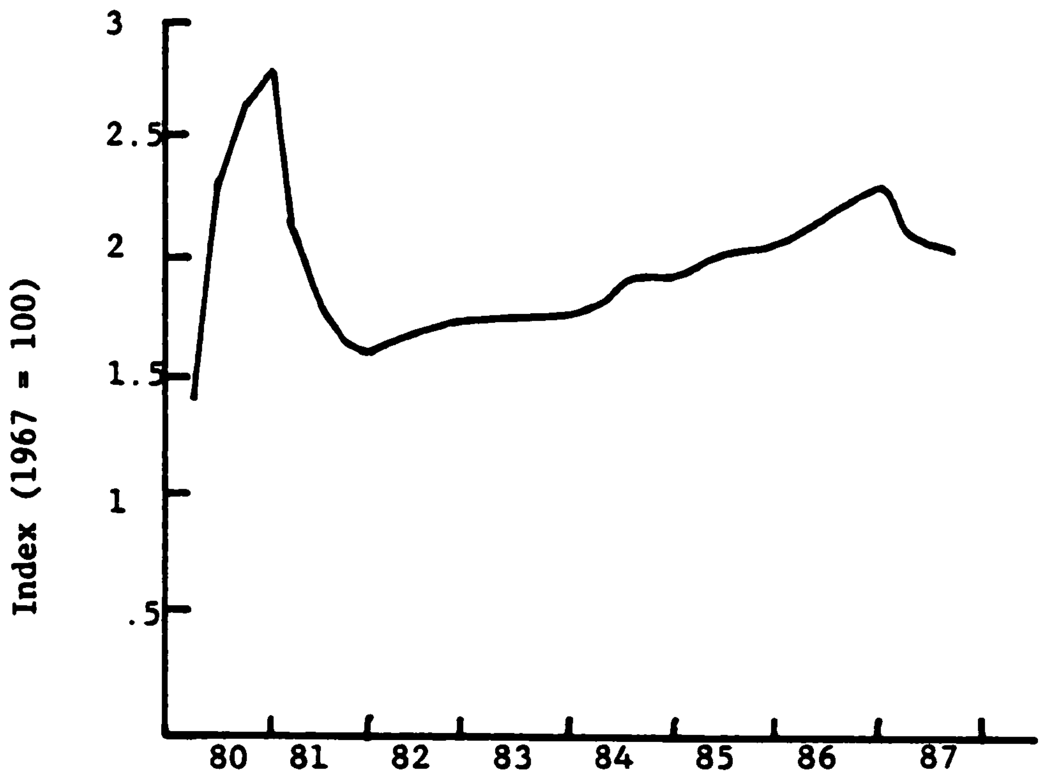

Figure 6.4b. New Car Price Exogenous

In light of these considerations, let us view the price-endogenous projection as an optimistic estimate, one that could have occurred had the regulation been imposed under more stable, less pressurized environmental conditions. Let us view the price-exogenous projection as a realistic estimate, but one that may slightly overstate the impact. The price-exogenous projection is, therefore, the more desirable of the two, since the philosophy we have consistently applied is that an overestimate is preferable to an underestimate.

The Projected Change in Used Car Prices

Of passing interest is the projected impact on the price of used cars. As shown in Figure 6.4b,* used car prices are projected to rise quite dramatically in 1980, decrease in 1981, and stay significantly above their baseline level as far as the projection shows. The initial increase in used car prices may be attributed to the market effect of the simulated increase in new car prices; the subsequent downturn and then re-ascent of the index are caused by a combination of factors which includes: (1) current movements in the new car price index, (2) past movements in the new car price index, and (3) changes in the availability of used cars.

That the price of used cars increases as a result of the regulation is of significance from a policy perspective

* Note that the version of the used car price model shown in Equation 3.15 was used to generate the forecasts presented in Figure 6.4.

because higher used car prices mean that lower income consumers will be affected by the regulation. Further, increased used car prices add to the inflationary impact of the regulation. Figure 6.4b shows, however, that, at most, used car prices will increase by 1.5 percent — by itself, an impact not great enough to cause undue hardship for consumers or major economic woes for the country.

The Projected Impact on the Industry's Labor Requirements

Figure 6.5 shows a plot of the quarter-by-quarter change in the number of production workers needed by the industry. Positive numbers on the vertical scale represent the number of workers hired, and negative numbers, the number of workers laid off. In this case, as in others, the price-exogenous forecast projects a much greater impact than does the price endogenous forecast. Let us direct our attention to the former, in which rather severe lay-offs are projected for 1980. Followed by three quarters of lay-offs, the curve in Figure 6.5b crosses the horizontal axis and remains on the positive side until the fourth quarter of 1984, indicating a long, but less than inspired, period of rehiring. The curve dips below the axis twice more before the end of the forecast period, most notably in 1985 when a forecasted 900 workers are laid off.

A more telling picture of the impact of the regulation on the labor force is shown in Figure 6.6b. This plot shows the cumulative change in the number of employed workers or the total number of workers who are projected to be out of

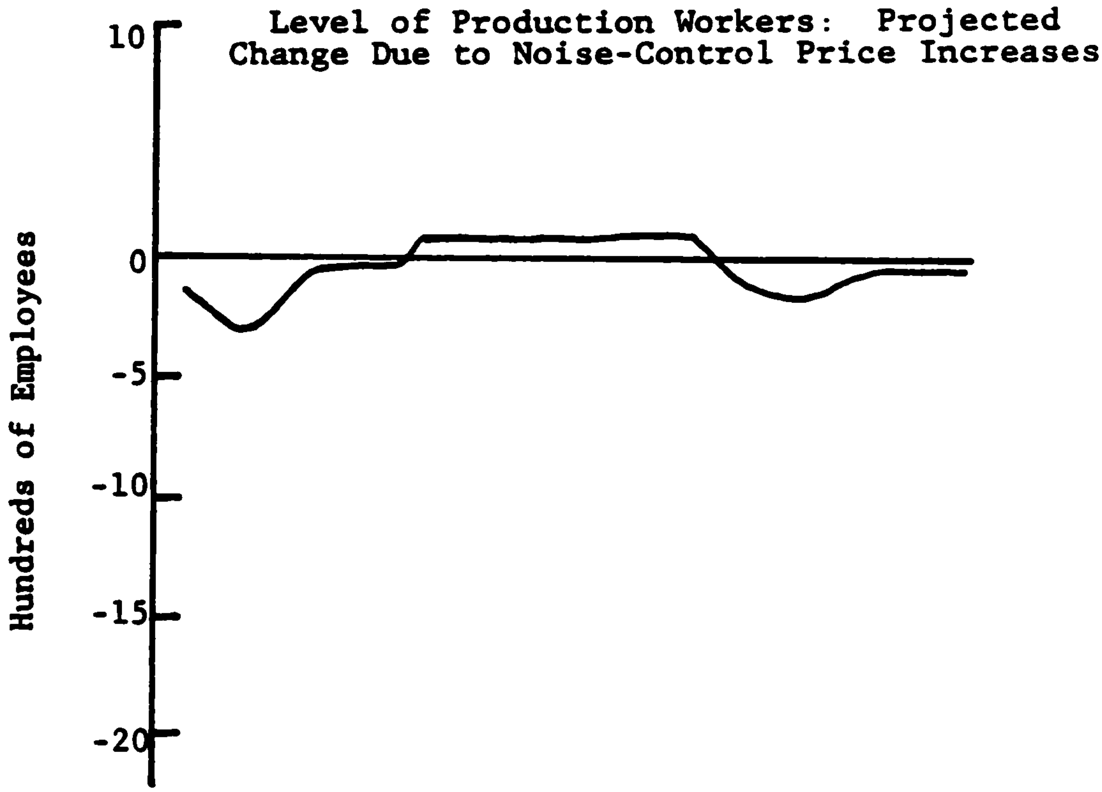

Figure 6.5a. New Car Price Endogenous

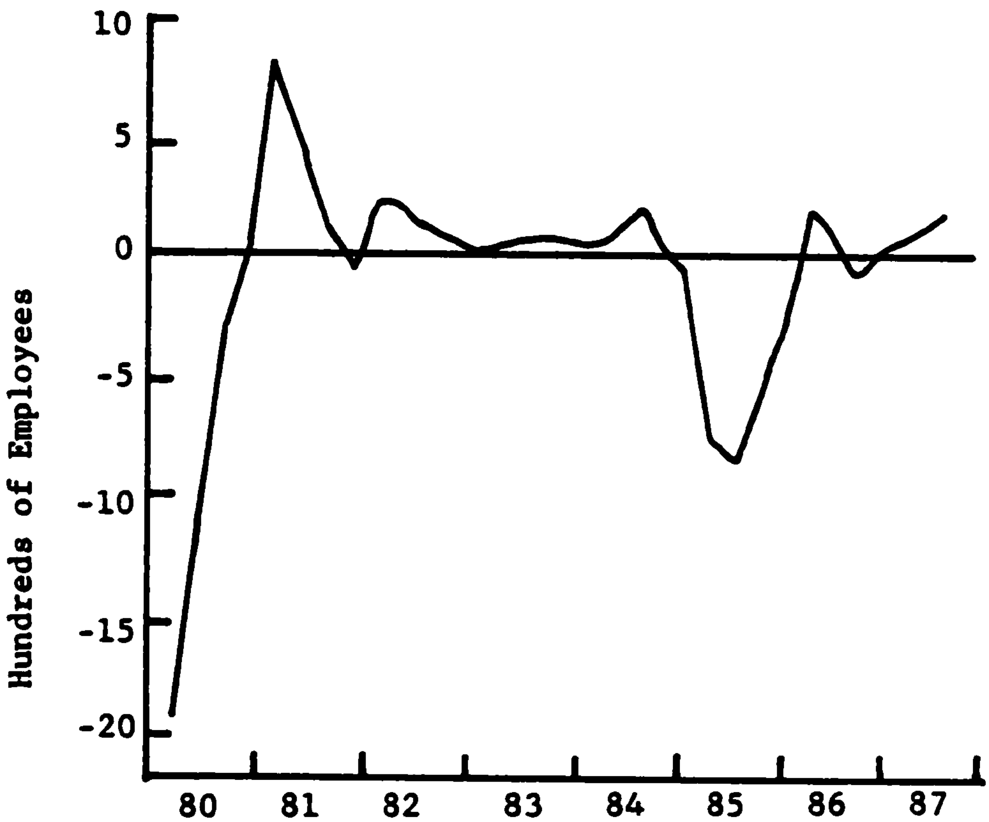

Figure 6.5b. New Car Price Exogenous

Level of Production Workers: Cumulative Change

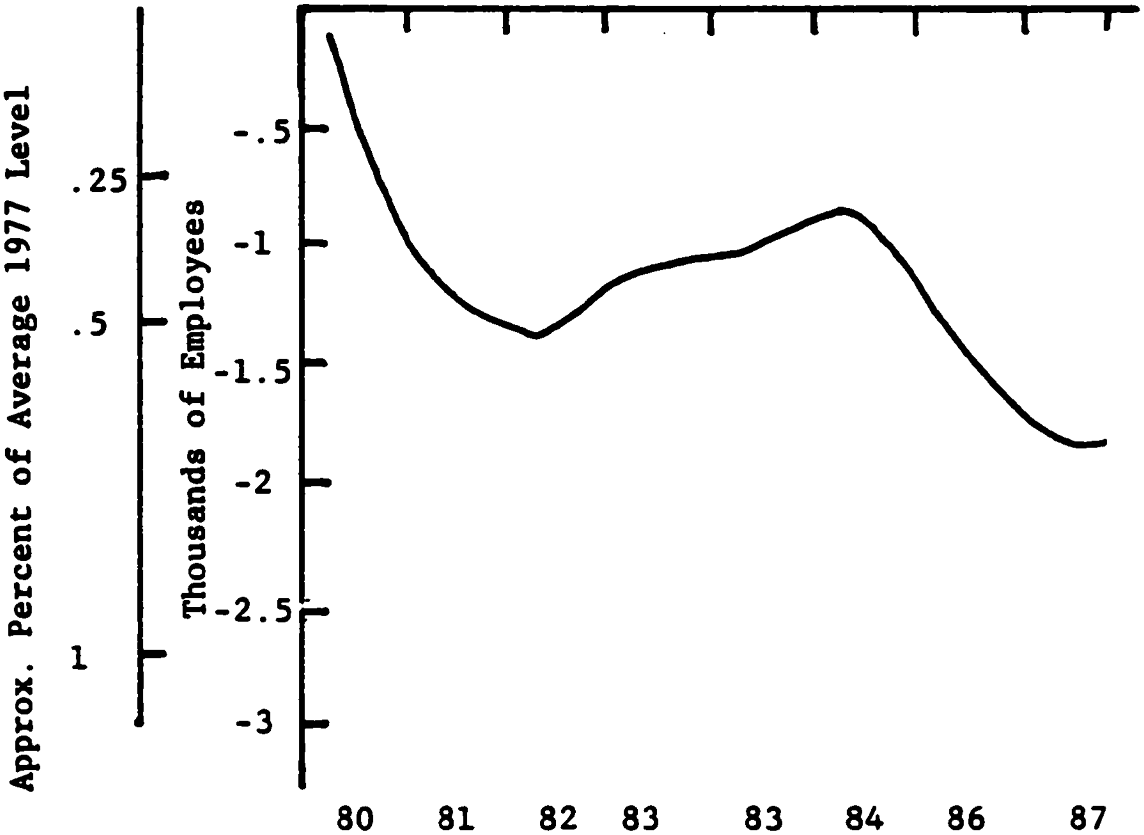

Figure 6.6a. New Car Price Endogenous

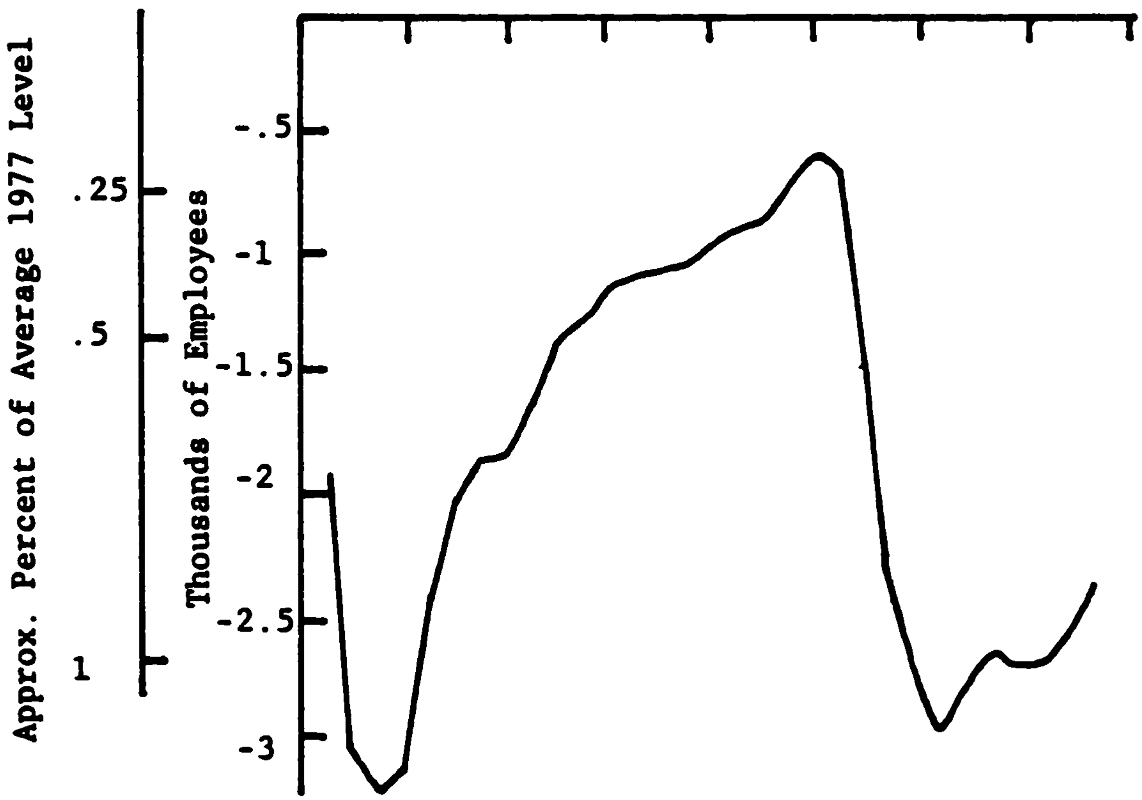

Figure 6.6b. New Car Price Exogenous

work during each period. The curve indicates that the most extreme circumstance will occur during the third quarter of 1980 when an estimated 3200 workers will be unemployed. From that point on, no less than 500 workers will be without jobs. In 1985, a poor sales year because of feedback effect of distorted replacement cycles, a large number of workers will again be laid off, bringing the total to near 3000.

