FORECASTING MARKET SHARES OF ALTERNATIVE FUELS IN TURKEY

by

Semin Erbil

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APPROVED BY

Doç. Dr. Ceyhan Uyar

Sibel Tanberk

Doç. Dr. Seyhan Tuğcu

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The objective of this study is to examine the interfuel substitution mechanism, and thus to forecast the market shares of alternative fuels, in Turkey. Alternative energy sources are assumed to be bituminous coal, lignite, petroleum and electricity.

It is of increasing interest to energy policy makers to determine the demand response of users to increasing fuel prices. In this study, consumption trends and interfuel substitution mechanism are examined through the use of a forecasting model. A multinomial logit formulation is used as the functional form to explain the market shares of the four main fuel types. The model specification indicates that the dependent variable is the logarithm of the ratio of share of the other fuels to the forth, where the base share can be chosen arbitrarily. On the other hand, the independent variables of the model are relative prices. This simultaneous model is also dynamic in structure so that long term reactions to explanatory variables can be assessed.

The model is implemented using time-series data at the national level, and the two-stage least squares technique of Zellner (1962). The estimated elasticities indicate that relative changes in fuel prices have significant effects in the short-and especially in the long-runs. The results also imply that petroleum and charcoal are the most price responsive fuels.

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In order to forecast the future market shares, eight alternative pricing scenarios are developed. Although the forecasts vary depending on the assumptions used; we can conclude that bituminous coal and lignite will be substituted for petroleum, and petroleum share will continue to decline as long as its relative price continues to increase.

TÜRKİYE'DE ALTERNATİF YAKITLARIN PAZAR PAYLARININ TAHMİNİ

Bu çalışmanın amacı Türkiye'deki değişik yakıt tipleri arasındaki ikame mekanizmasını incelemek ve bu yakıtların gelecekteki pazar paylarını tahmin etmektir. Konu edilen yakıt tipleri taşkömürü,kömür,linyit,petrol ve elektriktir.

Enerji fiyatlarının sürekli artmasıyla, milli bir enerji politikası saptamaya çalışanların dikkatleri talep yapısına çevrilmiştir. Bu çalışmada ise, tüketicilerin eğilimleri ile yakıtlararası ikame mekanizması bir ön kestirim modeli aracılığıyla incelenmiştir. Yukarıda belirtilen dört ana yakıt tipinin pazar paylarını açıklamak için bir "multinomial logit" formülasyonu kullanılmıştır. Önce rastgele bir yakıt tipi seçilmiş, ve diğer yakıtların pazar paylarının seçilen yakıta oranlarının logaritması bağımlı değişken olarak modele konmuştur. Böylece değişik yakıt tiplerinin piyasa payları birbirine bağımlı olarak bulunmaktadır. Diğer taraftan, yakıt tiplerinin nispi fiyatları bağımsız değişkenleri oluşturmaktır. Aynı zamanda dinamik bir yapıya da sahip olan bu model, uzun dönemde fiyatlara karşı meydana gelebilecek tepkileri de gözönüne almaktadır.

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Model, Türkiye seviyesindeki zaman serileri verileri ve Zellner'in (1962) iki aşamalı en küçük kareler yöntemi kullanılarak çalıştırılmıştır. Çıkan sonuçlar, fiyat artışlarının talebi önemli boyutlarda etkilediğini ortaya koymuştur. Fiyat elastikiyeti en fazla olan yakıtlar ise petrol ve taşkömürüdür.

Gelecekteki pazar paylarını tahmin etmek için sekiz değişik fiyat senaryosu denenmiştir. Tahminlerin kullanılan varsayımlara göre değişiklikler göstermesine karşın denilebilir ki, petrolün payı fiyatları arttığı sürece düşmeye devam edecek, ve kömür ve linyit petrolün yerini almaya başlayacaktır.

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LIST OF SYMBOLS

P_c : Price of coal (TL/10^3 kcal)

P_e : Price of electricity (TL/10^3kcal)

P_l : Price of lignite (TL/10^3 kcal)

P_p : Price of petroleum (TL/10^3 kcal)

S_c : Market share of coal

S_e : Market share of electricity

S_l : Market share of lignite

S_p : Market share of petroleum

Note: Throughout the text, the word "coal" refers to the"bituminous coal"

I. INTRODUCTION

1.1. ENERGY IN THE ECONOMY

Energy and economy are closely interrelated. Energy is both a productiv input and a consumption object. Almost all productive facilities use energy as an input. On the other hand, as a consumption good, it is used for a variety of end uses such as heating, lighting, cleaning, cooking, transportation, etc.

Energy is a vital component in the economic and social well-being of a nation and must be considered explicitly in the formulation of the national and international policy.

The Turkish economy faces serious problems arising from energy shortage and high dependence on imported energy. The energy bottleneck leads to underutilization of productive facilities, unemployment, decreasing competitive power in international markets and deficiencies in balance of payments. There is a strong need for a national energy policy which is closely interrelated with economic and social policy and with international developments. Questions of economic growth, balance of trade, and protection of the environment must be considered in a balanced way, and complex trade-offs must be made among these and other national objectives.

As the importance of energy in policy making becomes apparent, research and analysis in the field of energy forecasting becomes important, too. And, it is of increasing interest to energy policy makers to determine not only the demand response of users to increasing fuel prices, but also the substitution relationships between the primary fuels consumed. Most energy is interchangeable in many uses and the choice of energy is greatly dependent on proximity, availability, relative cost and feasibility of use.

Short-term demand for energy can be estimated through the use of a forecasting model. The model developed in this study aims at understan of consumption trends and interfuel substitution mechanism and thus forecasting the market shares of alternative fuels in Turkey.

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1.2. ENERGY SCENE IN TURKEY

The primary energy sources that are currently significant are as the following:

- Commercials: Bituminous coal, Lignite, Petroleum, Hydropower
- Non-commercials: Firewood, Animal and vegetable wastes (Dried dung)

The sources that are planned to be used by 1990 are:

- Nuclear Energy
- Geothermal Energy
- Solar Energy
- Natural gas
- Biomass

And, the new energy sources that have started to be used in other countrie but not in Turkey are:

- Wind Energy
- Tidal Energy
- Magneto-hydrodynamic Power

On the other hand, the energy consumers can be grouped as five different sectors:

- Industrial Sector
- Residential Sector
- Transportation Sector
- Agricultural Sector
- Electricity Generation

And, the alternative sources for each of the above sectors are:

Industrial: Petroleum, coal, lignite, electricity, firewood and natural gas.

Residential: Petroleum, coal, lignite, electricity, firewood, dried dung, geothermal energy, solar energy and natural gas.

Transportation: Petroleum, coal and electricity.

Agricultural: Petroleum, electricity, firewood and dried dung.

Electricity: Petroleum, coal, lignite, hydropower and nuclear energy.

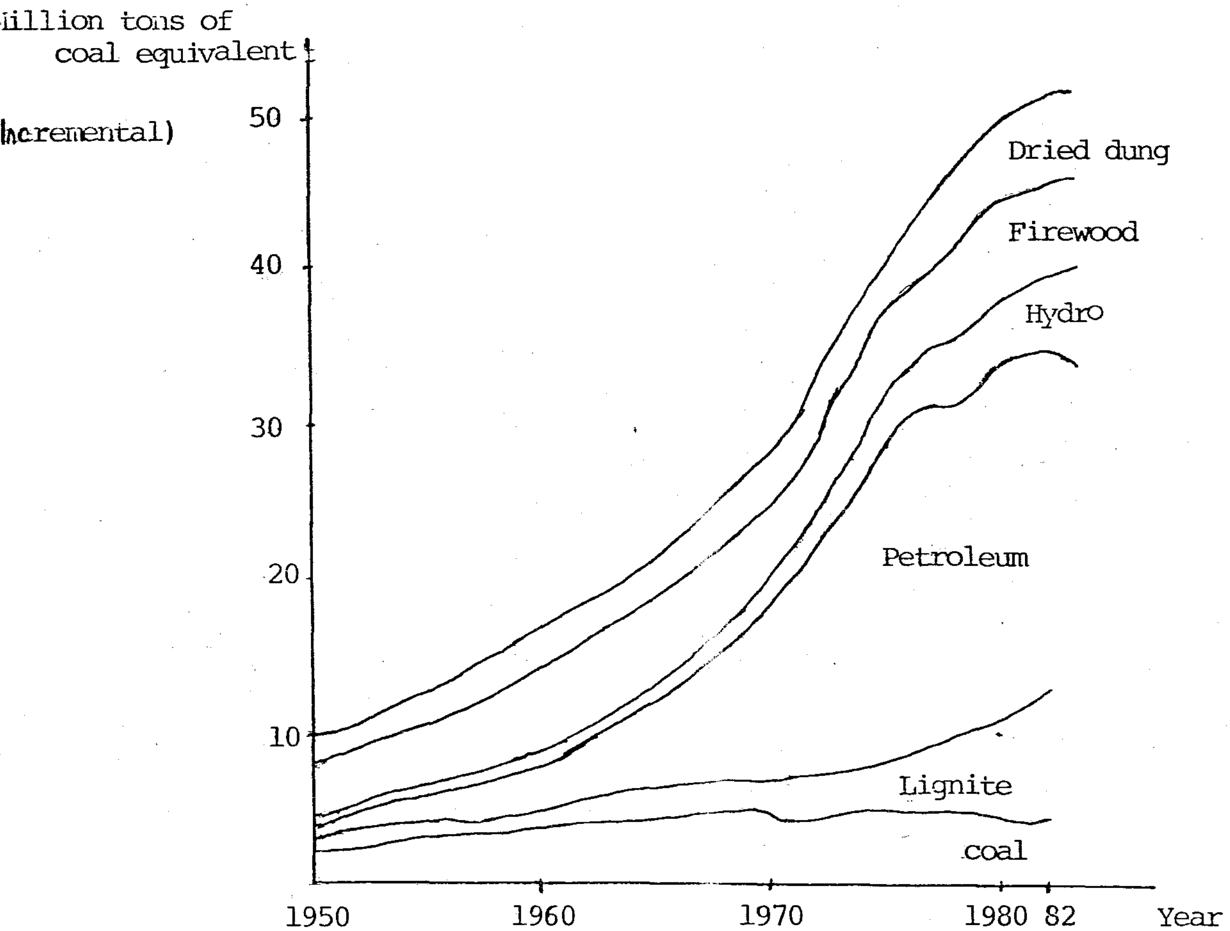
Before discussing each of the major supply options, it is better to make an overview of our energy consumption, reserves and energy sources. Severa important points emerge from examining our energy scene, as summarized below.

The consumption shares of the energy sources in 1982 are as follows[1/]

Petroleum	44.9 %
Lignite	14.3 %
Coal	7.6 %
Hydropower	8.9 %
Natural gas	0.1 %
Firewood	13.5 %
Animal and vegetable wastes	9.6 %
Imported electricity	1.1 %

For about two decades, the pattern of energy consumption in Turkey has been constantly changing. Up to 1950, we see a shift from noncommercial fuels to coal. But from this point on, and up to mid-seventies we can see a change from a coal to an oil age (See: Figure 1)

Figure 1. Energy Consumption in Turkey, 1950-1982



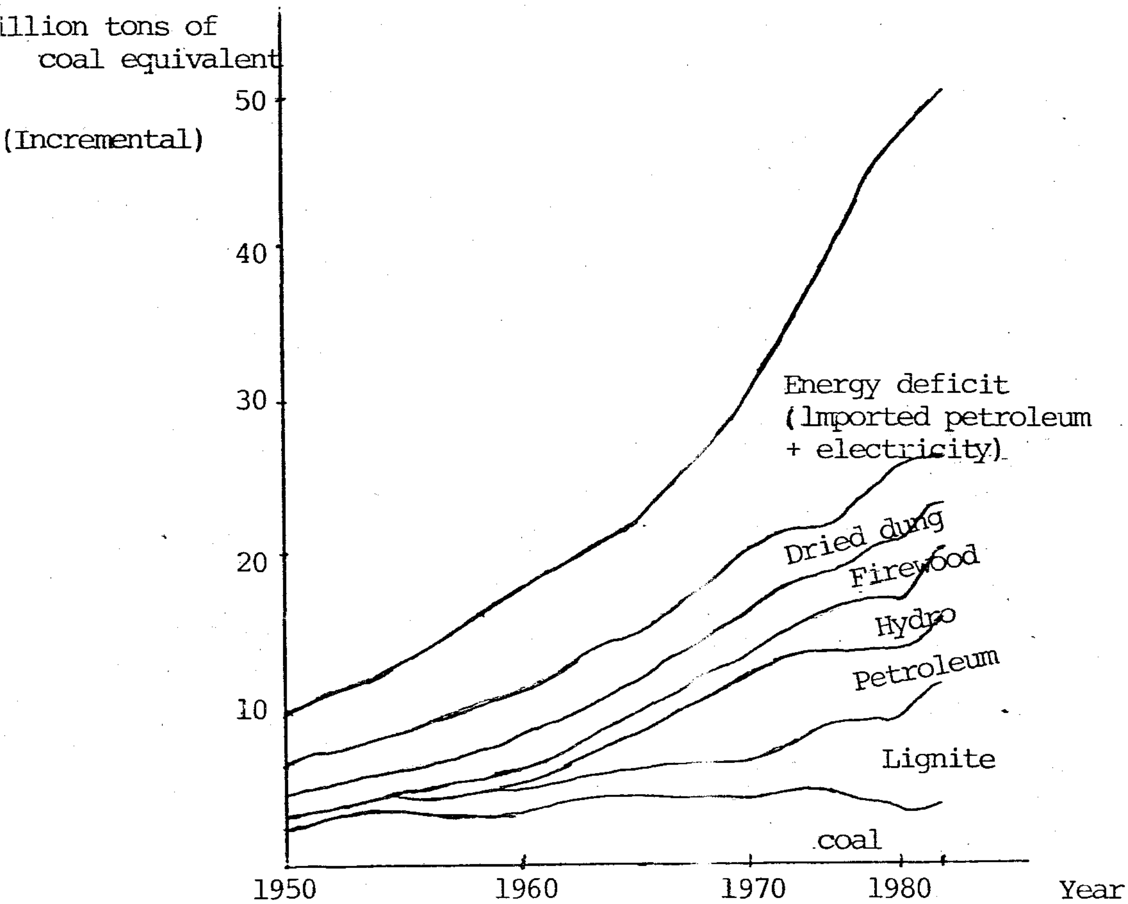
Source : SPO

1/ Source: State Planning Organization. 5th 5year Development Plan, Special Commit
Preparatory report on Energy.

The abundant availability of petroleum, its convenience and its lower price has led to the substitution of coal by petroleum. In 25 years (between 1950 and 1975) market share of petroleum has increased from 7 percent to 50.5 per cent, while share of coal has declined from 24 per cent to 10 per cent. On the other hand, growth rates of lignite and hydropower shares have been very small. Lignite share has increased from 5 per cent to 10 per cent and hydropowe share has increased from 0.1 per cent to 5 per cent in 25 years. 1976 is a turning point, so that with increasing petroleum prices the share of petroleum (which was 51 per cent in 1976) has started to decrease and reduced to 45 per cent in 1982. This new trend is expected to continue in the coming years. Because, high current prices and uncertainities as to the future price and availability of petroleum lead the users to shift increasingly toward other fuels.

The change in demand lies not only in alteration of consumption patterns, but in a significant increase in the demand for imported energy . The increasing dependence on imported energy can be seen from Figure 2.

Figure 2. Energy supply in Turkey, 1950 - 1982



Source: State Planning Organization

2 - 5th 5 year Development plans Special Committe Reports on Energy.

So, our energy problem in one of the discrepancy between the forms of energy we are consuming and the form we have domestically. 45 percent of our energy consumption is petroleum, but our petroleum reserves are very small as compared to large amount of reserves of the other sources. Table 1 shows the known reserves of energy sources.