Evaluating the real cost of lost jobs is an impossible task. In light of the facts – that we are speaking about UAW members, that the UAW has tremendous political power, and that the popular sentiment is that auto workers are overpaid and underproductive – the general concensus of the citizenry may be to discount these costs. However, if the impact of the regulation were to be measured abstractly in terms of "the change in the quality of life," job losses should probably be ranked first among the costs of the regulation. Placing a measure on the cost of these job losses will be left to the reader.

The Projected Impact on the Industry's Capital Requirements

The industry's level of investment in property, plant, and equipment would be affected as shown in Figure 6.7. This impact we have referred to as the change in induced investment. Notice that investment spending is not altered until the last quarter of 1980, three quarters after the initial change in price. This occurs because of the three-quarter delay between appropriations and actual spending that the

Capital Expenditures (PPE): Projected Induced Change Due to Noise-Control Price Increases

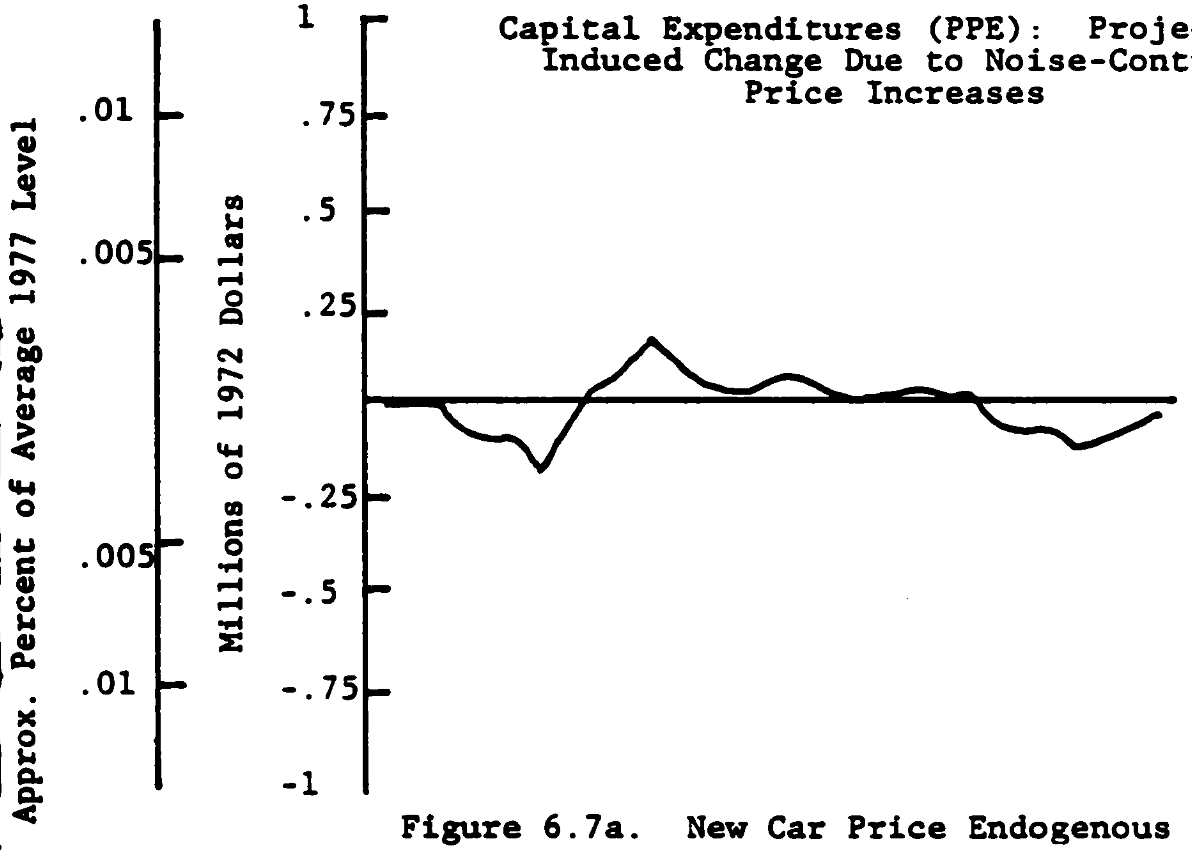

Figure 6.7a. New Car Price Endogenous

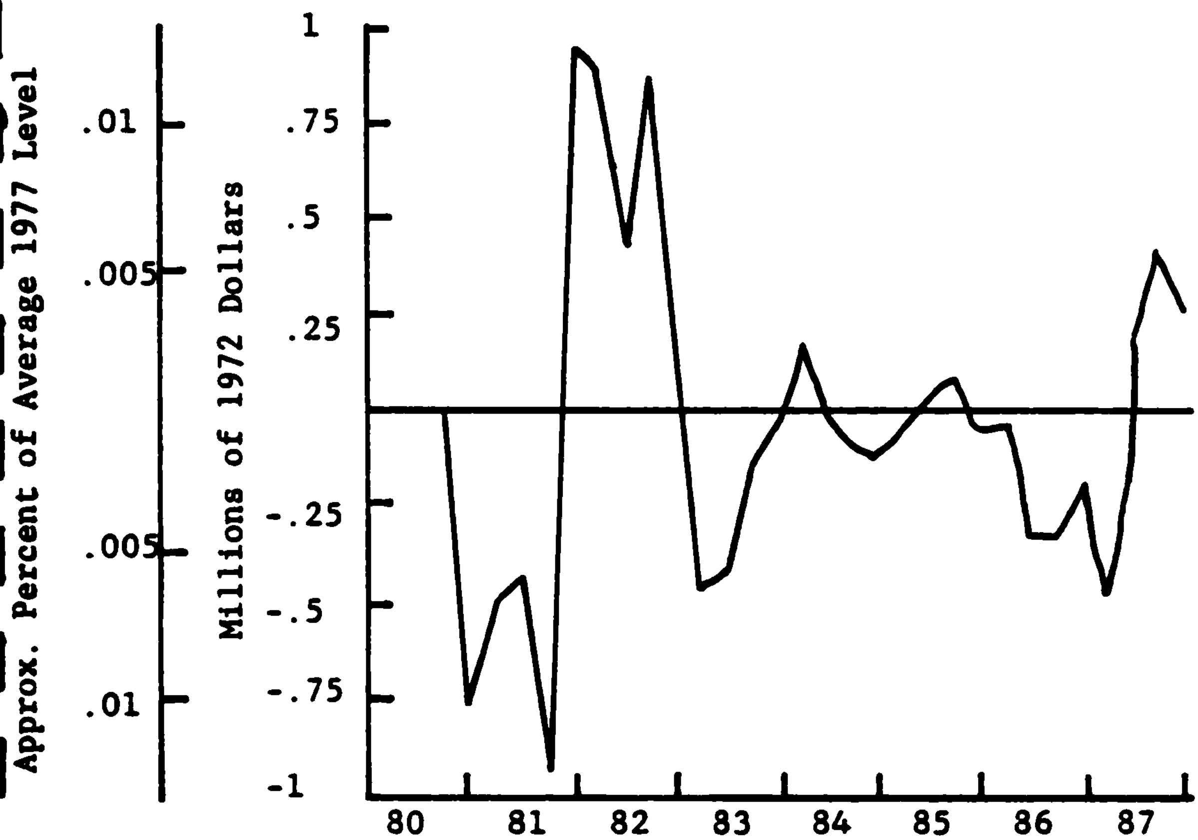

Figure 6.7b. New Car Price Exogenous

model of investment spending provides for. In the fourth quarter of 1980 and the first three quarters of 1981, Figure 6.7b shows that investment spending dips sharply; however, even at the most extreme point, investment spending in the policy scenario is only $1 million or about .015 percent less than in the baseline scenario. This dip is followed by an increase in spending of nearly equal magnitude during 1982. Thereafter, the curve oscillates and seems to dampen rapidly.

The magnitude of change in induced investment effected by the regulation must certainly be considered trivial, especially since the auto industry annually spends about $2-3 billion on property, plant, and equipment. However, the change in induced investment is only part of the total change in investment that the regulation would effect; the other part is the increase in investment required to manufacture noise abatement components. This sum, you will recall, was estimated to be about $2 per modified vehicle. By adding the two components of the overall change in investment together, we find that the impact of the investment required for manufacture of noise components far overshadows the change in induced investment. Figure 6.8 shows that, on an industry-wide basis, the regulation would cause capital expenditures to be consistently higher than they would have been, chiefly because of the property and equipment required to manufacture noise abatement parts. The average quarterly increase in investment is shown to be about $1.5-2 million; the cumulative change over nine years, to be about $60 million.

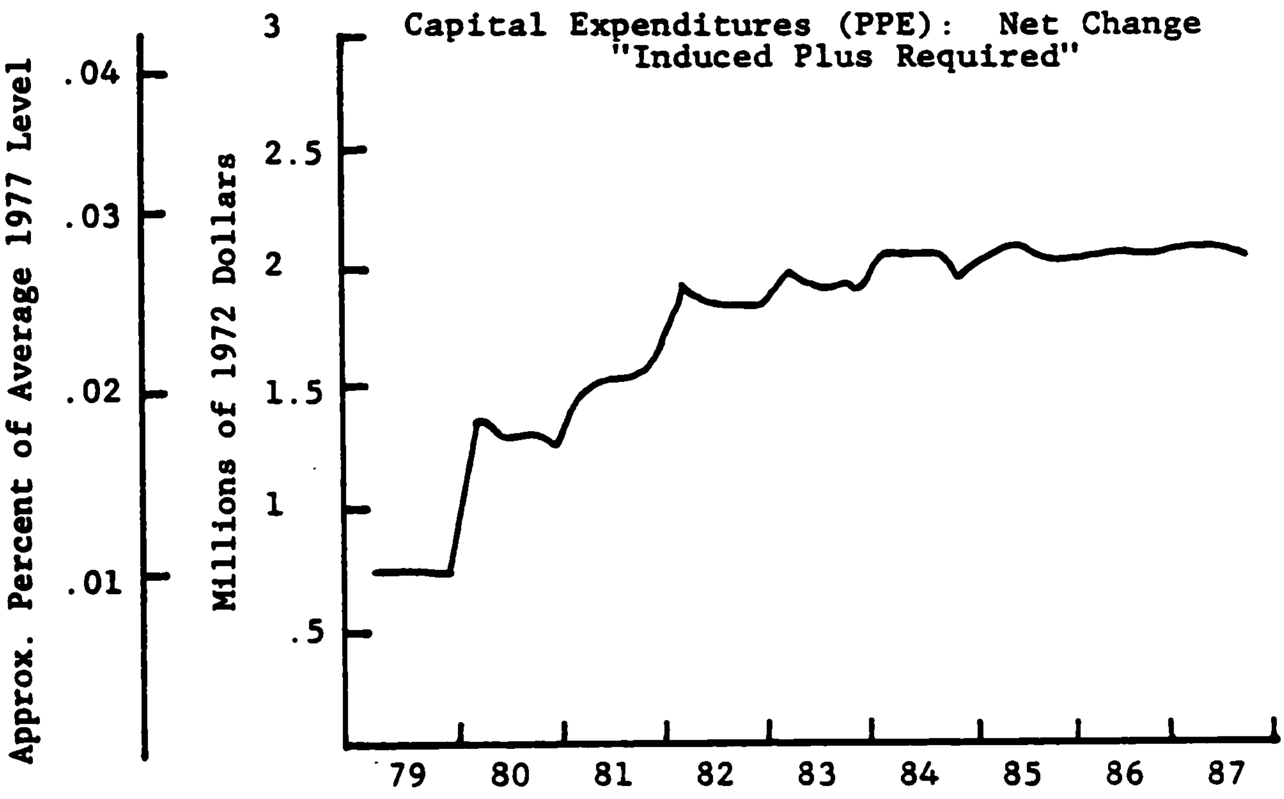

Figure 6.8a. New Car Price Endogenous

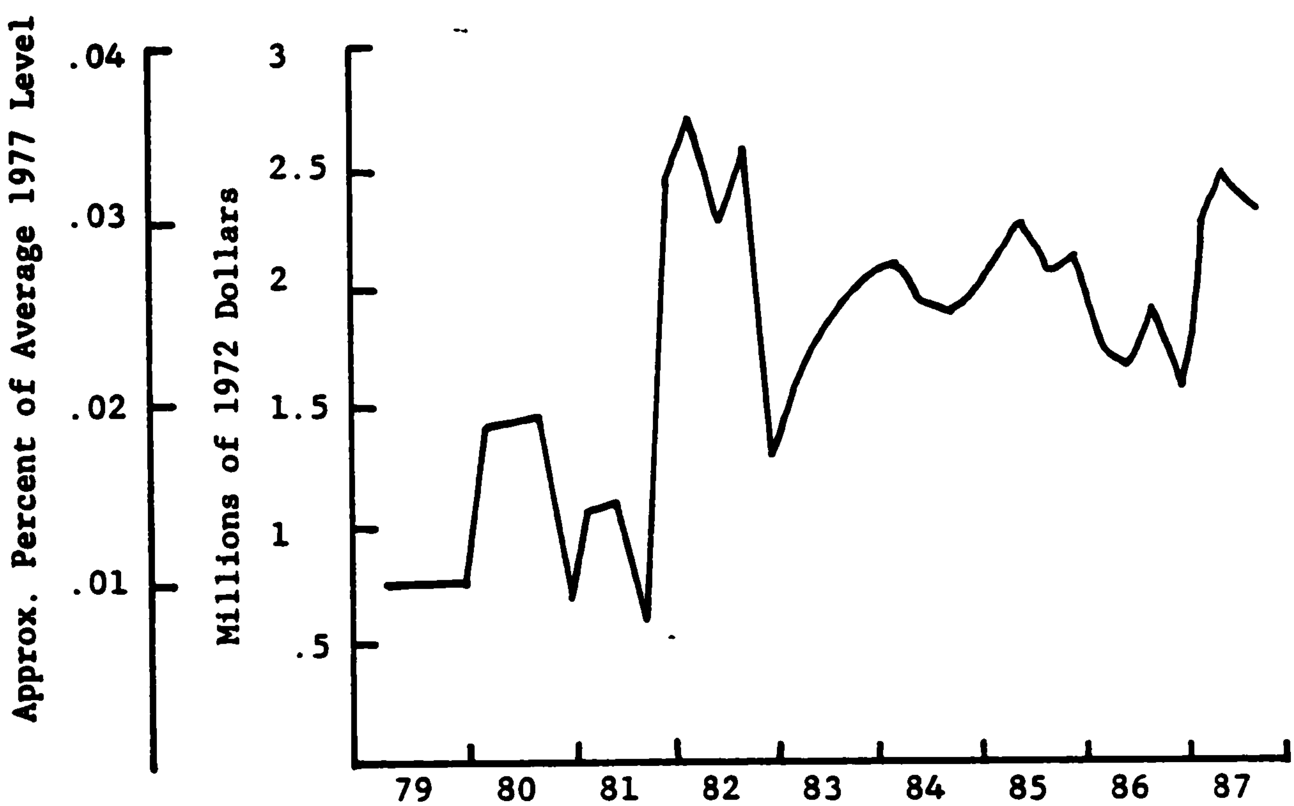

Figure 6.8b. New Car Price Exogenous

EVALUATING THE PROJECTION

Let's try now to determine the significance of our findings from a policy-making perspective. What we have found is that a Government standard on the level of auto noise emissions would:

- Increase the average price of new cars
- Decrease new car sales
- Increase the average price of used cars
- Reduce the auto industry's labor requirements
- Increase the industry's level of capital spending

We have found that, by any yardstick, all of these impacts would be of small magnitude. However, we have yet to translate our identified set of partial impacts into what may be considered an assessment of the regulation's overall impact.