Table 1. Energy reserves in Turkey[2/]

	Mil.tons of coal eg.[3/]		Mil.tons of coal e
Petroleum	90	Nuclear	1020
Coal	1240	Hydro	55
Lignite	2520	Geotermal	10
Natural Gas	20	Solar	20

Another point of interest, regarding the energy sources consumed is that they do not include renewable sources such as solar and geotermal energy. Use of hydropower, an important renewable source, is also very small as compared t the large amounts of hydro reserves. (Only 11 per cent of the usable potential is being used.)

1.3. ALTERNATIVE ENERGY SOURCES

This section outlines the alternative sources of energy to meet present and prospective demand.

1.3.1. Petroleum:

Until 1973, petroleum has been the cheapest and the most convenient energy source. Turkish petroleum production has also increased until 1970 (See: Figure 3). From this point on, declines in domestic petroleum production and increases in imported petroleum price have led to huge amount of import bills.

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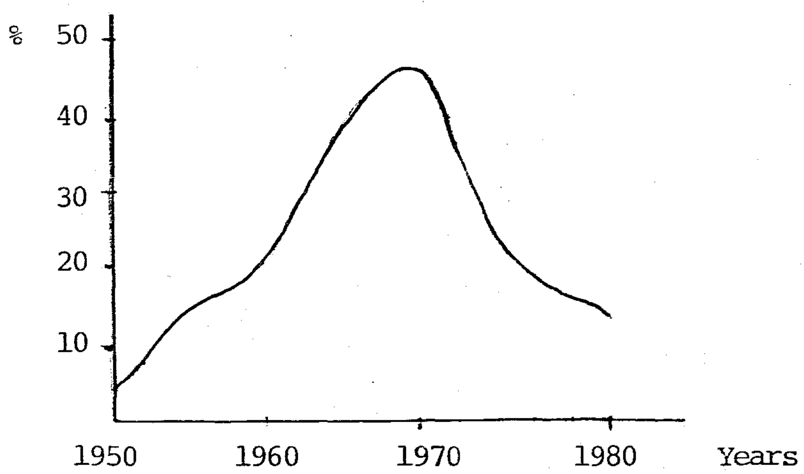
2/ State Planning Organization, 5th 5 year Development Plan, Energy, Special Committe Pre-report.

3/ Conversion factors are listed in Appendix A.

Figure 3 : Ratio of domestic petroleum production to the total petroleum consumption.



Source : SPO

2-5th 5 year Development Plans, Special Committe Reports on Petroleum

The objective of energy policy must obviously be to reduce the dependence on petroleum to a sufficient extent to allow normal economic forces of substitution and creation of alternatives to begin to work effectively.

1.3.2. Bituminous Coal

Coal is one of our oldest commercial energy sources. Main resource is in Zonguldak region with a known reserve of one billion tons. It is possible to increase coal production by 50 percent until 1990[4/].
Coal imports may also increase.

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4/ State Planning Organization
5th 5 year Development Plan , Special Committe Preparatory report on Energy.

Coal can substitute for petroleum in several areas. First, it can be used for heating purposes in industrial and residential sectors. Second it is a primary energy source in electricity generation. Moreover, it is an important input of iron-steel industry.

1.3.3. Lignite:

Lignite production has shown a continuous increase from 1950 on. But because of its low specific heat, and difficulties in its transportation and usage, it has not been preferred as much as coal and petroleum. But now, increasing oil prices and difficulties in coal production has made the lignite an important alternative.

Reserves are very close to the surface of the earth, and lignite mining does not require a high technology. With known reserves of eight billion tons, lignite can be the most important source that will bring solution to the energy problem in the short and medium term. Lignite can substitute for petroleum in industrial and residential sectors, and in electricity generation.

1.3.4. Hydropower:

Hydropower is the most important renewable energy source and Turkey has fairly reach reserves. The usable potential is around 142 billion kwh/ year (Approximately 10 times of today's usage)[5/]. This potential makes it possible to increase the share of hydroelectricity in total energy consumption. But, to generate electricity from hydropower requires very large and costly investments and very long lead times.

1.3.5. Natural Gas

It is known that, the world has natural gas reserves as much as petroleum reserves. As many other countries, Turkey has natural gas reserves, too. Known reserves are about 15 billion m^3.[6/] Production has started in 1977, but today natural gas consumption is only 0.1percent of the total energy consumption. And, in the short run, a significant change in its share is not expected.

Natural gas can be directly combusted or converted to liquid fuels. Its transportation is very easy, and can also be used in transportation sector in combination with petroleum products. It can also be used in fertilizer and petro-chemical industries.

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5/ The State Hydroulic Works.
6/ State Planning Organization.
5th 5 year Development Plan, Special Committe Pre-Report on Energy.

1.3.6. Solar Energy:

The greatest advantage of olar energy is its ubiquitousness. But the usage areas are limited to heating and obtaining process heat. And direct use of solar is often more expensive than the other conventional sources. Because of the many low cost alternatives, use of solar energy in the generation of power is unlikely. Without substantial incentives, usage of solar energy will remain quite low over the next years.

1.3.7. Nuclear Energy:

Nuclear energy offers the otential for meeting a significant fraction of our energy needs far into the future. But uncertainties are very great for nuclear energy. ne energy potential is very high, and so are the social and environmental risks.

1.3.8. Geothermal Energy:

Geothermal energy, the natural heat of the earth holds great promise to be one of the abundant forms of energy. Geotermal potential of our country is very high (4500 MW or [illegible].000 termal MW).[7/] It can be used both for electricity and heat generation. But the required investments are very costly and have long lead times.

1.4. SCOPE OF THE STUDY

In this study, energy sources such as natural gas and nuclear energy are not take into consideration, because it is not possible to make use of them in the short run. On the other hand, the competitive interactions among the alternative source in electricity generation are not taken into account because of the very long lead times involved in these interactions. This analysis covers only the demand for fuels which are available for end use in the other four sectors (industrial, residential, tnarsportation and agriculture). Thus, the alternative fuels become:

Commercials: Petroleum, coal, lignite and electricity.

Noncommercials: Firewood and animal-vegetable wastes.

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7/ State Planning Organization
5th 5 year Development Plan, Special Committe Pre-Report on Energy.

From 1950 on, there has been a transition from noncommercial fuels to commercials. Share of noncommercial fuels in total energy consumption has declined from 64 per cent to 23 per cent, from 1950 to 1982 (See also Figure 1). But this transition involves not so much substitution of one source for another, but the use of new energy sources for new activities. Therefore, it seems better to concentrate only on the substitution between petroleum, coal, lignite and electricity.

1.5. ENERGY DEMAND AND INTERFUEL SUBSTITUTION

Accepting that the competitive energy sources are coal, lignite, petroleum and electricity, alternative sources with respect to sectors can be summarized as in Table 2.

Table 2. Breakdown of alternative energy sources by sectors

Source \ Use	Industrial	Residential	Agriculture	Transportation	Electricity Generation
Coal	x	x		x	x
Lignite	x	x			x
Petroleum	x	x	x	x	x
Hydro					x
Electricity	x	x	x	x	

Several factors influence the preference pattern of users in selecting among the above alternatives. Some of these factors determine the size of the total market, others measure the switching pattern among the fuels. These factors are as follows:

- National income, GNP
- Population trends
- Fuel prices
- Price predictions
- Rate of change of prices
- Stocks of energy using goods
- Government policies
- Supply availability of alternative fuels
- Air pollution abatement requirements
- Investment level of the industr
- New construction,etc.

Assuming that the above factors are explanatory variables, demand equations can be derived in order to forecast the market shares.

It is useful to model the demand for energy sources in terms of their market shares rather than absolute quantities. Using market shares rather than quantities as dependent variables has certain advantages. First, this procedure avoids inclusion of some independent variables necessary with the latter type of demand model (income, population, etc.) For example, one need not include income variables in the market share model for which changes in income would be expected to influence demand for all fuels equally. And second, the model concentrates attention on the competitive interactions among the fuels.

A traditional approach to estimate the energy demand has been to develop separate demand equations for each fuel. But, the individually forecasted demands may not be reasonable, because the models are estimated independently. The equation system should incorporate the choices of all fuels simultaneously.

In this study, a multinomial logit formulation is chosen as the functional form to explain market shares of the four main fuel types: coal, lignite, petroleum and electricity. This simultaneous model is also dynamic in structur so that long-term reactions to explanatory variables can be assessed.

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II. LITERATURE SURVEY

Energy system models are formulated and implemented by the theoretical and analytical methods of several disciplines including engineering, economics, operations research and management science. Models based primarily on economic theory tend to emphasize behavioral characteristics of decisions to produce and/or utilize energy, whereas models derived from engineering concepts tend to emphasize the technical aspects of these processes. Behavioral models are usually oriented toward forecasting uses, whereas process models tend to be normative.

The energy models can be divided into several groups according to their scope and they range from demand models of a single fuel to models encompassing the overall energy system within the economy. As Hoffman and Wood (18) suggested, the three major groups of energy models and forecasts are:

1. Sectoral Models, covering the supply or demand for specific fuels or energy forms;
2. Industry Market Models, which include both supply and demand relationships for individual or related fuels;
3. Energy System Models, which cover supply and/or demand relationships for all energy sources.

In recent years, a spate of papers has appeared that have been developed and applied to the analysis of the energy system and to the development of forecasts for planning purposes. This chapter is devoted to review some of these papers. The emphasis is on the models which attempt to estimate the behavioral demand for energy.

2.1. SECTORAL MODELS

Sectoral models are defined as relating to some specific energy activity forming a part of a specific energy industry market. Econometric models are used most often for characterizing energy demand.

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Most sectoral econometric modelling efforts in the energy area have focused upon the demand for a single energy input in one particular use. Such models are used principally to provide an analysis of the determinants of demand and to forecast demand with given estimates of the variables that are exogenous to the model, including price and other variables measuring the market size for the energy inputs (population, GNP, income, etc.). These models have been designed to focus on specific policy issues such as price policy. Since they are limited in scope, they generally do not have broad applicability.

Taylor (36) surveyed and evaluated econometric models of the short-and long-term demand for electricity in the residential and commercial sectors. The models surveyed are classified according to sectoral detail (residential, commercial and industrial) and the measure of electricity price used, and short-and long-term prices and income elasticities are summarized. Taylor reviewed the special problems associated with modelling the demand for electricity, including the fact that such demands are derived demands depending on the stock and utilization rates of equipment, the fluctuating utilization rates for the equipment (Peak demands), and the effects of the regulatory process on the pricing schedules. Taylor concluded that, to varying degrees, modelling efforts have not yet dealt with these problems.

Chern and Just (10) presented a regional electricity demand forecasting model developed at the Oak Ridge National Laboratory. The model has the following important features. First, the model is regional and provides state-by-state forecasts. Second, the model takes into account both short-run and long-run responses to several important exogenous factors. Third, the model is sectoral, it forecasts demands for the residential, commercial and industrial sectors. Finally and most importantly from a forecasting point of view, a structural specification is developed for the cost-price component of the model which takes account of the cost justified price increase mechanism imposed on utiliti This structure is important in obtaining mutually consistent forecasts of costs and prices.

The model is basically a simultaneous equations system in which both electricit demand and price are endogenously determined. The most important exogenous fact of the model are income variables and prices of substitutes.

In the study by Wills (42), short-and long-run responses by households to changes in the price of electricity are estimated using data which permit measurement of the marginal price of electricity, the inframarginal demand charge, and estimates of household appliance stocks. The price elasticities of high-and low-level users of electricity - who are hypothesized to maximize utility - are compared. And, the theoretical bias in price elasticity estimates resulting from neglect of the infra-marginal demand charge is shown to be emprically insignificant.

In a recent paper, Huq and Dynes (20) examined the residential demand for electricity in Virginia. Huq and Dynes derive seasonal estimates of price elasticities from a detailed integrated econometric and end-use model that does not constrain the demand function to constant elasticities with respect to explanatory variables. The elasticity coefficients derived from the model conform to expectations based on theoretical considerations.

Sweeney (33) has developed a model of the demand for gasoline in order to support analysis of conservation policies effecting automobiles. Vehicular gasoline consumption for any time period is a derived demand that depends on the total number of miles driven and the average number of miles per gallon for the fleet in operation during the period. The demand for vehicle miles is estimated by a function of real disposable income per capita, the unemployment rate, and the cost per mile of automobile travel, including the cost of gasoline and time.

Another model of the demand for gasoline has been developed by Greene and Kulp (16). In that study unprecendented declines in highway use of gasoline in the United States in 1979 and 1980 are analyzed by means of a gasoline demand model. Approximately half of the reduction in use in each year over the preceeding year can be attributed to the short-run effect of higher gasoline prices. Most of the remainder can be traced to declines in real household incomes and increasing fleet fuel efficiencies.

A recent paper by Brown (7) has presented an aggregative model of United States consumption of petroleum and products, of a type which might potentially be used to derive short-term forecasts of U.S. petroleum consumption and imports. The model attempts to separate income-and weather-related changes from those induced by changes in relative prices, with emphasis on the dynamic path of consumption responses to price changes. Estimation results suggest that there are still significant price effects six years after a change in the relative price of petroleum.

2.2. INDUSTRY MARKET MODELS

Models for energy industry markets include process and econometric models as well as process/econometric models, which characterize both the supply and the demand for a specific or related set of energy products. The greatest utility of such models is in providing a consistent frame-work for planning industrial expansion and studying the effects of regulatory policy on the industry. Much of the modelling work in this area involves the coupling of process and econometric techniques to represent supply and demand relationships, respectively.

Adams and Griffin (1) combined an LP model of the United States refining industry with econometric equations determining endogenously the prices, quantities demand, and inventory adjustments for the major petroleum product. Exogenous inputs to the econometric/LP model are the refining process configurations, product quality specifications, factor input prices (crude oil, etc.), economic activity and the stocks of petroleum-consuming equipment. In the first step, the requirements for the various petroleum products are determined in the demand equations. Using these requirements as output constraints, the solution to the LP model indicates the volume of crude-oil required, process capacity utilization, operating costs, and outputs of by-products such as residual oil. In turn, capacity utilization, inventory levels and crude-oil prices determine the product prices.

A system dynamics model of the coal industry has been developed by Naill, Miller and Meadows (32) to study the role of coal in the transition of the U.S. energy system from oil and gas to renewable resources up to the year 2100. The interrelationships in the coal production sector between demand, investment, labor and production are modelled along with the oil and gas sector and the electric sector. Time delays associated with R&D and plant construction are included in the synthetic fuel sector where liquid and gaseous fuels are produced from coal. The demand for energy and the market shares of various fuels are determined endogenously as a function of price, GNP, and population. These variables are exogenous to this model, although in more comprehensive system dynamics models they are also determined endogenously.

Mc Avoy and Pindyck (30) developed an econometric policy simulation model of the natural gas industry. The model has been used extensively to analyze the effect on the industry of current and proposed regulation of the well-head price of gas and permissible rates of return for pipeline companies purchasing and selling natural gas in interstate markets. Demand for natural gas by industrial, residential, and commercial costumers depends on the whole-sale price of gas, the prices of alternative fuels, and market size variables such a population, income and investment levels.

Griffin (17) has developed an econometric model of the supply and demand for electricity. The model is estimated by using U.S. national time-series data. Major variables determined by the model include the demand for electricity in the residential, industrial and commercial sectors, nuclear capacity expansion distribution of generation requirements between nuclear, petroleum, gas and coal, and the price of electricity. Important exogenous variables include various measures of market size such as population, real disposable income, GNP, the price of petroleum, gas and coal, the GNP deflator, total generating capacity, construction costs, and other operation costs. The model is simultaneous because the average price of electricity, a determinant of demand, depends on the generating mix. The model has been used to conduct simulation studies of the impact on demand and the generating mix, alternative projections of relative fuel prices.