Inflationary Impact

One obvious effect of the regulation is its impact on the cost of living. If, as in the worst case, the index of new car prices increases by three points and the index of used car prices increases by 2.25 points, the consumer price index for all items will increase by about .17 points by 1987. This impact, although seemingly small, would weigh heavily against the chances of the regulation ever being implemented, especially in light of the executive branch's current anti-inflation program.

Impact of Productivity

Henry L. Duncombe, Jr., Vice President and Chief Economist at General Motors and leading auto industry spokesman in Washington, recently stated that, in his opinion, the main effects of Government regulations are higher prices and lower productivity.* Productivity, he says, is affected not only because of reduced profit margins and, hence, reduced capital formation, but also because capital funds that are available must be diverted from productive equipment to investments required to comply with regulations. Duncombe also points out that a slowdown in productivity now increases the possibility of future production bottlenecks that could cause further price inflation.

Our analysis only partially substantiates Duncombe's arguments. We have not directly addressed the issue of the regulation's impact on auto companies' profitability. We have assumed that noise components would add to the price of new automobiles by an amount that would earn the automaker his average rate of return at standard volume. Thus, if automakers immediately and fully adjusted prices to reflect the additional cost of noise devices (as is assumed in the price-exogenous projection), then the only way their profitability could be reduced is if the price increase caused output levels to fall below standard volume. Figure 6.3 indicates that the regulation may indeed cause output levels to fall below standard volume, but only temporarily. Thus, if automakers adjust

* (Duncombe, 1978).

prices fully and immediately, then we must assume that the impact of the regulation on the industry's profitability would be minor and somewhat shortlived.

Alternatively, suppose that automakers adjusted prices according to the sticky price model. In this case, as is shown in Figure 6.2, they would be absorbing a good part of the costs of noise devices, at least initially, and their profitability would be affected more substantially. This would be the poorer of the two price strategies to use in this instance.

Concerning the other of Duncombe's arguments — that regulations divert capital resources — we must concur. Our analysis indicates that investment funds that could otherwise be used for other purposes would be needed to buy capital equipment to produce noise devices. Whether this would ever lead to production bottlenecks is, as Duncombe points out, a matter of chance.

We should also give the viewpoint opposite to Duncombe's equal time. Proponents of this viewpoint would agree that regulations do create the need for investment dollars that could otherwise be devoted to improving productivity. However, they would argue that, were the need for this investment not created by the regulation, then the dollars would not be invested, but instead used for some other purpose such as paying stockholder dividends. Thus, they would add that the financial impact of regulations on the company is not as great as industry executives would have the public believe. (A weak link in this argument is its neglect to consider the financial consequences of paying smaller dividends to stockholders.)

Impact on Employment and Aggregate Economic Activity

We have already measured the regulation's impact on employment and economic activity (as measured by unit sales) in the auto manufacturing industry. Now we must consider the regulation's impact on employment and economic activity in other industries that are related to the auto manufacturing industry.

When the retail sales of new automobiles decrease, economic activity in many sectors of the economy may also decrease. Indeed, fluctuations in new car sales have a significant and widespread impact on the level of sales, employment, and capital expenditures in other industries. A 1974 analysis by Wassily Leontief, commissioned by the New York Times, estimated that one job was lost for every four autos not produced domestically.*

Industries whose sales depend on the level of demand for new automobiles may be divided into five basic categories: (1) materials suppliers, (2) special parts and components suppliers, (3) tools and equipment suppliers, (4) automobile manufacturers, and (5) sales, repair, and other consumer industries.

* (Kearney, 1977), p. II-24.

The flow of goods and services between automotive-related industries is conceptually represented in Figure 6.9. The automobile assembly operation is shown to be the focal point of the flow of goods and materials: all materials, auto parts and accessories, and machine tools and equipment are either transferred to an assembly plant or are used to manufacture a good which is itself eventually transferred to an assembly plant.

Material Suppliers

Materials which are used to manufacture automobiles include various types of steel, aluminum, copper, iron, zinc, lead, rubber, plastics, glass, and cotton. Raw materials are processed in some manner before they can be used in the assembly stage of auto manufacture. For example, metals may be forged, casted, rolled, or drawn. Some of these operations may, in fact, take place at an auto assembly plant or at a near-by site that is owned by the automaker. The larger automakers perform most of these operations themselves.

Auto Parts and Components

Automobile parts and components include items such as engines and engine parts, metal stampings, tires, electrical equipment, lights, brake parts, air conditioners, radios, and so on, right down to nuts, bolts, and washers. Producers of these goods are supplied by raw material industries and

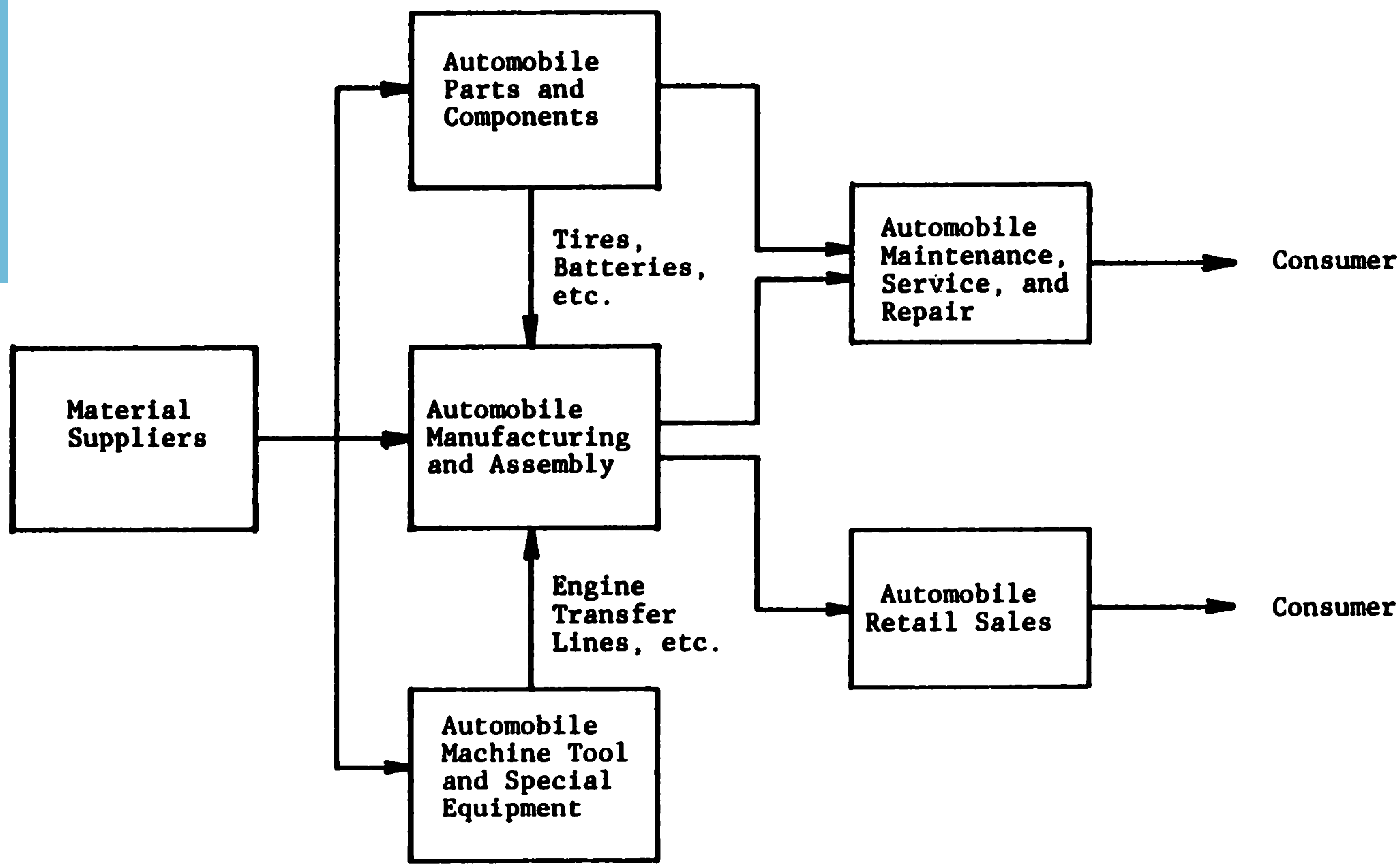

Figure 6.9. Automobile Manufacturing and Related Industries

directly supply automakers. Once again, the larger carmakers such as GM and Ford manufacture many of these goods themselves.

Auto Machine Tools

Machine tools are, despite what the name implies, machines that are used to cut, form, or shape metal. Besides machine tools, special dies, jigs, and fixtures are also included under the generic "Machine Tools and Special Equipment." What these goods have in common is that they are capital goods; they are used to form, cut, or shape the exterior parts of automobiles – auto bodies. Since auto bodies are frequently changed, the useful life of these types of equipment may be short. Automakers, therefore, amortize the cost of machine tools over the expected life of the body style which the machines are used to manufacture. Machines that are purchased to replace worn-out predecessors are directly expensed.

Auto Dealers

The automobile retail sales industry consists of roughly 25,000 franchise dealerships spread out across the country. These establishments are typically not totally dependent on new car sales for their revenues; they may also sell used cars and operate parts and service departments.

Other industries that deal directly with consumers include the automobile service and repair industry, the gas station industry, the insurance industry, the aftermarket parts industry, and other much smaller industries. These industries are only indirectly affected by fluctuations in new car sales. Most are directly affected by the number of cars on the road, but affected by sales only inasmuch as sales affect the aggregate number of auto miles traveled. Some, such as the auto repair, gas station, and auto parts industries, may make more sales to owners of old cars than to owners of new cars. Thus, fluctuations in new car sales would be expected to affect them little.

Input/Output Effect

One need not consult an input/output table to determine that the impact of the decrease in new car sales shown in Figure 6.3 will be minor. Using Leontief's rule of thumb that, for every car not produced domestically, a decrease in domestic production of 48,000 units would result in 12,000 lay-offs nation-wide. This would be the impact in the first year; after that production would be stepped up and many of the laid-off workers would be rehired.

Because the impact of the regulation on auto-related industries, according to our projection in Figure 6.3, would be temporary, measuring all of the individual impacts is not altogether necessary.* Instead, let us focus on the five industries that would be affected the greatest: (1) the

* See Appendix C for a detailed input/output table.

motor vehicles parts and accessories industry, (2) the blast furnace and basic steel products industry, (3) the automotive stampings industry, (4) the iron and steel foundries industry, and (5) the tires and inner tubes industry.

Input/Output Structure of the U.S. Economy: 1967, a document published by the U.S. Department of Commerce, includes input/output tables of the U.S. economy describing the flow of goods and services between industrial sectors.* For any single industry, the tables indicates: (1) the amount of goods and services purchased from all other industries in 1967, (2) the direct purchases (or requirements) from all other industries needed to produce $1 of final output, (3) the total requirements (direct and indirect) from all other industries to produce $1 of final output.

From these input/output tables, the total requirements of the automobile manufacturing industry for input from these

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* These tables have their limitations. For example, they are over ten years old; the automobile industry requirements have probably changed since the tables were produced. Secondly, the information used to produce the tables may not be entirely accurate. Companies are sent reporting forms to fill out and submit, and some companies may have been less than candid in their disclosure of sensitive information. Thirdly, the categorization of industries used has well-known limitations due to the fine lines of distinction that must be drawn between products and between industries. The inevitable overlap that occurs within individual companies also creates measurement problems. Finally, since automobile manufacturers produce many of their base supply requirements and purchase only additional requirements arising from high demand from suppliers, the input/output coefficients may understate the effect of a decrease in automobile production on demand for suppliers' goods.

Despite these shortcomings, the tables are still the best source of input/output information available.

five supplier industries have been derived.* Table 6.3 shows the estimates of direct, indirect, and total requirements from these industries. The direct requirements figures indicate, for example, that the auto industry purchases about three cents worth of goods from the blast furnace and basic steel industry for every one dollar of auto output. The indirect requirements figures indicate that nine cents worth of goods were purchased from the steel industry by auto industry suppliers for every one dollar of auto output. Thus, the figures for total requirements involve double (or multiple) counting of auto industry purchases. To illustrate, the steel that is purchased by the automotive stampings industry to produce metal stampings for autos is counted as an indirect requirement from the steel industry and a direct requirement from the automotive stampings industry. The cost of the steel shows up twice in the total requirements account for the auto industry.

The total requirements figures indicate that the automobile parts and accessories industry supplies more goods to the automobile manufacturing industry than any other supplier industry. For every dollar of auto output, about 28 cents worth of input is required from the auto parts industry. The steel industry, auto stampings industry, iron and steel foundries, and tires and inner tubes industry follow in decreasing order of importance. Notice that all except the

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* Since the automobile parts and accessories industry (SIC 3714) is part of the automotive sector which includes SIC's 3711 and 3714, a special procedure has been used to estimate the input requirements of SIC 3711 for SIC 3714 output. See Appendix C.

Table 6.3

Input Requirements of the Auto Manufacturing Industry

SIC Code	Industry Title	Direct Requirements per Dollar Output	Indirect Requirements per Dollar Output	Total Requirements per Dollar Output
3714	Automobile Parts and Accessories	.248	.0297	.2777
331	Blast Furnace and Basic Steel Products	.03219	.09325	.12544
3465	Automotive Stampings	.05012	.02953	.07965
332	Iron and Steel Foundries	.02483	.01666	.04149
3011	Tires and Inner Tubes	.01015	.00586	.01601
	Total	.36529	.175	.54029

Sources: (1) Input/Output Structure of the U.S. Economy, U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of Economic Analysis, 1974.

(2) See Appendix C for further information concerning the derivation of coefficients.

steel industry supply most of their input directly to automakers; most steel industry input is supplied indirectly through other supply industries.

To estimate the effect of a certain dollar decrease in auto output, one need only multiply the total requirements figures by the appropriate number. Assuming $50 billion per year in auto industry output, a one percent decrease would amount to $500 million. Multiplying this number times the total requirements coefficients, the corresponding decrease in supplier industry output is found to be as shown in Table 6.4.