Baughman and Jaskow (3) have also developed an engineering/econometric model of electricity supply and demand. The model combines an engineering supply model with an econometric model, and links the two with an explicit model of the regulatory process by which the price of electricity is determined. Demands for electricity, natural gas, coal and oil are estimated for the residual, commercial and industrial sectors by functions of fuel prices and various market-size variables.

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2.3. ENERGY SYSTEM MODELS

Analysis and modelling of the overall energy system, including all fuels and energy forms, were stimulated largely by the need to develop forecasts of total energy demand, of an individual sector or of the whole energy market.

Much of the initial work in this area involved the development of energy balances in which forecasts for individual fuels were assembled. These forecasts highlighted many problems involving such factors as resource definition and interfuel substitution, which must be handled in a consistent manner for all fuel types and sectors and which led to increasing modelling of the entire energy system.

In most of the forecasting studies, the energy balance methodology has been employed in the following way: Independent estimates of demand by each of the major end-use sectors, for each of the detailed energy types are developed by relating demand to aggregate economic activity and trends in energy consumption. Independent estimates of supply of major energy types are developed and compared with the demand estimates. Differences are resolved, usually in a judgemental way, assuming that one energy type is available to fill any gap that may exist between supply and demand. This energy type is normally assumed to be petroleum, including crudeoil and refined petroleum products.

The interfuel substitutions in these models having separate demand equations for each fuel can only be explored by including prices of competing fuels in each equation. But this ignores the interrelationships of consumption between the fuels. To estimate energy demand requires a simultaneous equation system. But, the models developed with the simultaneous equation approach are very few as compared to the models using the traditional approach. Some of these models are summarized below.

The model developed by Baughman (2) to study interfuel competition uses system dynamics to simulate the flow of resources (coal, oil, natural gas and nuclear fuel) to the various demand sectors (residential, commercial, industrial, transportation, and electricity). The model has been applied at the U.S. national Level. And, it includes representation of the economic cost structure of the energy system along with investment decisions and physical constraints on the supply of coal, oil, natural gas, and nuclear fuels. Demands are developed in two components, a base demand that is not sensitive to price changes, and a market-sensitive demand that includes incremental and replacement demands. The model is used to simulate interfuel competition and to develop the quantities and prices of fuels.

In the study by Halvorsen and Ford (1979), complete systems of energy demand equations are estimated for individual industries. Duality theory is used to derive the systems of demand equations from flexible cost functions which impose only those restrictions on the estimated elasticities of demand and substitution that are implied by the economic theory. The results include estimates of own-price elacticies of demand for electricity, oil, gas, capital, production workers and non-production workers. Almost all of the estimated own-price elasticities are significant and indicate price responsiveness of demand.

Another model of interfuel substitution has been developed by Uri (37), which studies the short-run energy demand by electric utilities. The model estimates the own-and cross-elasticities of demand and substitution for coal, oil and natural gas. Duality theory is used to derive systems of fuel-demand equations that are consistent with profit maximizing behaviour by electric utilities. The quantity of electrical energy produced is assumed to be a transcendental logaritmic function of both variable and fixed inputs. Each utility maximizes restricted profit with respect to variable inputs (coal, oil and natural gas), given the quantities of fixed inputs (labor and capital), the prices of variable inputs, and the price of electrical energy. Restrictions on the elasticities of demand and substitution are limited to those consistent with economic theory. The estimation technique is the iterative Zellner method (44). The demand equations are estimated with both current-period fuel prices and with fuel prices lagged various number of months. The results indicate that relative changes in fuel prices have significant effects in the short-run.

In a later study by Uri (38), again a model has been developed to forecast consumption of four fossil fuels (residual fuel oil, distillate fuel oil, crude oil and natural gas) by electric utilities. This time a multinomial logit formulation is used. The specification indicates that the dependent variable is the log of the ratio of share of the three fossil fuels to the forth, where the base is chosen arbitrarily. On the other hand, the share of each of the fuels is a function of relative prices, weather, time and seasonal factors. Using the iterative Zellner (44) technique, the model is implemented. And, the results show that the responsiveness of the relative fossil shares to changes in fuel prices is consistently significant. The results of forecasting, also agree with actual shares.

A similar model has been developed by Cohn (11) studying fuel choice and aggregate energy demand in the residential and commercial sectors. The demands for energy in both sectors are examined separately using a refined data base. For each sector, a multinomial logit formulation is utilized, along with an aggregate demand equation to determine analytically short-and long-run fuel price elasticities of demand for the major fuels consumed (electricity, natural gas and fuel oil). The shares depends on prices of these fuels, per capita disposable income, climatic variables, and a variable representing the availability of natural gas. On the other hand, the Koyck Lagged structure used implicity assumes the dynamic adjustment for the above explanatory variables. That is, a variable explaining the demand of today is the demand of yesterday. The fuel share equations and the aggregate demand equation are estimated simultaneously by joint generalized least-squares technique.

Recently, Uri (39) has studied energy demand and interfuel substitution in the United Kingdom. Total energy demand is examined as a part of a simultaneous static decision on the optimum levels of all inputs-capital, labour, materials and energy. The approach for the estimation of substitution relationships is the translog price possibility frontier. The price possibility frontier is a transcendental function of the logarithms of the prices of inputs. All energy sources (coal, oil, natural gas and electrical energy) are demonstrated to be substitutable. Using the concept of duality, market share equations are derived from translog price possibility frontier, where the ratio of shares depends on energy prices. The share equations are estimated jointly as a multivariate regression system, using Zellner's (44) two stage least-squares procedure.

It should be noted that the above review does not include any study which has been done for Turkey. Energy demand models developed for the Turkish economy are all of the traditional type, combining independent estimates for each energy source.

The behavioral demand model developed in this study is similar to Uri's (38) and Cohn's (11) studies, in the sense that a multinomial logit formulation is chosen as the functional from to explain market shares of the major fuel types. The model also considers dynamic structure of energy demand as in the study by Cohn. In estimating the model, two stage least-square technique of Zellner (44) is used, as an efficient method of estimating simultaneous equations.

The next chapter covers the explanation of the model and the estimation procedure.

III. MODEL AND RESEARCH DESIGN

3.1. THE FUEL SHARE MODEL

An econometric model has been developed which explains the competitive interactions between four main fuel types: coal, lignite, petroleum and electricity.

Demand for each fuel type is modelled in terms of its market share rather than quantities. Since the energy market has clearly defined limits, it is relatively easy to construct share proportions to regress upon various decision variables. On the other hand, using market shares as dependent variables has certain advantages. First, this procedure avoids inclusion of some independent variables such as income and population for which changes would be expected to influence demand for all fuels equally. And second, the model concentrates attention on the competitive interactions among all fuels.

This section includes the model specification subsequent to the important features of energy demand and the basic assumptions underlying the model.

3.1.1. ESSENTIAL FEATURES OF ENERGY DEMAND

One essential feature of energy demand is its derived nature. In general, energy is not desired for its direct effect, but for the utility derived from its use-heat, light or power. For example, there is not a demand for electricity, but a demand for electric heat, electric light or electric power. For example in estimating the demand for electricity as a direct function of real income and relative prices of fuels, one is implicitly suggesting that electricity demand is derived from the use of goods whose determinants themselves are real income and relative prices of fuels. In essence, the estimating equation for electricity is the reduced form of a system of two equations. The first determines the rate of purchase of goods, which provide services with electricity input, the second determines the amount of electricity input utilized in the use of these goods.

The demand for energy is then derived from, and ultimately connected to the stock of energy using goods. Thus, energy demand depends on the existing stock of energy using goods, their depreciation rate, additions to the stocks, and the rate of utilization of the stock. Changes in the demand for energy can quite easily be seen to differ substantially in the short and the long-runs. A short run is characterized as the time when the stock of energy-using assets is fixed, and a long-run, when the stock is variable.

The division of adjustment periods for energy use between a short and a long run suggests that estimating forms should be dynamic. A static equation will not be able to pick up the important differences in the rate of adjustment between a short and a long run.

To estimate energy demand requires a simultaneous equation system. The system is simultaneous because the consumer's choice of a particular fuel is based partially on that individual choice of fuel using appliances, while the particular appliance choice is dependent on the relative price of fuels. Moreover, the simultaneous equation system must incorporate the choices of all fuels simultaneously. For example, it is incorrect to attempt to model the household's choice of coal as a separate decision from the household's choice of fuel-oil.

A traditional approach to estimate the demand for energy has been to develop separate demand equations for each fuel. The interfuel substitutions in these models can only be explained by including prices of competing fuels in each equation, but this ignores the interrelationships of consumption between the fuels. In addition, the effect of a price increase of a particular fuel on total energy consumption is uncertain using individual fuel demand equations. Since these types of models are estimated independently, it is unsure if the sum of the individually forecasted demands are reasonable.

Thinking in terms of a simultaneous equation system naturally leads to a number of constraints on this system. One simple constraint would be that the market shares of all fuels add up to unity. Second, the constraints which the demand theory suggests should be incorporated in this simultaneous equation system. These constraints deal with the price elasticities of demand. For example, own-price elasticities should be negative and cross-price elasticities should be positive. Of course, the constraints on the system necessiate special econometric treatment.

On the other hand, comparisons among the four principal sources of energy call for some common standard of measurement. By converting all quantities into their kilocalories equivalent, we can have a common data base.

3.1.2. VARIABLES INFLUENCING ENERGY DEMAND

Several factors influence the pattern of energy demand. Some of these factors determine the size of the total market, others influence the preference pattern of users among the alternative energy sources. These factors are as follows:

- National income, GNP
- Population trends
- Prices
- Price predictions
- Rate of change of prices
- Stock of energy using goods
- Government policies
- Supply availability of alternative fuels.
- Air pollution abatement requirements
- Investment rate of the industry
- New construction

As the most important and quantifiable variables, we can specify national income, relative prices, rate of change of prices and stock of energy using goods.

Modelling the demand for alternative fuels in terms of their market shares rather than absolute quantities makes it possible to eliminate some of the above factors which determine the size of the total market. (e.g. national income, population)

In summary, the most effective factors in determining a fuel share are prices, prices of substitutes and existing stock of energy using goods.

On the other hand, dynamic nature of energy demand suggests lagged effect of these variables. The demand equations can be estimated with both current-period fuel prices and with fuel prices lagged various number of periods.

3.1.3. BASIC STRUCTURE OF THE MODEL

Based on the above discussion, basic structure of the model has been developed as follows:

Market share of fuel (i) in year (t) = f → Price of fuel (i)
→ Prices of substitutes
→ Stock of energy using appliances.

In constructing the model, it has been assumed that energy prices are exogenous, i.e. demand effects can be identified as separate from supply effects. It has also been assumed that energy will be available to fulfill demand at these exogenous costs and prices. If these two assumptions are not true, one would want to build a supply side into this model also.

Effect of the stock adjustment mechanism is quantified by means of lagged variables. In the following specification, the lagged dependent variable causes the influence of previous values of the independent variables to enter the equation:

Market share of fuel (i) in year (t) = f → Price of fuel (i)
→ Prices of substitutes
→ Market share of fuel (i) in year (t-1

The above model allows for some dynamization of the relationship so that a long-term reaction to prices can be assessed.

3.1.4. MODEL SPECIFICATION

Given the constraint that each of the shares is contained within the interval (0,1), a linear model specification is unacceptable due to the possibility that forecasts may lie outside of it. The obvious solution is to have a transformation, for all possible values that yield forecasts in (0,1) interval. This requirement suggests the use of a cumulative function, whose upper bound is one and whose lower bound is zero and will provide a suitable transformation.

The transformation adopted here is the multinomial logit specification, and similar to the Cohn's (11) work on energy use in residential and commercial sectors, and Uri's (38) study on electric utility fuel consumption.

The logit model is based on the function:

$$S_{it} = \frac{1}{1 + \exp\left(\alpha_i + \sum_{j=1}^{n} \beta_{ij} x_{jt}\right)} \qquad (1)$$

where S_{it} denotes the share of fuel (i) in period (t), the x_{jt}'s are the exogenous factors causing variations in the fuel share (i) in period (t) and $\alpha_i, \beta_{i1}, \ldots, \beta_{in}$ are coefficients.

The specification provided in Equation (1) can be estimated directly by means of nonlinear least squares or, after a suitable transformation of the dependent variable, by means of ordinary least squares. However, such a process would not use all of the information efficiently. The estimation procedure should consider the fact that the sum of shares is equal to unity, given that the available choices are mutually exclusive.

To extend the logit model to the four-choice case that exist here, we write:

$$\mathrm{Ln}\left(\frac{S_c}{S_p}\right)_t = \alpha_c + \sum_{j=1}^{n} \beta_{cj} x_j \qquad (2a)$$

$$\mathrm{Ln}\left(\frac{S_L}{S_p}\right)_t = \alpha_L + \sum_{j=1}^{n} \beta_{Lj} x_j \qquad (2b)$$

$$\mathrm{Ln}\left(\frac{S_e}{S_p}\right)_t = \alpha_e + \sum_{j=1}^{n} \beta_{ej} x_j \qquad (2c)$$

where, S_c , S_l, S_e, S_p denote the market shares of coal, lignite, electricity and petroleum, respectively.

Each of these equations presumes that the logarithm of the ratio of the share of one fuel to one minus the share of that fuel relative to a similar ratio for another fuel is a linear function of the set of explanatory factors. These values depend on the values associated with the remaining equations only to the extent that the system must be constrained so that the sum of individual shares is unity.

Assuming that the explanatory variables are relative prices and lagged market shares, the fuel share model becomes:

$$Ln\left(\frac{S_c}{S_p}\right)_t = \alpha_c + \beta_{c1} Ln\left(\frac{P_c}{P_p}\right)_t + \beta_{c2} Ln\left(\frac{P_L}{P_p}\right)_t + \beta_{c3} Ln\left(\frac{P_e}{P_p}\right)_t + \beta_{c4} Ln\left(\frac{S_c}{S_p}\right)_{t-1} + u_{ct} \quad (3a)$$

$$Ln\left(\frac{S_L}{S_p}\right)_t = \alpha_L + \beta_{L1} Ln\left(\frac{P_c}{P_p}\right)_t + \beta_{L2} Ln\left(\frac{P_L}{P_p}\right)_t + \beta_{L3} Ln\left(\frac{P_e}{P_p}\right)_t + \beta_{L4} Ln\left(\frac{S_L}{S_p}\right)_{t-1} + u_{Lt} \quad (3b)$$

$$Ln\left(\frac{S_e}{S_p}\right)_t = \alpha_e + \beta_{e1} Ln\left(\frac{P_c}{P_p}\right)_t + \beta_{e2} Ln\left(\frac{P_L}{P_p}\right)_t + \beta_{e3} Ln\left(\frac{P_e}{P_p}\right)_t + \beta_{e4} Ln\left(\frac{S_e}{S_p}\right)_{t-1} + u_{et} \quad (3c)$$

where S_c : Market share of coal

S_l : Market share of lignite

S_p : Market share of petroleum

S_e : Market share of electricity

and P_c : Price of coal (TL/kcal)

P_p : Price of petroleum (TL/kcal)

P_e : Price of electricity (TL/kcal)

P_l : Price of lignite (TL/kcal)

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The market shares are further defined by:

$$S_c = \frac{Q_c}{Q_t}\ ,\ S_l = \frac{Q_l}{Q_t}\ ,\ S_e = \frac{Q_e}{Q_t}\ ,\ S_p = \frac{Q_p}{Q_t}\ \text{and}\ Q_t = Q_c + Q_l + Q_e + Q_p \qquad (4)$$

where Q_i is the annual consumption of fuel (i) in kilocalories.

Here, the base share is chosen arbitrarily to be petroleum. And, all variables in the above equations are entered as their logarithms in order to interpret the regression coefficients as point elasticities.

The specification with the lagged dependent variable represents the reduced form, or estimable equation, rather than the structural from equation. The lagged market share causes the influence of previous values of the independent variables to enter the equation.[8/] Such a specification may assess the long-term reactions to prices.

The demand equations can be estimated with both current-year prices and with prices lagged various number of years.