Table 6.4

Decrease in Supplier Industry Output Resulting from a One Percent Decrease in Auto Output*

Industry Title	Decrease in Output (millions of dollars)	Percent Decrease in Output
Auto Parts and Accessories	138.85	.76%
Blast Furnace and Basic Steel Products	62.72	.16
Automotive Stampings	39.83	.75
Iron and Steel Foundries	20.745	.21
Tires and Inner Tubes	8.01	.16

* Assuming $50 billion auto output per year.

The table indicates that the impact on the auto parts and accessories industry would be the greatest; its output would decrease by $138 million or .76 percent. The auto stamping industry's output would be reduced by about $40 million or .75 percent; the steel industry's, by $63 million or .16 percent, and so on. These figures, however, are for annual output and the forecasted effect of noise regulation indicates that annual auto output would not be reduced by as much as one percent. Therefore, these estimates of the input/output effects of noise regulation, as small as they are, overestimate the impact somewhat.

Employment in Supplier Industries

In another Government publication, The Structure of the U.S. Economy in 1980 and 1985, published by the Department of Labor, the total employment required per billion dollars of auto sales is estimated. Tables in this document show, for example, how many full-time steel workers are employed to produce the steel required for every billion dollars worth of new autos. These employment input/output coefficients have been used to estimate the number of jobs that would be lost as a result of a $500 million or one percent decrease in auto sales. The results are shown in Table 6.5.

Table 6.5

Decrease in Employment Resulting from a One Percent Decrease in Auto Output

Industry Title	Number of Jobs Lost
Auto Parts and Accessories	5,330
Blast Furnace and Basic Steel Products	1,628
Automotive Stampings	1,307
Iron and Steel Foundries	780
Tires and Inner Tubes	245

The total number of jobs lost nationwide is estimated to be 36,315 according to the Government tables. Assuming that the average price of a new car is about $5,000, a $500 million decrease in auto output would correspond to a 100,000 unit decrease. Use of Leontief's rule of thumb would result in an estimate of 25,000 lost jobs, a somewhat lower estimate. No matter which estimate is closer to the truth, it must once again be pointed out that noise regulations would produce temporary lay-offs and not permanent job losses. Thus, the real effect of job losses would be less dramatic than these five-digit estimates alone suggest.

Supplier Industries' Capital Spending

Would supplier industries' capital spending be affected? Probably not. Low levels of demand must be sustained for some time before significant changes in capital spending occur. Since slumps in auto demand caused by the regulation are estimated to be no more than one year long, supplier industries' capital budgeting plans would probably not be significantly altered. Suppliers know the auto industry to be characterized by large fluctuations in output; hedging on these fluctuations must certainly be a routine operating procedure. Slumps in auto demand are seen by supplier industries as temporary aberations, not permanent changes that would signal a need to revise capital budgets.

Summary

Overall, the effects of the regulation on supplier industries and other auto-related industries are estimated to be small. An important point to remember is that, because the major impact of the regulation on car sales passes quickly, the secondary effects of the decrease in car sales will be shortlived and, hence, rather mild. This is not to say that the local effects in all regions of the country will be equally mild. Certainly the effects will be felt greatest in Michigan, Ohio, Wisconsin, Illinois, Indiana, and Pennsylvania — the auto and steel regions of the country. However, even if the national impact is localized to these regions alone, the effect would still be small.

We should also point out that, because the three largest automakers are vertically integrated to a considerable degree, a good part of the impact on "supplier industries" would actually fall on the shoulders of GM, Ford, and Chrysler. Considering that the auto parts and components production volume from these three companies alone constitutes over 60 percent of the auto equipment and parts industry's total output, they are their own largest suppliers. We have emphasized the need for the large group of small, independent suppliers that make up the remainder of the auto parts and components industry to routinely hedge on their level of business, because their work is typically on a year-by-year contract basis. Automakers usually plan to produce a certain base amount of their supply requirements themselves and contract the difference between their expected sales volume

and this base load to independent firms. The independent suppliers do business in a risky environment; one that can change dramatically from year to year. After the 1974-75 slump in auto sales and the accompanying drought for auto parts contractors, many of these firms (the ones that survived), have diversified into more stable business areas.

EQUITY OF THE REGULATION

We have now identified the major costs of the regulation to both business and consumers. We could carry our analysis further by listing possible, but unlikely, repercussions of the regulation, but this would serve no real purpose. The impacts we have identified are not only the major ones, but also the most likely. Therefore, we have assembled what we consider to be a "best guess" of the regulation's impact.

To assess the equity of the regulation, we must determine whether those who pay for the regulation will receive its benefits and, conversely, whether those who receive its benefits will share in its cost. It has already been determined that new car buyers as a group will, at least initially, pay for the regulation. To a certain extent, they will be able to pass the cost on to used car buyers; and, used car buyers may be able to do the same to other used car buyers. Thus, the costs of the regulation will be distributed among car buyers as a group.

The benefits will be received principally by those people who live or work near areas of high density auto traffic, such as urban centers. To a lesser extent, the regulation's benefits will accrue to anyone who is near a public highway or street — a vast majority of the nation's population. An important point to make here is that the noise of high-speed traffic, such as the noise that may disrupt those who live near expressways, comes chiefly from the friction of tires and road surface, not from the engines of cars. In contrast, the noise from "stop and go" traffic is basically engine noise (accompanied by the sounding of horns).

We may make the general conclusion that the regulation is equitable inasmuch as those who will pay its costs — car owners — will surely share in its benefits. We cannot conclude, however, that all those who receive benefits will contribute to the repayment of its costs. In fact, since urban dwellers are less likely to own an auto than suburban or rural inhabitants, those who receive the greatest benefits may not share in the costs at all.

A broader definition of the regulation's costs would include its side effects, such as unemployment. Using this broader definition, the regulation must be viewed as being grossly inequitable to a small minority of the population — those who would become unemployed. That passing cars would be making less noise would be cold comfort to this group.

Joint Effects With Other Government Regulations

Although our estimates have indicated that the impact of the noise control regulation will generally be quite small, the same cannot be said for the combined impact of this regulation with all current and proposed regulations. No accurate estimates of the combined impact can be made; however a rough guess would place it at 10 to 15 times of size of the noise regulation impact alone. Translated in terms of impact on aggregate prices, productivity, and employment levels, this is indeed a national economic concern of sizeable proportions, one that should be given close attention by Government officials.

It has not been our purpose to make recommendations concerning the implementation of noise regulations or any other regulations; we have tried, rather, to assess the impact of noise regulations while making no judgements concerning the ultimate policy decision. The decisions that face Government are difficult ones — ones that will require large amounts of information. This case study briefly illustrates means by which one may acquire at least part of the information needed to make these decisions.

Government officials may also want a sensitivity analysis performed in which the stringency of the noise standard is varied and the resulting impacts are weighed. In this manner, a noise standard can be found whose costs seem to balance with resulting benefits. This, in our judgement, is the only fair and rational way to set policy.

SUMMARY

The effect of noise emission standards may be summarized in terms of the maximum possible costs that will be incurred at any point in time. These are listed on the following page.

- A 60,000 unit decrease in annual new auto sales
- A 3,000 worker decrease in auto industry labor requirements
- An increase in auto industry capital requirements of no more than $10 million per year
- A decrease in the output of all auto-related industries of no more than .76 percent
- A decrease in national employment of no more than 36,000 workers
- An increase in the consumer price index of .17 points

Qualitatively, these costs are viewed as being small in comparison to the aggregate level of economic activity. The severity of their impact would depend upon the concurrent macro-economic conditions; if the maximum effect of the regulation were to occur during a recession, its impact would be more acute than if it took place during a boom.

By itself, this assessment indicates only that the costs of the regulation would not be prohibitive. It does not mean, nor is it meant to suggest, that the regulation is, or would be, worthwhile; this must be decided by policy-makers who will weigh these costs against the perceived benefits of the regulation.

CHAPTER 7

CONCLUSIONS

A REVIEW OF THE ISSUES AND FINDINGS

Aggregate Demand for New Automobiles

Our most notable finding concerning auto demand is that it is highly elastic to price changes in the short run, but almost perfectly inelastic in the long run. This means that, when prices increase, buyers may delay their purchases, but not for very long - perhaps one or two years. Such behavior can be explained intuitively in terms of:

1. The lack of good substitutes for new cars
2. The "conspicuousness" of new car ownership
3. The reliability of new cars

The implications of this finding were made clear in Chapter 6 where it was found that a price increase caused the "change-in-auto-sales" function to plummet initially, but then to rebound and become positive. That the function became positive, it was pointed out, could be attributed to a return to the market of those buyers who had initially decided to delay their purchases. This was a significant finding inasmuch as, intuitively, many might think that a price increase would result in the change-in-sales function being continually negative.

Note that this finding suggests that a short-run effect of an increase in the price of a durable good may be a temporary decrease in the marginal propensity to consume. This stands in contradiction to the traditional idea that an increase in the price of a good will lead to a substitution effect. Our findings suggest, instead, that an increase in the price of a durable good (for which no acceptable substitutes exist) will not lead to a substitution effect of any appreciable size, but, rather, to a delay in purchase and, hence, a temporary increase in the marginal propensity to save. This may be a possible direction for future research into the demand for consumer durables.

Determination of New Auto Prices

Estimating how automakers change prices in response to increases in their costs has been something of a menace to our work because it is such an uncertain issue. In Chapter Three, by fitting a regression equation to historical data, we found that, historically, automakers have adhered to the cautious, oligopolistic pricing policies that would be expected of them. We found a propensity to leave prices at current levels despite changes in costs and demand. The data also indicated, however, that manufacturers may make slight short-run adjustments in price to spur sales or, equivalently, to control retail inventory levels. It also suggested that, in the long run, increases in manufacturing costs are fully passed on to price along with an additional mark-up.

In Chapter Six, we ran two simulation experiments: one that assumed automakers would use the sticky price policy that they had historically used, and a second that assumed automakers would pull no punches — they would immediately pass through all additional costs plus mark-up to price. The results of the two simulation experiments clearly indicated that, in terms of automakers' profitability, the sticky price strategy would be the less desirable of the two; by using the cautious, oligopolist pricing strategy, the results indicated that automakers would end up paying for a large part of the regulation's cost.

From this finding, it may be concluded that, because the auto industry has historically tended to hedge on uncertainty by adjusting prices slowly, automakers will end up, as the model predicts, paying for the regulation. However, recent developments in auto industry pricing practices would lead one to conclude otherwise. As was mentioned in Chapter Three, General Motors has recently led the way in publicizing the auto industry's new, more flexible pricing policy. This new policy allows for adjustment of prices during model years – this being something of a rarity under the previous policy – which will enable manufacturers to respond to changes in costs or competitive conditions sooner than they could previously. In retrospect, it seems as though the institution of this new policy may have been hastened by the proliferation of costly Government regulations; without the new pricing policy, automakers would be paying for regulations; with the new pricing policy, they may not be.

This, although seemingly a simple point, is a major revelation of the study that was identified only after the simulation experiments were performed in Chapter Six. Only after analyzing the results of the two simulations did it become apparent that the sticky price strategy is poorly suited for the auto industry of today and would, in fact, be an irrational strategy to use given the current environmental conditions. It is this reasoning that led us, in Chapter Six, to de-emphasize the results of the price endogenous forecast and to emphasize the results of the price exogenous forecast.

This issue also raises some interesting questions that could be addressed in future research. For instance, from a marketing standpoint, the auto industry should know the relative advantages and disadvantages of making one huge price increase versus a series of small ones. A study of this type could lead to some interesting findings regarding the oligopolistic pricing model, the psychology of inflation, or consumer psychology in general.

Determination of Used Car Prices

One of the unstated sub-objectives of this study was to identify the relationship between used car prices and new car prices — a relationship that has been the subject of much discussion in the literature, but one upon which little light has been shed. We can claim only partial success on this count.

In Chapter Three, we estimated two alternative used car price equations — Equations 3.14 and 3.15. Equation 3.14 was theoretically appealing, but, after all was said and done, was judged to have multicollinearity problems; Equation 3.15 was less appealing from a theoretical perspective, but suffered from no statistical maladies. Both equations indicated that change in the level of new car price is a significant determinant of change in the level of used car price. This is an important finding inasmuch as previous authors have claimed that used car prices are totally independent of new car prices; it is less than totally satisfying in that it cannot be neatly filed on your economics bookshelf. We must conclude that, since the theory did not fit the data as well as we expected it to, the used car price/new car price issue has not been totally solved.

Clearly, this is another area where future research could be done. New findings would not come from research efforts using the same data sets that were used here, that can be guaranteed, but other data series are available and their use could lead to positive results.

The Supply Side of the Market

You will recall that the supply side of the market is the name we have given to a group of equations that explain the determination of retail inventory levels, production volume, factory sales, labor requirements, and capital requirements. On the whole, the modeling of these equations and their use in the simulation model was quite successful. Perhaps the finding most integral to the working of the model, although no great surprise, is that the level of retail inventory has an effect on pricing and production planning decisions. Also integral to the success of simulation experiments were the resource requirement equations which proved to be surprisingly accurate.

This set of equations together adds to the model's emphasis on the short-run dynamics of the market. Typically, variables such as the level of retail inventory would not be included in a macro-model — in this sense, our model is unique and somewhat more like a sales forecasting model that a corporation might use than a macro-economic model that the Government or an econometric model-building firm would use.

The Effects of Government Regulation

In Chapter Six, we demonstrated how our model could be used to evaluate the impact of a Government regulation. We drew some conclusions concerning the likely impact of noise emission regulations on the auto industry and the national economy that can now be generalized. In essence, we found that Governmental regulation of the auto industry:

- Adds to the auto industry's unit manufacturing cost
- Causes automakers to increase prices by at least as much as the amount by which costs increase
- Decreases the sales volume of the auto manufacturing industry, supplier industries, and after-market industries
- Increases the capital requirements of the auto industry
- Reduces the productivity of the auto industry
- Decreases the labor requirements of affected industries, thereby adding to national unemployment
- Adds to price inflation

We feel that we have identified the major effects of Government regulation, but believe that our list is by no means exhaustive. Certainly other less serious effects could be identified and certainly other possible, but less likely, effects could be added to the list. Practically speaking, however, we have covered the most important areas.

It should be pointed out that the desirability of Government regulations cannot be judged by these findings alone. To make such a judgement, estimates of regulations' benefits would also be required. We have intentionally avoided taking a stand on the cost-benefit issue because it is a sensitive, sometimes emotional, topic in which one who is trying to maintain objectivity should not become involved. We should, however, repeat what we stated in the introduction — that the Government has some difficult decisions to make in setting regulatory standards — and add to it what we have learned in this study — that impact assessment studies can provide valuable input to these decisions.

It should be reiterated that this study has dealt only with the costs of regulations, not the benefits. Theoretically, both the costs and benefits of a governmental policy should be measured to determine whether it is worthwhile. For this reason, we cannot draw any firm conclusions about the desirability of regulating the auto industry.