And, the constraints on the equations 3 (a–c) are:

$S_c + S_l + S_p + S_e = 1$ (Sum of shares is unity) (5)

$\beta_{c1}, \beta_{l2}, \beta_{e3} \leq 0$ (Own price elasticies are negative) (6)

$\beta_{c2}, \beta_{c3}, \beta_{l1}, \beta_{l3}, \beta_{e1}, \beta_{e2} \geq 0$ (Cross price elasticities are positive) (7)

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8/ The assumed structural form equation is:

$$\text{Demand}_t = \alpha + \beta \sum_{i=0}^{\infty} \lambda^i \,\text{Price}_{t-i} \quad \text{where} \quad 0 < \lambda < 1$$

Which allows for a distribution of prices in a geometrically declining fashion. The reduced form, or estimable equation is:

$$\text{Demand}_t = \alpha' + \beta' \,\text{Price}_t + \lambda \,\text{Demand}_{t-1}$$

3.2. ESTIMATION PROCEDURE

We are now in a position to estimate the parameters of the model: $\alpha_c, \alpha_L, \alpha_e, \beta_{c1}, \beta_{c2}, \ldots, \beta_{c4}$. Since the dependent variables in equations 3 (a-c) are market shares, the disturbance terms can be expected to exhibit joint covariance. Efficiency can be gained by using the iterative seemingly unrelated (two-stage least squares) technique of Zellner (44). This is simply a generalized least squares estimation procedure to account for correlation among the error terms associated with each equation in the multinomial model.

In this procedure regression coefficients in all equations are estimated simultaneously by applying Aitken's generalized least squares to the whole system of equations.[9/] To construct such Aitken's estimators, Zellner's two-stage method employs estimates of the disturbance term's variances and covariances based on the residuals derived from equation by equation application of least squares.[10/]

The system of equations can be written in the form:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_M \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \cdots & 0 \\ 0 & X_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & X_M \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_M \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_M \end{bmatrix} \quad (8)$$

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9/ Aitken's generalized least squares is given in a number of books. For example, Lee,T.C., Judge, G.G. and Zellner, A., Chapter 6, 'Estimating the Parameters of the Markov Probability Model from Aggregate Time Seri Data', North Holland Co., 1970, pp 73-84.

10/ This procedure has been applied to estimate the parameters of simultane equation energy models developed by Chern (10), Cohn (11) and Uri (37 , 38 and 39) or more compactly

$$y = X\beta + u \quad (9)$$

where y is a n M x 1 vector of observations on all dependent variables, X is a $nM \times \sum_m K_m$ matrix of explanatory variables, and u is a nMx1 vector of random disturbances. Further, let

$$E(uu') = \Omega$$
$$= \Sigma \otimes I \quad (10)$$

where $\otimes$ denotes the Kronocker product, $\Sigma = [\sigma_{mp}]$ is a MxM symmetric and positive definite matrix (m, p = 1,2, ..., M), and the dimension of I is nxn. If Ω is known, then the best linear unbiased estimator of Ω is given by

$$b^* = (X'\Omega^{-1}X)^{-1} (X'\Omega^{-1}y) \quad (11)$$

which is the Aitken's generalized least-squares estimator with variance

$$\text{Var}(b^*) = (X'\Omega^{-1}X)^{-1} \quad (12)$$

But Ω is rarely known, so that (11) is not applicable. Zellner suggests replacing Ω by its consistent estimator

$$\hat{\Omega} = \hat{\Sigma} \otimes I \quad (13)$$

where $\hat{\Sigma} = [s_{mp}] = [u_m' u_p] = [(y_m - X_m\beta_m)'(y_p - X_p\beta_p)]$

is a MxM matrix based on single equation ordinary least squares residuals. Zellner's two-stage Aitken estimator then is:

$$b = (X'\hat{\Omega}^{-1}X)^{-1} (X'\hat{\Omega}^{-1}y) \quad (14)$$

with variance given by

$$\text{Var}(b) = (X'\hat{\Omega}^{-1}X)^{-1} \quad (15)$$

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The estimator owes its name to the fact that its construction consists of two stages, the first involving the calculation of least squares estimates and the residual variance - covariance matrix, which is then used in the second stage in accordance with (14) above.

In this study, first, the three equations are estimated independently by ordinary least squares. The estimated residuals in addition to the original data, are then used as input to a computer program which computes the iterative Zellner estimates.

For the ordinary least squares, the SPSS package in UNIVAC 1106 library has been used. For the second stage of estimation a FORTRAN program has been written. The simplified flowchart and the list of this program are presented in Appendix D.

Before proceeding with the presentation of estimation results, a discussion of data is in order.

3.3. DATA

The share equations are estimated with annual data across all consuming sectors for the years 1956 - 1982.

Annual consumption data for the primary energy sources are obtained from the State Planning Organization, whereas the electricity consumption data are collected from the State Institute of Statistics.

Since making any changes in the shares of fuels in electricity generation would require large investments and very long lead times, competitive interactions among the alternative fuels in electricity production are not taken into account. And, demand for coal, lignite and petroleum are found by substracting the consumption amount of each fuel in thermo-electric production from the total consumption amount of that fuel. It should be noticed that the market shares in Chapter 1 are based on primary energy sources, whereas, from now on, they mean the share of the fuels which are available for end uses. (coal, lignite, electricity and petroleum)

The annual consumption figures in original units are transformed to their kilocalories equivalent by using the conversion factors which are listed in Appendix A. Market shares are then computed by using equation 4. (See: Section 3.1.4.)

In line with the view that energy demand is derived, one should measure the consumption in terms of output rather than input kilocalories. Input calories are the measurement of the kilocalories equivalent of the flow of a specific fuel to sectors. Output calories represent the energy available after the conversion to satisfy the use to which it is to put. But, because of measurement problems, we use input consumption.

Figure 4 illustrates the market shares of the four fuel types, for the years 1955 - 1982, where detailed consumption data are listed in Appendix B.

Retail price data for petroleum are obtained from the General Directorate of Petroleum Works; for electricity from the State Institute of Statistics and from the Turkish Electricity Authoritiy; and for coal and lignite from the Turkish Coal Enterprises.

The model uses relative prices rather than absolute prices, and thus necessitating the use of a common unit for each fuel. Therefore, the prices in original units are transformed to their TL/kcal equivalents.

Variations in specific heats and prices of the petroleum products are handled by using weighted average prices of these products as the petroleum price. The weighed average is computed by giving weight to each petroleum product according to its specific heat and its share. That is,

$$\text{Weighted average petroleum price} = \sum_{i} \left(\begin{array}{l} \text{Unit price of} \\ \text{product (i) in TL/kcal} \end{array} \right) \times \left(\begin{array}{l} \text{Share of product (i) in} \\ \text{total petroleum} \\ \text{consumption} \end{array} \right) \quad (15$$

Here, petroleum products are gasoline (super and normal), fuel-oil and diesel oil.

Prices of coal and lignite which are obtained from the Turkish Coal Enterprises are also based on weighted averages.

The price data are presented in Appendix C.