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APPENDIX A

DESCRIPTION OF DATA SERIES (all quarterly)

1. Retail Sales of New (Domestic plus Imported) Automobiles, (D)

   Source: Survey of Current Business, p. S-40, monthly issues
   Sample Mean: 2367 Scale: Thousands of units per quarter

2. Retail Sales of New Domestic Automobiles, (RS)

   Source: Survey of Current Business, p. S-40, monthly issues
   Sample Mean: 2021 Scale: Thousands of units per quarter

3. Price Index for New Cars, (P_N)

   Source: Survey of Current Business, p. S-8, monthly issues
   Sample Mean: 115.3 Scale: index (1967=100)

4. Price Index of Used Cars, (P_u)

   Source: Survey of Current Business, p. S-8, monthly issues
   Sample Mean: 119.5 Scale: index (1967=100)

5. Consumer Price Index - All Items, (CPI)

   Source: Survey of Current Business, p. S-8, monthly issues
   Sample Mean: 125.4 Scale: index (1967=100)

6. Unemployment Rate - Civilian Labor Force, (UE)

   Source: Survey of Current Business, p. S-13, monthly issue
   Sample Mean: 5.33 Scale: percentage

7. Domestic Automobile Production, (PRD)

   Source: Automobile Facts and Figures
   Sample Mean: 2064 Scale: Thousands of units per quarter

8. Number of Production Workers - SIC 3711, (EMP)

   Source: Employment and Earnings, Bureau of Labor Statistics
   Sample Mean: 270 Scale: Thousands of workers

9. Factory Sales of New Domestic Automobiles, (FS)

   Source: Survey of Current Business, p. S-40
   Sample Mean: 1961 Scale: Thousands of units per quarter

10. Retail Inventories of New Domestic Automobiles, (RINV)

    Source: Survey of Current Business, p. S-40
    Sample Mean: 1467 Scale: Thousands of units at beginning of quarter

11. Average Overtime Hours per Week – SIC 3711, (OT)

Source: Employment and Earnings, Bureau of Labor Statistics
Sample Mean: 4.8 Scale: Hours per week per worker

12. Average Weekly Hours – SIC 3711, (AWWK)

Source: Employment and Earnings, Bureau of Labor Statistics
Sample Mean: 43.5 Scale: Hours per week per worker

13. Canadian Imports of Domestic-Type Cars to U.S., (CI)

Source: Survey of Current Business, p. S-40, monthly issues
Sample Mean: 144 Scale: Thousands of units per year

14. Disposable Personal Income, (DPI)

Source: Survey of Current Business, p. S-2, monthly issues
Sample Mean: 754 Scale: Billions of current dollars – annual rates

15. Average Hoursly Earnings – SIC 3711 Production Workers, (WAG)

Source: Employment and Earnings, monthly issues
Sample Mean: 5.08 Scale: Current dollars

16. Expenditures for New Plant and Equipment – SIC 371, (I)

Source: Survey of Current Business, September issues
Sample Mean: .45 Scale: Billions of dollars per quarter

17. Deflator for Non-Residential Fixed Investment, (DEF)

Source: Survey of Current Business, p. S-2, monthly issues
Sample Mean: 100.1 Scale: index (1972=100)

18. Wholesale Price Index – Crude Materials for Further Processing, (WPI)

Source: Survey of Current Business, p. S-8, monthly issues
Sample Mean: 139.3 Scale: index (1967=100)

19. Index of Consumer Sentiment, (ICS)

Source: Business Indicators Digest, monthly issues
Sample Mean: 85.82 Scale: index (1966=100)

20. Number of Family Units, (FAM)

Source: Population Characteristics, Bureau of the Census Series P-20, No. 327
Sample Mean: 52182 Scale: Millions

21. Percentage of Families Earning $15,000 or more (1976 $)

Source: Consumer Income, P-60, No. 116, Bureau of the Census, Series

Sample Mean: 44.6 Scale: percentage

22. Percentage of Families Earning $25,000 or more (1976 $)

Source: Consumer Income, P-60, No. 116, Bureau of the Census, Series

Sample Mean: 16.1 Scale: percentage

23. Permanent Income, (PI)

Derivation: PI is calculated as a weighted average of disposable personal income for the previous nine years (or thirty-six quarters). The weights (by year) for DPI_{t-i}, i=1, 2, ... 9 are .339, .227, .152, .102, .069, .046, .031, .021, .013. The sum is then divided by CPI.

Sample Mean: 5.00 Scale: Hundreds of billions of 1967 $'s

24. Production Worker's Hourly Wage Adjusted for Overtime, (SWAG)

Derivation:

$$SWAG = \frac{(WAG/CPI) * MNHRS * 100}{MNHRS + .5 * OT * EMP}$$

Sample Mean: 3.85 Scale: Constant dollars

25. Average Production Man-hours per Week, (MNHRS)

Derivation: MNHRS = EMP * AWWK

Sample Mean: 11745 Scale: Thousands of hours

26. Labor Union Strike Dummy, (STRIK)

Derivation: STRIK is coded on the basis of the following historical data concerning labor strikes:

Year	Target Company	Approximate Length
1964	General Motors	29 days
1967	Ford	50 days
1970	General Motors	67 days
1973	Chrysler	10 days
1976	Ford	25 days

27. Automobile Stock, (S_i, i=1, 2, 3, 4, 5)

Derivation: Automobile stock of vintage i is calculated as a weighted average of past sales. For example:

$$S_{1t} = W_1 D_{t-1} + W_2 D_{t-2} + W_3 D_{t-3} + W_4 D_{t-4}$$

where D is retail sales and the W_i's are weights that represent the probability of a car i quarters old being in operation. Since there are five stock variables, there are twenty W_i's:

Stock Vintage	W_i, i=1, 2, ... 20
1	.9980, .9965, .9949, .9933
2	.9918, .9889, .9860, .9833
3	.9805, .9760, .9717, .9670
4	.9629, .9564, .9498, .9432
5	.9366, .9270, .9178, .9085

Estimates of the W_i's were obtained in (Wharton EFA, 1977).

28. Capital Stock, (K)

Derivation: K is calculated by the equation:

$$K_t = K_{t-1} + I_t - \delta K_{t-1}$$

where I is investment and δ is the depreciation rate estimated from industry financial reports to be .0325. A starting value for K was obtained from the Wharton Annual Industry Forecasting Model Data Bank.

APPENDIX B

THE INVESTMENT EQUATION — BACKGROUND

INTRODUCTION

Economists have long been concerned with the determinants of investment. The investment function had been widely discussed and analyzed even before the time of Keynes' General Theory. Since then, many different theories have been espoused. Today, as in the past, there is no single, widely agreed upon empirical explanation of investment behavior (see Jorgenson, 1970, Klein, 1974, and Eisner, 1967). Here we will briefly review a few of the major developments in the theory and the econometric study of investment behavior, concentrating on the issues that have caused a disparity of opinion.

The accelerator model of investment behavior, popularized by J. M. Clark (1917) and R. Harrod (1936), states that businesses' desired stock of capital is proportional to the level of output it desires to produce. Stated symbolically:

$$K_t^d = \alpha O_t \qquad \text{(B-1)}$$

where K_t^d is the desired stock of capital at time, t; α is the capital output ratio; and O_t is output. In this model, if the level of a business' output remains constant, its desired stock of capital will also remain constant. On the other hand, when output increases steadily, actual capacity will lag behind desired capacity, and this will prompt investment spending. Thus, this model would explain net investment by changes in output or:

$$I_t^{net} = \alpha \Delta O_t \qquad \text{(B-2)}$$

where I^{net} is net investment.

Implicit in this model of investment behavior is the assumption that capital stock adjusts instantaneously to changes in desired capital stock. It is this unrealistic assumption in the model that impelled Chenery (1952) and Koyck (1954) to develop the improved flexible accelerator model of investment.

In the flexible accelerator model, desired stock is still specified by Equation B-1; the difference introduced is in the specification of stock adjustment. The flexible accelerator model assumes that actual stock adjusts toward desired capital stock by only a proportion of the discrepancy between desired and actual capital stock (in the previous period). That is, if actual capital in period t is denoted by K_t and a weight between 0 and 1 by λ, then:

$$K_t - K_{t-1} = (1-\lambda)(K_t^d - K_{t-1}) \qquad \text{(B-3)}$$

It is interesting to note the various forms in which to express this simple equation. For example, if we successively subtract from Equation B-3, the quantity $\lambda^{\tau}\Delta K_{t-\tau}$ for $\tau = 1, 2, \ldots \infty$, we find that actual capital may be expressed as a weighted average of all past levels of desired capital:

$$K_t = (1-\lambda)\sum_{\tau=0}^{\infty}\lambda^{\tau}K_{t-\tau}^d \qquad \text{(B-4)}$$

Since $0<\lambda<1$, the weights on K^d terms form a geometrically declining series. By substituting Equation B-1 into B-4, we may express capital stock as a series of past levels of output with geometrically declining weights.

$$K_t = \alpha(1-\lambda)\sum_{\tau=0}^{\infty}\lambda^{\tau}O_{t-\tau-1} \qquad \text{(B-5)}$$

To estimate the parameters of Equation B-5, Koyck proposed a method of simplifying the equation. Rewriting Equation B-5 for capital stock at period t-1 and multiplying by λ gives:

$$\lambda K_{t-1} = \alpha(1-\lambda)\Sigma\ \lambda^{\tau} O_{t-\tau-1} \qquad \text{(B-6)}$$

and subtracting Equation B-6 from B-5 yields:

$$K_t = \alpha(1-\lambda)O_t + \lambda K_{t-1} \qquad \text{(B-7)}$$

One final change that is usually made involves specifying a model for replacement investment. The most widely used model sets replacement investment equal to depreciation and specifies a declining balance (geometric mortality) model of depreciation. Symbolically:

$$D_t = \delta K_{t-1} = I_t^R \qquad \text{(B-8)}$$

where D is depreciation, I^R is replacement investment, and δ is the depreciation rate. Further:

$$K_t - K_{t-1} = I_t - \delta K_{t-1} \qquad \text{(B-9)}$$

Now Equation B-9 is substituted in Equation B-7 so that:

$$I_t = \alpha(1-\lambda)O_t - (1-\lambda-\delta)K_{t-1} \qquad \text{(B-10)}$$

This model has been widely used, and it is generally agreed today that the flxible accelerator model represents a very sound step in the development of a theory of investment behavior. Most of the econometric work on investment functions since Koyck and Chenery has been based, at least indirectly, on their work. However, as Jorgensen, in his survey article of investment literature, points out, this is the point at which alternative opinions concerning certain aspects of investment behavior diverge. In another recent article, Klein (1974) offers a list of the salient issues in contemporary investment analysis that account for this divergence of opinion:

- Specification of a functional relationship for desired capital
- Treatment of replacement and capital consumption
- Time structure of investment decision and implementation
- Estimation methods appropriate to the investment model
- Testing of alternative models of investment behavior
- Applications to policy and forecasting

In the following sections, we will briefly review each of these issues.

SPECIFICATION

In the flexible accelerator model, desired capital is proportional to the level of output. This specification is based on the premise that, as more output capacity is required, more capital will be required. However, many theorists have offered alternative specifications, pointing out that, when firms have excess capacity, increasing output will not necessitate additional capital. Tinbergen (1938) and others have argued that desired capital should be proportional to profits, and Kuh (1963), Anderson (1964), and Evans (1969) constructed flexible accelerator models with desired capital proportional to sales. However, whether capital is specified as a function of output, sales, or profits, the same capacity accelerator principle underlies the specification.

Jorgenson's (1968) model is quite different; he bases his specification of desired capital on the neoclassical theory of investment behavior (Modigliani and Miller (1958)), which posits desired capital to be determined by the optimal time path for capital accumulation. Corresponding to Jorgenson's specification of desired stock is the requirement that a Cobb-Douglas production function be assumed. Thus, Jorgenson's model has a strong theoretical foundation, but may not be applicable in all cases.

In Klein's discussion of the specification of desired capital, he concluded that, no matter what underlying theoretical structure is assumed, the final model will always be approximate. He stressed that the objective of econometric specification should be to obtain a reasonably good approximation rather than a perfect model.

REPLACEMENT AND CAPITAL CONSUMPTION

In most of the empirical investment studies that incorporate replacement investment explicitly, replacement investment is specified as a fixed proportion of capital stock. Replacement investment is assumed to be equal to capital consumption (or in accounting terminology, depreciation). This model of capital consumption corresponds to a geometric mortality distribution (or the declining balance method of depreciation).

Jorgenson believes that the incorporation of replacement requirements in the flexible accelerator model is a significant extension. In contrast, Klein asserts that it is difficult to identify any particular investment outlay as being strictly for replacement in whole or in part. There have been no serious attempts to include other types of depreciation methods in investment equation specifications.

TIME STRUCTURE

The stages of the investment process include:

- Planning the investment project
- Appropriation of funds
- Preparation of blueprints
- Construction or fabrication
- Modification
- Installation or actual investment

These stages occur sequentially, as a general rule; however, there is obviously quite a bit of overlap in practice.

The "change in the demand for capital services" is an event that occurs either before the sequence shown above or during the planning stage. The usual way to forecast investment spending is to attempt to relate "changes in demand for capital services" to subsequent spending.* Since there are a whole sequence of events that take place between "changes in demand" and actual investment, the "changes in demand" proxy variable (which may be output, sales, profits, etc.)

* Investment intentions surveys are a bit different; since these are yearly surveys, most of the "intended investment" is really construction in progress or continuation of projects.

appears in the forecasting equation at a lag. Since the lag between "changes in demand for capital services" and "actual investment" varies (e.g., it may be three months for one project and six months for the next), a probability distribution is fit to the lag. This is called a distributed lag.

Several alternative lag distributions have been used for this purpose. Koyck used the geometric lag distribution in which the most recent time period is accorded the greatest weight, and the weights for following time periods are geometrically decreasing. Solow improved upon this by using the Pascal distribution (a convulsion of two similar geometric distributions). Jorgenson has used the general Pascal distribution which, theoretically, can approximate any type of shape of lag distribution.* Jorgenson seems to have brought the state-of-the-art in lag distributions to its ultimate and final resting point.**

ESTIMATION

There are two major estimation problems that are frequently encountered in investment studies. One problem that arises quite often when working with investment equations and distributed lag models in general is that the explanatory variables are collinear. Sometimes, when a distributed lag is

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* The general Pascal or rational distributed lag is employed in the investment equation presented in Chapter Four.

** See Jorgenson (1966).

specified in terms of rates of change (first differences) of the two variables, this problem is corrected. However, because of theoretical considerations, this may not always be appropriate. The work of Almon (1965) on finite distributed lags is an attempt to deal with this problem.

Another difficulty in estimating distributed lag models is that, due to the presence of one or more lagged dependent variables in the estimation form of the equation, ordinary least squares estimates of the parameters are inconsistent. P. J. Dhrymes, L. R. Klein, and K. Steiglitz, in an article entitled "Estimation of Distributed Lag" (International Economic Review, 1970), proposed a method for obtaining maximum likelihood estimates of the parameters in a distributed lag equation. The method involves a simple algorithm that begins with a set of consistent estimates obtained by Liviatan-type instrumental variable estimation and, based on an iterative prefitering and estimation process, ends with the maximum likelihood estimates. Maddala and Rao in another article proposed a similar technique based on the Dhrymes, et al., method for obtaining maximum likelihood estimates of distributed lags. Both of these studies have supplied useful estimation tools.

TESTING

Although the specification of desired capital, the time structure of the model, and the treatment of replacement investment are all important theoretical aspects of an investment equation, a better means of comparing alternative models is extrapolative simulation tests. Regardless of model structure, ultimately a model must be evaluated on the basis of multi-period ex-post simulation tests.

APPLICATIONS

For many applications of investment analysis, it may be plausible to use an already existing investment function; however, in other cases, none may be appropriate. Certainly for a particular application, certain specifications of investment may not be useful, and there are inevitable trade-offs as well. As Klein (1974, p. 48) avers, "It is just as important to estimate an investment process as part of an overall model as it is to incorporate the latest twists of the investment specialists. It is not very difficult to adapt "garden-variety" approximations to flexible accelerator functions . . . and produce results that are more plausible than those obtained from stricter adherence to optimization theory."

There are many variations to investment function analysis. Dale Jorgenson is at the forefront of the field; however, as Klein convincingly argues, Jorgenson's work has not resulted in the obsolescence of all previous work. "Many different schools of thought still have much scope for backing their entries." (p. 46)

APPENDIX C

DERIVATION OF INPUT/OUTPUT COEFFICIENTS

AUTO PARTS AND ACCESSORIES INDUSTRY, SIC 3714

Since the interindustry input/output tables combine SIC's 3711 and 3714 under the name "automobile industry", an estimate of SIC 3711's requirements for input from SIC 3714 is not given in the tables. This coefficient has been estimated on the basis of other data.

The 1972 Census of Manufacturers indicates that 76 percent of the SIC 3714 industry product was shipped (transferred) to U.S. motor vehicle manufacturers or their suppliers for use in original equipment. Of these shipments, we estimate that 95 percent of the total value goes to plants classified in SIC 3711. Therefore, about 72 percent of SIC 3714 value of shipments goes directly to SIC 3711.

Given that passenger cars account for about 76 percent of SIC 3711 value of shipments, we estimate that 55 percent (.72 x .76) of all SIC 3714 products are used in original equipment for passenger automobiles. This estimate is equivalent to an input/output coefficient in the information it conveys; it could be transformed to a direct requirements coefficient, which would indicate requirements for SIC 3714 input per dollar of SIC 3711 output, or to a transactions figure, which would indicate the transfer from SIC 3714 to to SIC 3711 in terms of dollar value. A total (direct plus indirect) requirements coefficient can also be derived from the data, since we know that about 58 percent (.76 x .76) of all SIC 3714 values of shipments is transferred either directly or indirectly to SIC 3711.*

EMPLOYMENT INPUT/OUTPUT

Interindustry employment tables published by the U.S. Department of Labor, Bureau of Labor Statistics, can be used to determine the dependence of employment levels in auto-related industries on the level of output in the auto industry. These tables show the employment required directly and indirectly per $1 billion of delivery to final demand by each of 129 different industries. One shortcoming of the tables is the industry classification scheme used – industries are categorized to only three SIC digits. Thus, the passenger automobile industry (SIC 3711) is not separated from the rest of the motor vehicles industry (SIC 371), which includes production of trucks, buses, tanks, etc. However, because the suppliers for the entire motor vehicles industry are basically the same, the table may still provide good estimates of the employment effect arising from a change in the sales of passenger automobiles (SIC 3711).

Where estimates of the employment requirements from four-digit SIC's have been made on the basis of three-digit SIC figures, output requirements have been used as the determining factor. For example, the employment requirement

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* 1972 Census of Manufacturers, U.S. Department of Commerce, 1974.

of SIC 2011 can be estimated from the employment requirement of SIC 201 by:

1. Finding the auto industry's total input requirements (in dollars) from SIC 201 and from SIC 2011
2. Taking the ratio of the two
3. Multiplying this ratio times the labor input requirement from SIC 201

Detailed input/output tables follow.

Table C.1

Direct Material Requirements of Automobile Manufacturing Industry

SIC Code	Title	Direct Requirements per Dollar Output
331	Blast Furnace and Basic Steel Products	.03219
332	Iron and Steel Foundries	.02483
2393-9	Fabricated Textile Products	.01408
3462	Iron and Steel Forgings	.01166
3211, 3229, 3231	Glass Products	.00804
3361	Aluminum Castings	.00513
3079	Miscellaneous Plastics Products	.00387
2851	Paints and Allied Products	.00340
3351	Copper Rolling and Drawing	.00283
3357	Nonferrous Wire Drawing and Insulating	.00148
3355	Aluminum Rolling and Drawing	.00125
3399	Primary Metal Products	.00105
2861, 289	Miscellaneous Chemical Products	.00094
3369	Nonferrous Castings	.00089
3392	Nonferrous Forgings	.00075
3334	Primary Aluminum	.00056
2821	Plastics Materials and Resins	.00055
281	Industrial Organic and Inorganic Chemicals	.00045
3339	Primary Nonferrous Metals	.00041
3362	Brass, Bronze, and Copper Castings	.00029
3332	Primary Lead	.00021

Source: Input/Output Structure of the U.S. Economy: 1967 Direct Requirements for Detailed Industries, U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of Economic Analysis, 1974.

Table C.2

Total Material Requirements Per Dollar of Final Demand: Major Input Requirements from Other Industries

SIC Code	Title	Total Requirements per Dollar Output
331	Blast Furnaces and Basic Steel Products	.12544
332	Iron and Steel Foundries	.04149
2393-9	Fabricated Textile Products	.02086
3462	Iron and Steel Forgings	.01815
281	Industrial Chemicals	.01678
3211, 3229, 3231	Glass Products	.01426
3031, 3069	Miscellaneous Rubber Products	.01081
3079	Miscellaneous Plastics Products	.01071
3361	Aluminum Castings	.00924
3351	Copper Rolling and Drawing	.00898
3334	Primary Aluminum	.00876
3355	Aluminum Rolling and Drawing	.00749
2851	Paints and Allied Products	.00701
3331	Primary Copper	.00699
2821	Plastics Materials and Resins	.00646
3357	Nonferrous Wire Drawing and Insulating	.00532
3339	Primary Nonferrous Metals	.00406
3333	Primary Zinc	.00220
3332	Primary Lead	.00173

Source: Input/Output Structure of the U.S. Economy: 1967 (Volume 3): Total Requirements for Detailed Industries), Supplement to The Survey of Current Business, U.S. Department of Commerce, 1974.

Table C.3

Direct Input Requirements from Automobile Parts and Accessories Supplier Industries

Industry	Direct Automobile Manufacturing Industry (SIC 3711) Purchases (percent of total output)	Direct Requirements of SIC 3711 per Dollar of Delivery to Final Demand
Motor Vehicle Parts and Accessories	55%[1]	.248
Tires and Inner Tubes	5.8[2]	.01015
Automotive Stampings	31[1]	.05082
Engine Electrical Equipment	17[2,3]	.01093
Storage Batteries	4.6[2,3]	.00138
Electric Lamps	3.3[2,4]	.00109
Brake Linings, Disc Brake Pads, Clutch Facing	19[1,3]	.00115
Carburetors, Pistons, Rings, and Valves	40[1,3]	.00919
Mechanical Rubber Products	21 [1,3]	.00524
Vehicular Lighting Equipment	N/A	N/A
Refrigeration and Heating	8 [1,3]	.01022
Screw Machine Products	14[1,3]	.00718
Hardware	29[1,3]	.01574

1 Estimated by procedure previously described.

2 Source: Input/Output Structure of the U.S. Economy, U.S. Department of Commerce, Bureau of the Census, 1974. (Adjusted to remove purchases made for manufacture of trucks and buses.)

3 Indicates combined purchases of SIC 3714 and 3711 for manufacture of passenger automobiles.

4 Combination of electric lamp and vehicular lighting equipment industries.

Table C.4

Number of Relevant Captive Establishments Owned by the "Big Four"

SIC Code	Industry	American Motors	Chrysler	Ford	General Motors
2851	Paints	0	1	1	0
3211	Sheet Glass	0	1	2	0
3312	Steel	0	0	1	0
3321 3322	Iron Foundries	0	4	3	12
3361	Aluminum Foundries	0	0	1	2
3369	Nonferrous Foundries	0	2	0	0
3462	Steel Forgings	0	2	1	0
3465	Automotive Stampings	1	7	4	8
3519	Diesel Engines	0	1	0	3
3562	Ball and Roller Bearings	0	0	0	2
3592	Carburetors, Pistons, Rings, and Valves	0	0	1	1
3621	Motors and Generators	0	0	0	2
3647	Vehicular Lighting Equipment	0	0	0	1
3651	Household and Auto Radios	0	0	0	1
3691	Storage Batteries	0	0	0	2
3694	Engine Electrical Equipment	1	1	0	3
3544	Special Dies and Tools	0	1	1	2
3929	Hardware	0	0	0	5
3357	Drawing and Insulating of Nonferrous Wire	0	0	0	1
3079	Miscellaneous Plastic Products	0	0	0	2
	Totals	2	19	15	47

Source: Dun & Bradstreet Reference Book of Manufacturers, Dun & Bradstreet, Fall, 1975, as cited in Economic Impact Analysis of Regulations on the Automotive Industry — Industry Description, A. T. Kearney, Inc., 1977.

Total Employment (Direct and Indirect) per Billion Dollars of Delivery to Final Demand, 1970

(Producer's Value - 1963 Dollars)

Industry Code	Motor Vehicles
Livestock and Liverstock Products	125
Crops and Other Agricultural Products	247
Forestry and Fisheries	21
Agriculture, Forrestry, and Fishery Services	63
Iron Ore Mining	127
Copper Ore Mining	109
Other Nonferrous Metal Ore Mining	84
Coal Mining	244
Crude Petroleum	142
Stone and Clay Mining and Quarrying	76
Chemical and Fertilizer Mining	16
New Residential Building Construction	0
New Nonresidential Building Constr.	0
New Public Utilities Construction	0
New Highway Construction	0
All Other New Construction	0
Maintenance and Repair Construction	446
Guided Missiles and Space Vehicles	5
Other Ordnance	30
Food Products	115
Tobacco Manufacturing	2
Fabric, Yarn, and Thread Mills	704
Miscellaneous Textiles and Floor Coverings	299
Hosiery and Knit Goods	40
Apparel	124
Miscellaneous Fabricated Textile Products	285
Logging, Sawmills, and Planing Mills	178
Millwork, Plywood, and Other Wood Products	227
Household Furniture	49
Other Furniture	10
Paper Products	285
Paperboard	205
Publishing	344
Printing	340
Chemical Products	505
Agricultural Chemicals	13
Plastic Materials and Synthetic Rubber	194
Synthetic Fibers	145
Drugs	9
Cleaning and Toilet Preparations	14
Paint	210
Petroleum Products	88
Rubber Products	821
Plastic Products	722
Leather, Footwear, and Leather Products	30
Glass	560
Cement, Clay, and Concrete Products	73
Miscellaneous Stone and Clay Products	268
Blast Furnaces and Basic Steel Products	3256
Iron and Steel Foundries and Forgings	2594
Primary Copper Metals	54
Primary Aluminum	109
Other Primary and Secondary Nonferrous Metal	124
Copper Rolling and Drawing	165
Aluminum Rolling and Drawing	216

Industry Code	Motor Vehicl
Material Handling Equipment	73
Metalworking Machinery	1409
Special Industry Machinery	107
General Industrial Machinery	808
Machine Shop Products	1898
Computers and Peripheral Equipment	33
Tipwriters and Other Office Machines	22
Service Industry Machines	715
Electric Transmission Equipment	160
Electrical Industrial Apparatus	405
Household Appliances	88
Electric Lighting and Wiring	432
Radio and Television Sets	207
Telephone and Telegraph Apparatus	50
Other Electronic Communication Equipment	88
Electronic Components	436
Other Electrical Machinery	657
Motor Vehicles	26,651
Aircraft	126
Ship and Boat Building and Repair	51
Railroad and Other Transportation Equipment	12
Miscellaneous Transportation Equipment	14
Scientific and Controlling Instruments	744
Medical and Dental Instruments	30
Optical and Ophthalic Equipment	21
Photographic Equipment and Supplies	45
Miscellaneous Manufactured Products	117
Railroad Transportation	873
Local Transit and Intercity Bus	93
Truck Transportation	1589
Water Transportation	72
Air Transportation	250
Other Transportation	65
Communications, except Radio and TV	513
Radio and TV Broadcasting	134
Electric Utilities	325
Gas Utilities	103
Water and Sanitary Services	27
Wholesale Trade	3656
Retail Trade	1326
Finance	698
Insurance	478
Owner-Occupied Dwellings	0
Other Real Estate	292
Hotels and Lodging Places	200
Other Personal Services	141
Miscellaneous Business Services	1727
Advertising	141
Miscellaneous Professional Services	637
Automobile Repair	764
Motion Pictures	84
Other Amusements	71
Health Services except Hospitals	32
Hospitals	5
Educational Services	13

Table C.5 (Cont'd.)

Other Nonferrous Rolling and Drawing	125	Nonprofit Organizations	1[illegible]
Miscellaneous Nonferrous Metal Products	714	Post Office	5[illegible]
Metal Containers	36	Commodity Credit Corporation	
Heating Apparatus and Plumbing Fixtures	66	Other Federal Enterprises	[illegible]
Fabricated Structural Metal	205	State and Local Government Enterprises	2[illegible]
Screw Machine Products	2542	Directly Allocated Imports	
Other Fabricated Metal Products	2103	Transferred Imports	
Engines, Turbines, and Generators	379	Business Travel, Entertainment, and Gifts	
Farm Machinery	29	Office Supplies	
Construction, Mining, and Oilfield Machinery	120	Total	72,6[illegible]

Source: The Structure of the U.S. Economy in 1980 and 1985, U.S. Department of Labor, Bureau of Labor Statistics, 1975, pp. 254-255.

APPENDIX D

AUTO MANUFACTURERS' PRICING PROCEDURES

INTRODUCTION

The most detailed, publicly available information concerning automobile manufacturers' pricing procedures comes from the testimony of auto industry executives before various Congressional committees. In 1955 and 1958, industry officials testified before the Senate Subcommittee on Anti-Trust and Monopoly during Congressional hearings into administered prices in the U.S. economy. In 1968, hearings on planning, regulation, and competition in the automobile industry took place before the Senate Select Committee on Small Business and, in 1975, auto executives appeared before the Automobile Industry Task Force of the House Committee on Banking, Currency, and Housing.

GENERAL MOTORS*

General Policy

If one certainty about automobile industry pricing procedures came out of all Congressional hearings, it is the application of standard volume pricing at General Motors. Standard price under the standard volume concept is developed by:

- Determining rated plant capacity
- Setting standard volume expressed as a percentage of rated capacity

* This section as well as the discussions of pricing procedures at Ford, Chrysler, and AMC is a condensation of material from the U.S. Department of Transportation National Highway Traffic Safety Administration, Office of Automotive Fuel Economy, Data and Analysis for 1981-1984 – Passenger Automobile Fuel Economy Standards, Document I, Automotive Demand and Marketing, February 28, 1977.

- Identifying the firm's total investment (this includes investment in plant and other fixed assets plus gross working capital requirements at standard volume)
- Determining direct labor and material costs for each unit at standard volume
- Identifying all indirect production costs and all fixed expenses associated with carrying on the firm's business
- Allocating all indirect costs and fixed expenses to standard volume units
- Identifying a percentage return on total investment which will yield a certain return on net worth
- Establishing a price per unit which will include at standard volume all variable and fixed expenses plus an increment which on the average will yield the target return on net worth.

Determining Standard Volume

At GM, standard volume is expressed as 80 percent of rated capacity and rated capacity is 16 hours or two shifts* of production for 225 days or 45 five-day weeks.** Standard volume is a measure used for planning purposes. Many organizations equate standard volume with average expected capacity over some planning horizon (five years perhaps). Thus, because of the seasonality of production and unexpected changes in demand, actual volume and standard volume for any period usually differ.

Capital Employed and Net Worth

Whether the terms "capital employed" and "net worth" are synonomous is a source of misunderstanding. Although GM officials, including Harlow Curtice in 1958 and Albert Bradly in 1955, assured the Anti-Trust and Monopoly Subcommittee that they are identical, according to an article published by former

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* (U.S. Congress, 1958), pt. 6, p. 2521.

** (U.S. Congress, 1955), pt. 7, p. 3584.

GM executive Donaldson Brown, they are not. In Brown's articles, the term "capital employed" is a broader concept than "net worth" – the former includes gross working capital and the latter does not.* The Judiciary Committee Report on the 1958 hearing commented on this discrepancy; the report concluded that "capital employed" and "net worth" were not synonomous terms and that, given GM's asset base and net worth, an annual return of 15 percent on the asset base would provide a return of about 20 percent on net worth (both returns being after tax).**

Determining Costs and Using the Standard Volume Concept

It appears from Curtice's 1958 testimony that GM is able to identify its direct costs of production without much difficulty.

> "Certain unit costs are relatively easy to determine. These are the so-called direct costs of production, labor, material, services, and so forth. Our production engineers and cost estimators know, of course, the amount paid for each purchased part that goes into an automobile. They carefully determine the quantity of various kinds of raw material used in producing each car and ascertain costs in this area. They estimate the hours of labor required in manufacturing and assembling operations and convert this to a dollars and cents figure. In this way, the direct costs of producing each car are developed.

> "The so-called fixed costs include: supervision, maintenance; depreciation; tooling, styling, and engineering costs; and administration expenses, insurance, and local taxes.

> "How do we make use of the standard volume concept? First, labor and materials costs that are directly applicable to each unit produced are calculated on the basis of current wage rates and material prices. Indirect or overhead costs are then determined on a

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* (Brown, 1924, pp. 218-238.

** (U.S. Judiciary Committee, 1958), p. 105.

cost per unit basis by distributing them over the determined standard volume."*

Curtice testified that the standard volume method of estimating unit costs provides GM with a benchmark against which the actual cost-price relationship can be evaluated. He said that "... the method provides us with a consistent set of cost data ... measures by which we can gauge the efficiency of our performance, from month to month, and from year to year."**

Further insight into the mechanics of the standard volume pricing method is given in a 1957 Wall Street Journal article that reports in-depth conversations with industry executives.**

> "The pricing procedure begins with the assignment of an 'asset base' to each division. Target return pricing is applied to all principal products of the corporation.
>
> "For illustration, say the division's asset base is set at $600 million. The division will be required to earn a certain return on this asset base, say 30% before taxes. At year's end, it is expected to turn over to the corporation $180 million in earnings.†

In the hypothetical case described in the article, the division knows its required profit even before costs are estimated. The article also makes clear that unit profits are not the same for all models. Profits may be shaved on

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* (U.S. Congress, 1958), pt. 6, p. 252.

** Cordty, D., Wall Street Journal, December 10, 1957.

† Ibid.

one model and recouped on another. Stripped versions may be sold for little profit while accessories not only carry their share of profits, but help to make-up the loss on stripped models.

Another source of pricing information is published in the 1968 Hearings. Prior to the hearings, the Senate Select Committee on Small Business requested each manufacturer to submit a breakdown by model of the increase in price which would be directly attributable to compliance with the Initial Federal Motor Vehicle Safety Standards. This request followed statements by the automobile firms that compliance with safety standards would necessitate substantial price increases in 1968 models.

In response to this request, GM President Roche stated, somewhat in contradiction to earlier company statements,* that GM's basic car prices were determined by the firm's competitive position and were established model by model in the light of many factors, including costs. He said that prices were not determined as the sum of the "prices" of the parts of each model and that only those parts which were sold separately – as options or accessories – were priced individually.

FORD MOTOR COMPANY

At the 1958 Hearings, Theodore Yntema, Ford's Vice

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* In all fairness to GM, however, both statements are probably true. Cost increases do cause price increases, but these price increases cannot be identified for individual models.

President of Finance, described pricing activities at Ford in very broad terms. According to his testimony, price determinations at Ford focused more on what the competition was doing than on a predetermined profit target. He emphasized that there was an enormous amount of study on what competitors were charging for each model, including accessories and all the hundreds of possible model/accessory combinations. The essence of his comments was that, while costs provide Ford with a price floor, competitors provide a price ceiling. He stated that Ford did not have a predetermined target figure in mind when establishing price.

Yntema stated that the range of discretion in setting car prices on a car line is small, usually less than $100. Ford, he said, found it impossible to price substantially below competition and still make a reasonable profit. In fact, at times they have to price car lines below cost to remain competitive, Yntema claimed.

In June 1968, Ford President Secrest replied to the Senate's request for information on the pricing effects of safety standards. He stated that to ascribe a portion of a given price change solely to a safety standard or to any other specific design change would be virtually impossible.

CHRYSLER CORPORATION

L. L. Colbert, President of Chrysler, described a pricing procedure in which fixed costs were allocated on the basis of a long-term average annual volume. He did not state what constituted that volume. He indicated that, in the early stages of a new model's development, particular attention was directed toward identifying cost increases or decreases resulting from design specification changes.

According to Colbert, Chrysler takes competition into consideration by estimating the cost changes and prices of competitors and then by pricing as close to the competition as possible. He testified that his firm could not price as low as the competition because Chrysler did not have the requisite volume.

In 1968, Chrysler President Virgil Boyd responded to the Senate committee's request for price information. He indicated that initial prices were based on the expectation of a reasonable profit over total costs. After this determination, each such price was reviewed against the competition and adjustments in the price of each model were made. For these reasons, he said it was impossible to attribute any specific price change for a particular model to only one item of increased cost.

Boyd stated further that it would not be possible to segregate the cost of such improvements with any degree of accuracy.

> "It would certainly not present an accurate picture of our costs if we simply were to include the cost of labor and material involved in adding any particular item at the production level. We would have to consider the added cost in engineering and development work, the increased cost of necessary administrative procedures, and many other such added indirect costs. We do not isolate our indirect costs in this manner, rather we deal with them in the aggregate based on the overall job that has to be done.*

* (U.S. Senate, 1968).

Boyd was explicit in stating that the cost change involved in a particular model does not necessarily reflect itself directly in the price of that model.

AMERICAN MOTORS CORPORATION

The testimony of George Romney, President of AMC, to the 1958 Senate Subcommittee was not very explicit. In general terms, he described AMC as a company that had to set price within the margins provided by GM and Ford. He stated that, if GM reduced its prices, the other three would have to follow or else suffer the economic consequences. He said that, if GM were compelled to earn a so-called "average" profit, the other companies would be forced to operate at their break-even point, and firms, such as AMC and Chrysler, would be pushed out of business.

In 1968, W. V. Luneburg, President of AMC, in responding to the Congressional request for pricing information, stated that the prices of AMC cars were established "primarily through the evaluation of competitive factors in the marketplace."* He stated further than such a policy was the appropriate and only feasible course of action for the smallest producer in the industry.

Luneburg, like the other three automobile company presidents, stated that cost data was confidential, and, furthermore, the cost of meeting safety standards was only one of several factors taken into account in pricing.

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* (U.S. Senate, 1968).

A GENERAL PRICING FORMULA FOR THE INDUSTRY

Although parts of the testimony of industry executives may seem to be contradictory, as a whole, the testimony provides a consistent picture of industry pricing.* By taking the liberty of reading between the lines, one may conclude that all four automakers use essentially the same pricing procedure. The only difference is that for AMC, Chrysler, and Ford competitors' prices have greater influence on pricing decisions than they do for GM. As a consequence, AMC, Chrysler, and Ford have less "control" over their target returns than does GM.

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* Although no information about the pricing procedures of foreign manufacturers is available, assume that their procedures are similar to domestics.

APPENDIX E

CHANGES IN THE DISTRIBUTION OF AUTO SALES (BY SIZE, CLASS, AND TYPE) RESULTING FROM NOISE REGULATIONS

INTRODUCTION

Price increases resulting from noise regulation of automobiles may affect the size-class distribution of auto sales since some models may increase in price and others may not. To estimate how the sales distribution of models will change, one must first estimate how the prices of various models will change; and, to do this, one must identify automakers' motivation for changing prices in various ways. The question must be put in proper perspective by considering current and future aspects of the market and industry that are particularly pertinent.

TWO RECENT PROJECTIONS OF AUTO SALES DISTRIBUTION

Two recent studies of the effect of passenger automobile fuel economy standards have projected the future distribution of passenger automobiles by size-class. In the first study, Data and Analysis for 1981-1984, Passenger Automobile Fuel Economy Standards, conducted by the U.S. Department of Transportation, National Highway Traffic Safety Administration, a baseline projection of sales by size-class was made using the TSC/WEFA* automobile demand model. The projection showed a marked shift from subcompact and mid-size autos to full-size

* The Transportation Systems Center (TSC)/Wharton Econometric Forecasting Associates (WEFA) model was constructed by WEFA for TSC.

and luxury classes with little change in the compact class. The projected shift can be attributed to the baseline assumptions of the forecast which include certain demographic trends (an older population and fewer licensed drivers per family) and economic forces (income increases and fuel economy improvements which more than offset the effects of increasing fuel and car prices). The assumed scenario did not consider the effect of fuel economy regulations on product mix since this effect was expected to be minor. The projection, summarized in Table E.1 considered a base case, although admittedly a pessimistic case from a fuel conservation standpoint.

In another study, prepared for the Transportation Systems Center by Arthur D. Little, Inc., a baseline size-class projection of automobile sales was made on the basis of consumer survey results. A national sample of new car buyers was asked which car they would buy in each of five possible future scenarios. The results of the survey showed definite trends in the tastes and attitudes of the new car buying public. The projection of car sales by size-class, which is also presented in Table E.1, indicates that by 1980 the distribution will shift slightly toward small cars, and by 1985 small cars will constitute 62 percent of the total market.* The great shift in sales distribution between 1980 and 1985 was attributed to: (1) differences in the physical characteristics of the models offered by manufacturers, a change resulting from fuel economy regulations, and (2) increased small car demand arising from

* The 1985 projection was taken from "Subcompacts Set Pace for Future Car Design," Automotive News, December 26, 1977, p. 8. This projection includes consideration of the effect of Government regulation.

Table E.1

Product Mix Projections

Projected Distribution

	DOT/NHTSA			ADL - TSC		Actual
Category	1977	1980	1985	1980	1985	1977
Subcompact	22.	20.	17.	20.	35.	27.
Compact	19.	20.	21.	30.4	27.	26.
Mid-Size	25.	23.	23.	25.	29.	23.
Full-Size	34.	37.*	39.*	24.3	9.	24.

Sources:
1. Data and Analysis for 1981-1984, Passenger Automobiles Fuel Economy Standards, USDOT/NHTSA, 1977.
2. Study of Automobile Market Dynamics, Volume 1: Description, Arthur D. Little, Inc., for Transportation Systems Center, 1977.
3. Automotive News, December 26, 1977.

* Includes luxury class.

improvements in small car design (e.g., safety, interior roominess, dieselization). The car category definitions used in the ADL study are slightly different than those used by DOT/NHTSA.

Since the ADL study did not produce any short-term projections, we have no way to test the accuracy of their forecasts; these projections must, therefore, be judged skeptically. However, as shown in the table, DOT/NHTSA did make a projection for the 1977 distribution of car sales; this provides an objective criterion — a comparison of their projection for 1977 with the actual 1977 results — for evaluating the accuracy of their projections. Such a test reveals that the 1977 projection overestimated the sales share of full-size and mid-size cars and underestimated that of compact and subcompact cars. And, since the distributions projected for 1980 and 1985 are quite similar to the 1977 projection (i.e., all are highly skewed to the small-size side of the distribution), one may guess that projections for all future years are similarly biased.

Because the 1985 projections from both the ADL and DOT/NHTSA studies seem equally incredible — one projecting a 35 percent share for subcompacts and the other projecting a 39 percent share for full-size cars — the best projection for the size distribution of automobile sales in 1985 may be much closer to the actual 1977 size distribution than either of them. A forecast for 1985 that lies somewhere between NHTSA's and ADL's is more credible, albeit more conservative.

KEY VARIABLES AFFECTING SIZE-CLASS DISTRIBUTION

It is useful to speculate as to why the DOT/NHTSA and ADL projections may be off the mark. By examining the differences in the underlying assumptions of each of the projections and further by identifying other information that was not considered in either projection, possible sources of error in the projections become apparent.

Many contributing factors together determine the size-class distribution of new car sales. Key factors among the total set include:

- Demographic variables
- Income and income distribution
- Consumer tastes
- Relative prices of models (including operating costs)
- Types of models offered by manufacturers

Demographic variables have a strong effect on the types of automobiles purchased; both DOT/NHTSA and ADL emphasized this in their reports and both have satisfactorily used current information to project future demographic conditions. Many population characteristics are rather easy to project; for example, since the number of male and female children born in 1960 is known, the 1985 population of twenty-five year olds of each sex can be accurately estimated. Projections of other demographic variables such as the average number of persons per family and the geographic distribution of the population are more difficult to predict, but even educated guesses may be fairly accurate.

Disposable personal income and its distribution among the population also affect auto sales by type. Income variables are difficult to accurately forecast many years in advance; projections from the large econometric models, when coupled with intuition, provide the best forecasts available. Once again, both the DOT/NHTSA and the ADL studies have considered the effects of income and its distribution satisfactorily.

Consumer attitudes and tastes must also be acknowledged as a factor determining the characteristics of future demand for new automobiles. In the past fifteen years, there has been a shift in new car buyers' preferences toward small cars. Admittedly, from a statistical viewpoint, this shift could be explained by demographic variables such as the increasing number of young, single, two-person and three-person households. Using the same statistical model as a forecasting tool, one would predict that, if the trend in demographic variables reversed itself, then the shift toward small cars would also subside. This is essentially the procedure used in generating the DOT/NHTSA projections.

The problem with this strictly objective type of analysis is that it neglects the considerations that the ADL study is chiefly concerned with, that is, the effects of changes in consumer tastes. Since small cars have become increasingly popular with a generation of new car buyers, market inertia alone should insure the continued popularity of small cars in the near future. Marketing studies have repeatedly shown that habit is an important determinant of consumer buyer behavior even for big-ticket items. Driving a small car may have become a habit for some; being more energy conscious may have become a habit for others. This same generation may continue to buy small cars or perhaps small station wagons when they form households and have children.* Thus, perhaps one reason for the apparent bias in the DOT/NHTSA projection is its failure to consider consumer tastes.

Another important determinant of the future size-class distribution of automobiles is the distribution of size-class prices or the relative prices of models. Will small cars become more expensive relative to large models, or will the opposite be true? The DOT/NHTSA projection is based on certain assumptions concerning the costs of owning and operating an automobile of which retail price is only a part. These assumptions, however, are not made explicit in the presentation of their work. Since there is no discussion of changes in the relative prices of models, they have probably assumed that no changes will occur. The ADL study takes no account of price changes whatsoever. Therefore, it must be judged as lacking in this regard.

The question of how relative model prices will change may have been skirted in both of these baseline projections because its answer depends upon the elusive answer to a related question: how will the physical characteristics of automobile models change? Since baseline projections are based on the most likely scenario and since information concerning future automobile designs may have been considered

* Although one is tempted to attribute the resurgence of full-size car sales during 1976 and 1977 to demographic changes, the 1978 sales distribution indicates that it was more likely a case of the forbidden fruit effect.

uncertain at the time the projections were made, it may have seemed reasonable at that time to dismiss such information as speculation.

Now much more reliable information is available. Central to manufacturers' plans for future design of automobiles are Federally mandated fuel economy requirements. Manufacturers are now making known their strategies for complying with this mandate.

For each model year between now and 1985, Congress, by passing the Energy Policy and Conservation Act of 1975, requires auto manufacturers to achieve a sales-weighted average fuel efficiency for their new cars. Each year the target sales-weighted average mpg increases. The standards are as follows:

Year	mpg	Year	mpg
1978	18	1982	24
1979	19	1983	26
1980	20	1984	27
1981	22	1985	27.5

If a manufacturer (including foreign manufacturers) does not meet the sales-weighted standard mpg, he will be penalized. For every one mile per gallon that the manufacturer's fleetwide average fuel economy falls short of the established requirement, a penalty of $5 per car (for every car in the fleet) will be levied.* Thus, if a manufacturer fails to comply with the requirements, his penalty could be very large. The Act also provides that manufacturers are given credits when their fleetwide average fuel economy

* A provision of The Energy Tax Act of 1978 is that the penalty may be raised to $10 per car at the discretion of the Secretary of the Department of Energy.

exceeds the requirements. Credits will not be paid in cash, but they can be used to offset penalties incurred within one year prior or subsequent to the year of penalty.

Auto companies have two possible strategies for meeting future fuel economy standards:

- Shift the distribution of their sales to small cars
- Improve the fuel economy of all models

The first strategy, by itself, is relatively unattractive, especially as a long-run solution. With the fuel economy of current models and the current characteristics of demand, no company could possibly meet the 1985 fuel economy standards simply by trying to sell more small cars and fewer large cars – consumers would not tolerate it, especially if competing automakers did not follow suit. It seems as though this strategy would not stand alone; if it were used, it would have to be used in conjunction with a program aimed at improving the fuel economy of all of an automaker's models.

Not surprisingly, GM, Ford, and Chrysler have all publicly announced that they plan to use the second strategy. They will do this by reducing the weight (and size) of models, expanding use of economical diesel engines, and improving the fuel efficiency of currently used engines. These three companies have already taken the initial steps in realizing their planned strategies. GM, for example, introduced its 1977 full-size and mid-size models a foot shorter and 700 pounds lighter than the predecessor versions. In 1978, GM marketed large Oldsmobiles and a luxury Cadillac model with diesel engines. They have announced plans to significantly increase the offering of diesel-powered mid-size and full-size cars in 1979 and in the early 1980's to complete their second stage of model down-sizing.* The two other major companies have made similar, but less dramatic, moves and have equally impressive plans in the offing.

All companies have made clear that they may not have to compromise on interior roominess of models and engine power as much as had previously been expected.** Lightweight materials such as aluminum, plastics, and high-strength, low-alloy steel will replace heavier materials currently used in autos, thereby limiting necessary reductions in size. Front-wheel drive vehicles will also become much more abundant. To boost the power of smaller four- and six-cylinder engines, turbochargers will be used extensively.

In 1985, automobile models and automobile size-class categories will be much different than they are today. The full-size model of 1985 will be smaller and lighter than its current counterpart and it will likely be diesel-powered. Lee A. Iacocca, when President of Ford, stated that the body of the standard Ford of 1985 will be about the same size as that of the new Fairmont, which is counted as a compact in 1978.† Although perhaps the currently popular method of categorizing cars as subcompact, compact, mid-size, or full-size may stay with us, the definition of each category will surely change.

* (Camp, 1978).

** Camp, Op. Cit.

† (Irvin, 1977).

This raises the question of whether projections of the size-class distribution of automobiles based on our current definitions of car categories are totally valid. Particularly, a shadow of doubt is cast on statistical extrapolations such as those presented by DOT/NHTSA. Since, in the future, consumers will be confronted with a different product choice, one that will include some new product alternatives and exclude some old ones, there's no way to judge statistically from the traditional consumer demand framework how consumers will behave. Even hedonic demand models may be less than adequate for making such projections.

This does not mean, however, that the forecasting tools developed by DOT/NHTSA and others are not useful for making projections of the car-category distribution. It does mean that it may be too soon to make a realiable statistical projection for the 1985 distribution — there is just not enough data available yet. By the end of the 1979 model year, after consumers show how they will react to big cars with diesel engines and less pick-up, to small cars with turbocharged engines, and to down-sized Fords and Chryslers, then statistical models will have the data necessary to make a valuable projection of the 1985 size-class distribution.

Until then, the best way to project sales distribution may be to anticipate manufacturers' product mix. Because of fuel economy regulations, manufacturers are somewhat constrained in making product mix decisions and, therefore, extrapolations based on these known constraints can be made.

THE DISTRIBUTION OF AUTOMOBILES BY ENGINE SIZE AND TYPE

For our purposes, the best method of categorizing automobiles is by engine size-type and transmission. A projection of the automobile distribution by engine size and type is more valuable for making inferences about fleetwide fuel economy and, as we shall show, for estimating the effect of noise control regulation on the distribution of automobiles.

Such a taxonomy classifies automobiles as:

- Eight cylinder
- Six cylinder automatic
- Six cylinder manual
- Four cylinder automatic
- Four cylinder manual
- Diesel

The 1977 distribution of automobiles according to this classification scheme is shown in Table E.2.

Table E.2

1977 Distribution of Automobiles by Engine-Transmission Categories

Category	% of Market
Eight Cylinder	56
Six Cylinder Automatic Six Cylinder Manual	19
Four Cylinder Automatic	7
Four Cylinder Manual	18
Diesel	0

Source: DOT/NHTSA, 1977.

As the table shows, many more eight cylinder automobiles are sold than any other types. Four cylinder manuals are the next most popular variety.

From a projection made in Data and Analysis for 1981-1984 Passenger Automobile Fuel Economy Standards – Automotive Design and Technology by DOT/NHTSA, a "baseline" forecast of the 1985 distribution of domestic automobiles can be derived. In the DOT report, three projections are made, each corresponding to an alternative scenario. The assumptions of, in our judgement, the most likely scenario, the third alternative, are as follows:

- Manufacturers will reduce vehicular weight by body redesign and material substitution. Body design changes will be completed by 1981, and major material substitution will be accomplished by 1985.
- The fuel economy of spark ignition engines will be improved by 10 percent, owing 8 percent to advances in integrated electronics and carburetor feedback technology and 2 percent to widespread use of fuel injection.
- Diesel-powered models will account for up to 25 percent of the fleet by model year 1985. This penetration will be achieved by phased increases of 5 percent penetration per year from 1981 to 1985. The fuel economy of diesel engines will be improved by about 5 percent between 1981 and 1985.
- Existing automatic transmissions will be replaced with four-speed automatics with torque converter lock-up. Where used, these transmissions will result in a 10 percent increase in fuel economy.
- Other fuel economy improvements include lower friction losses in engines and drivelines due to improved lubricants. A maximum of four percent fuel economy improvement was assigned to this category.
- Industry market share of each manufacturer will basically persist through 1985, American Motors, 3.3 percent, Chrysler, 12.4 percent, Ford, 26.3 percent, and General Motors 58 percent.

On the basis of this scenario, one that corresponds closely to automobile company's public statements of their plans, the following 1985 distribution of new domestic automobiles is suggested by DOT/NHTSA.

Car Category	% of Total Sales
1	8
2 & 3	26
4	29
5	16
6	21

Fuel inefficient eight-cylinder automobiles will be all but phased-out by 1985, as only eight percent of new domestic automobiles will have eight-cylinder engines. Large autos that are presently equipped with eight cylinders will be diesel-powered or perhaps will have turbocharged six-cylinder engines. The market will be dominated (45%) by models with four-cylinder engines, many of which will be turbocharged.

DOT/NHTSA estimates that, with this sort of sales distribution, auto companies would meet the 1985 corporate average fuel economy requirement of 27.5 mpg. Recent news releases indicate that auto manufacturers' strategies for meeting the 1985 standard would result in a similar sales distribution by engine type.*

CHANGES IN THE SALES DISTRIBUTION ARISING FROM NOISE REGULATION PRICE INCREASES

How much will the prices of particular models increase as a result of the cost of noise control devices? How

* (Irvin, 1977) and (Camp, 1978).

will these price changes affect the sales distribution of automobiles?

Because of the importance of energy conservation and, therefore, the importance of the fuel economy of new automobiles, these questions oblige consideration. If the prices of more fuel-efficient models are increased, buyers may shift to less fuel-efficient models and fleetwide fuel economy will then decrease. Such a result would be undesirable.

Price changes resulting from noise control regulations may seem, at least initially, to encourage an undesirable shift. The most fuel economical models, diesel-engined and four-cylinder gasoline engined cars, are also the noisiest; these are the only models that will require noise abatement to meet noise regulations. Manufacturers may decide to cover the cost of noise abatement devices by increasing the prices of these models. The distribution of auto sales would then tend to shift toward less fuel-efficient models and average fleetwide fuel economy would be impaired.

However, because manufacturers base model prices on a number of criteria, not just cost, an increase in the cost of a particular model may not necessarily be followed by an increase in the price of that model. In fact, manufacturers have a number of impelling reasons for not wanting to increase the prices of fuel-efficient models so as to lower their corporate fuel economy averages.

Fuel economy noncompliance penalties provide the strongest motivation for manufacturers. Since any shift in sales distribution toward less fuel-efficient models may risk noncompliance, manufacturers are loathe to effect such a shift by their pricing.

Another consideration is the sensitivity of demand to changes in price. Demand for less expensive, four-cylinder models is much more sensitive to price than is demand for other models. As a general rule, the more expensive a model is, the lower its price elasticity of demand will be. Economy-minded car buyers may switch to a used car if prices increase, the more conspicuous consumers may substitute a less expensive new model. Thus, a manufacturer is likely to lose more sales by increasing prices of four-cylinder models than by increasing prices of eight-cylinder models by the same amount. Correspondingly, increasing the price of large, diesel-powered models or of "loaded" four-cylinder models whose demand will likely be insensitive to price will pose less of a problem.

Competitive conditions in each submarket also affect manufacturers' pricing. In a recent survey conducted by the Motor Equipment Manufacturers Association, 45.2 percent of consumers surveyed said they would rather buy an imported small car the next time they purchase an automobile. More than half of the American motorists surveyed perceived imported small cars to be superior to their domestic counterparts in gas mileage, durability, and value. Since domestic manufacturers have a weak position in small car markets, they may be reluctant to raise prices of small models, especially in the absence of price increases by foreign manufacturers.

Because of these factors (i.e., fuel economy regulation, price sensitivity of demand, competition from imports), manufacturers will likely adjust prices so as to intentionally avoid a shift in their sales distribution. The domestic "big three" who produce a diversified line of models may pass-on part of the cost increase by increasing prices of expensive, six- and eight-cylinder models and of large diesel models and luxury, four-cylinder models.

AMC and foreign manufacturers who market a less diversified line of autos would have greater difficulty in distributing price increases. These manufacturers will face a decision between absorbing increased manufacturing costs or raising prices of their four-cylinder models by more than their competitors have. They may also choose among a number of other measures: (1) to increase prices by amounts similar to those made by competitors and to absorb the balance of the cost increase or (2) to offer special options on their four-cylinder models and to partially cover the costs of noise control in the pricing of these options.

In any case, the profitability of AMC and of foreign manufacturers may be affected, if not as a function of the competitiveness of their pricing, then as a result of their reduced unit margins. If their unit profits are affected, it will be by only a fraction of the amount by which noise regulations cause average prices to increase.

APPENDIX F

DYNAMIC MULTIPLIER ANALYSIS

The purpose of a dynamic multiplier analysis is to predict how a change in one variable will affect other "policy" variables over time. The dynamic multipliers of linear models can be expressed in a general parametric format. For example, we can determine the changes in W_t, X_t, and Y_t that would result from an increase in Z_t of 1, and the resulting multipliers can be used to determine the changes in W_t, X_t, and Y_t that would result from an increase in Z_t of any magnitude p simply by multiplying by p. Practically speaking, this saves us the time and cost of running the simulation model to answer every policy question.

Tables F.1 and F.2 present the changes in: (1) the level of total retail sales, (2) the domestic auto production volume, (3) the level of used car prices, (4) the level of auto industry employment (production workers), and (5) the level of capital spending by the auto industry (i.e., the dynamic multipliers) resulting from an increase of 1 in the CPI index for new automobiles. The multipliers presented in Table F.1 were generated with the new car price variable exogenous to the model; those presented in Table F.2 with the new car price variable endogenous to the model. In both tables, ΔP_N represents the change in normal price. The primary difference between the two analyses is that, in the "price exogenous" case, actual price is assumed to be fully and immediately adjusted to normal price, whereas, in the "price endogenous" case, the adjustment is made gradually according to the historical practices of the industry.* In both tables, changes in the five "policy" variables (dynamic multipliers) are given over 24 quarters or six years.

* In Chapter 6, we argued that because the industry has recently changed its pricing practices to allow for greater flexibility, the historical patterns of price movements provide a poor basis for predicting future pricing behavior. Because of this, the "price exogenous" case presented in Table F.1 provides better estimates of the dynamic price multipliers.

Table F.1

Dynamic New Car Price Multipliers
(New Car Price Exogenous)

Quarter	Total New Car[a] Sales	Used Car[b] Prices	Domestic[c] Production	Employment[d] (Production Workers)	Capital[e] Spending
1	-31.8	.91	-26.7	-13	0
2	-10.9	1.37	- 7.6	- 6	0
3	- 2.9	1.59	- 2.0	-22.5	0
4	- .1	1.71	0	- .4	- .67
5	26.5	1.21	16.7	7	- .06
6	4.9	.96	6.8	4.7	- .06
7	- .5	.83	.5	1.1	- .70
8	- 1.2	.77	- .5	0	.88
9	- .8	.74	2.8	2.5	.47
10	5.1	.73	2.3	1.9	.34
11	3.5	.72	1.4	1.1	.68
12	1.6	.72	1.0	.6	- .34
13	.5	.71	1.0	.5	- .30
14	.2	.71	0	.1	- .15
15	1.1	.71	.8	.5	- .02
16	1.2	.71	.9	.5	.14
17	.8	.71	.6	.5	0
18	.9	.70	.5	.4	- .06
19	.5	.70	.5	.4	- .06
20	.4	.70	.3	.3	- .03
21	.3	.70	.2	.2	.02
22	-13.4	.68	-11.2	- 5.3	0
23	-10.8	.68	- 8.4	- 5.3	- .01
24	- 6.2	.68	- 4.7	- 3.1	0

[a] Thousands of units

[b] Index (1967=100)

[c] Thousands of units

[d] Hundreds of workers

[e] Millions of 1972 dollars

Table F.2

Dynamic New Car Price Multipliers
(New Car Price Endogenous)

Quarter	Total New Car Sales[a]	Used Car Prices[b]	Domestic Production[c]	Employment (Production Workers)[d]	Capital Spending[e]
1	-2.7	.08	-2.2	-1.1	0
2	-3.9	.20	-3.1	-1.8	0
3	-4.0	.35	-3.2	-2.0	0
4	-3.6	.49	-2.8	-1.7	- .06
5	-1.0	.58	-1.1	-1.0	- .07
6	.1	.64	- .1	- .4	- .07
7	.3	.66	.2	- .1	- .12
8	.2	.68	.2	0	- .04
9	.1	.69	.4	.2	.02
10	.5	.69	.6	.4	.06
11	.8	.69	.7	.5	.11
12	.9	.69	.7	.5	.09
13	.8	.70	.7	.5	.05
14	.8	.70	.7	.4	.02
15	.8	.70	.6	.4	.01
16	.8	.70	.6	.4	.02
17	.8	.70	.6	.4	.02
18	.8	.70	.6	.4	.01
19	.8	.70	.6	.4	0
20	.7	.70	.5	.4	0
21	.6	.70	.5	.3	0
22	- .5	.70	- .5	- .2	0
23	-1.7	.70	-1.4	- .7	0
24	-2.3	.70	-1.9	-1.1	- .02

[a] Thousands of units

[b] Index (1967=100)

[c] Thousands of units

[d] Hundreds of workers

[e] Millions of 1972 dollars