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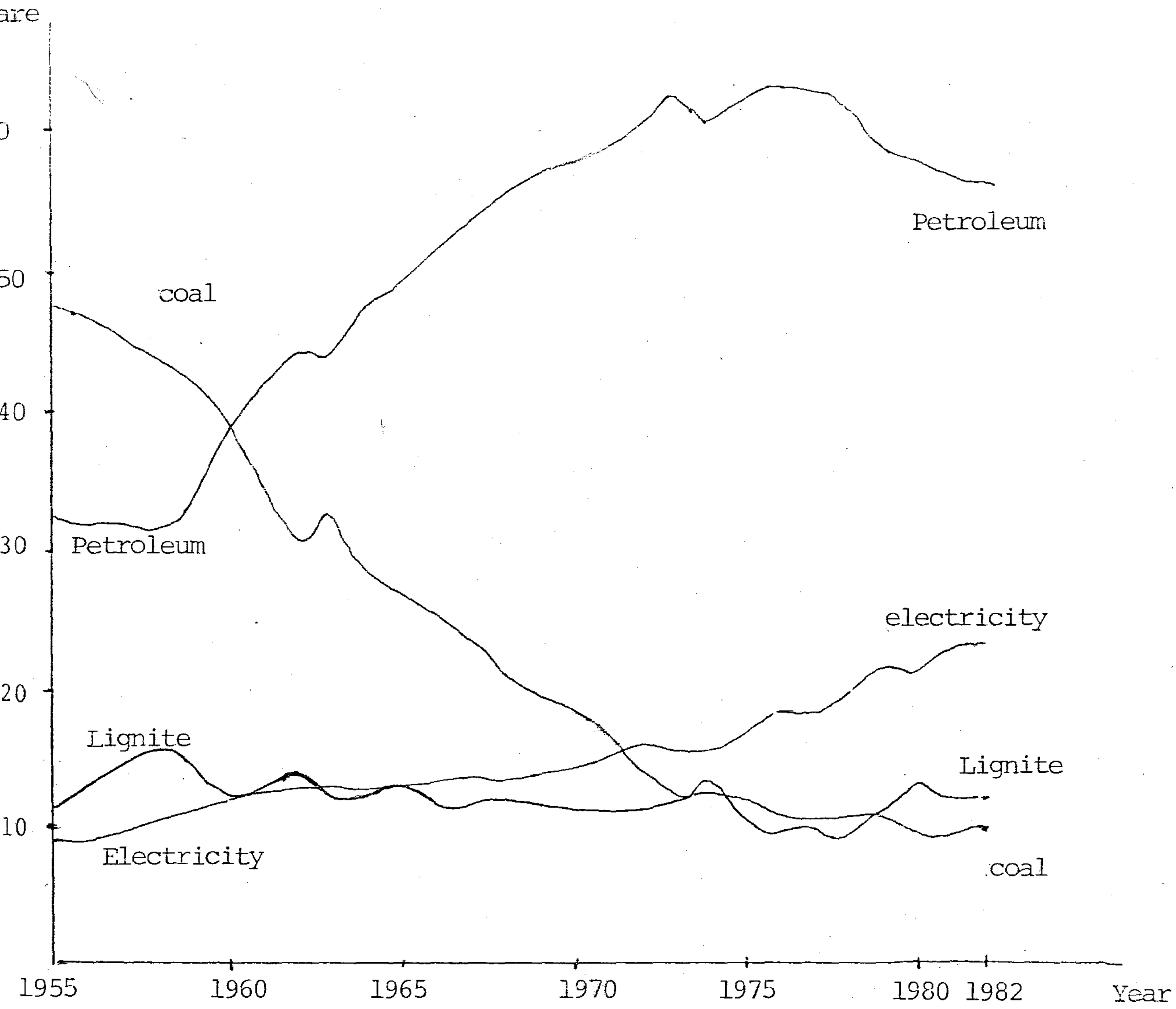
Figure 4. Market Shares of coal, lignite, petroleum and electricity 1955 - 1982.



IV. EXPERIMENTAL RESULTS

4.1. THE ORIGINAL MODEL

Using the specified data and estimating technique, the model was implemented. The estimation results for the fuel share equations are summarized in Table 3. The SPSS print out is also given in Appendix E.

Table 3. Parameter estimates for the original model

Equation 3a		Equation 3b		Equation 3 c	
Parameter	Estimate	Parameter	Estimate	Parameter	Estima
α_c	- 0.122	α_L	- 0.213	α_e	- 0.29
β_{c1}	- 0.130	β_{L1}	- 0.322	β_{e1}	- 0.14
	(0.142)		(0.130)		(0.04
β_{c2}	0.178	β_{L2}	0.277	β_{e2}	0.03
	(0.214)		(0.178)		(0.07
β_{c3}	- 0.201	β_{L3}	- 0.196	β_{e3}	- 0.14
	(0.116)		(0.119)		(0.07
β_{c4}	0.943	β_{L4}	0.782	β_{e4}	0.78
	(0.061)		(0.106)		(0.09
R^2 =	0.97	R^2 =	0.92	R^2 =	0.89
F =	467.67	F =	74.07	F =	53.68
D.W.=	2.61	D.W.=	2.36	D.W.=	2.33

Note : Standard errors of the parameters are given is paratheses.

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The results of the statistical analysis of the model can be summarized as follows, where the details of this analysis is given in Appendix F.

R^2 values of the three equations are quite large, near 1.0, indicating that most of the total variation in the dependent variables are explained by the full set of independent variables included in the model.

All F values are greater than the tabled value, so we can conclude that the model as a whole is a significant estimator of the fuel shares.

On the other hand, Durbin-Watson values indicate the absence of serial correlation among the residuals.

The lagged variables are very significant (at 99.5 % level). But it should be noted that most of the price elasticities (β_{c3}, β_{L1}, β_{L2}, β_{L3} and β_{e1}) do not have the appropriate sign. (Own-elasticities should be negative and cross elasticities should be positive). This condition indicates that, while the model demonstrates a significant relationship between the dependent variables as a group, the technique has been unable to separate the specific relationships between each independent variable and the dependent variable, and assigned arbitrary coeffients to the variables.

To overcome this difficulty, the model is modified by moving cross-price variables from the equations. Experimental results of the new model are presented in the next section.

4.2. THE MODIFIED MODEL

The modified model has the same formulation and constraints as of the original model, except the set of exogenous variables. In this model, exogenous variables are own-prices and lagged market shares. The following relations represent the new model.

$$Ln\left(\frac{S_c}{S_p}\right)_t = \alpha_1 + \alpha_2 \, Ln\left(\frac{P_c}{P_p}\right)_t + \alpha_3 \, Ln\left(\frac{S_c}{S_p}\right)_{t-1} + u_c \qquad (16\ a)$$

$$Ln\left(\frac{S_L}{S_p}\right)_t = \beta_1 + \beta_2 \, Ln\left(\frac{P_L}{P_p}\right)_t + \beta_3 \, Ln\left(\frac{S_L}{S_p}\right)_{t-1} + u_L \qquad (16\ b)$$

$$Ln\left(\frac{S_e}{S_p}\right)_t = \gamma_1 + \gamma_2 \, Ln\left(\frac{P_e}{P_p}\right)_t + \gamma_3 \, Ln\left(\frac{S_e}{S_p}\right)_{t-1} + u_e \qquad (16\ c)$$

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The constraints on the model are:

$$S_c + S_l + S_p + S_e = 1 \qquad (17)$$

$$\alpha_2,\ \beta_2,\ \gamma_2 \ \leq\ 0 \qquad (18)$$

Here, S_i and P_i are the market share and price, respectively, for fuel type i. (where i = e for coal, l for lignite, p for petroleum and e for electricity.)

As long as the accuracy of forecasting is concerned, the base share can be chosen arbitrarily. But it is observed that, the most important transition has occured between petroleum and the other fuels (Up to 1976, from coal, lignite and electricity to petroleum, after 1976 from petroleum to the others. The model uses shares and prices of fuels relative to that of petroleum, thus concentrating on the substitution between petroleum and the other fuels.

Using the data specified in section 3.3, the equations 16 (a-c) were estimated separately by ordinary least squares. The demand equations were estimated with both current-period fuel prices and with fuel prices lagged various number of years (one to five years). The best results were obtained when current-period fuel prices were used, and it is these results that are reported below.

The set of parameter estimates are shown in Table 4. The SPSS printout is also given in Appendix F.

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Table 4. Parameter estimates for the modified model
(Ordinary least squares)

Equation 16 a Parameter	Estimate	Equation 16 b Parameter	Estimate	Equation 16 c Parameter	Estimate
α_1	- 0.411	β_1	- 0.142	γ_1	- 0.119
α_2	- 0.267	β_2	- 0.079	γ_2	- 0.099
	(0.084)		(0.071)		(0.034)
α_3	0.940	β_3	0.982	γ_3	0.852
	(0.024)		(0.075)		(0.098)
R^2 = 0.99		R^2 = 0.90		R^2 = 0.86	
F = 859.42		F = 123.16		F = 78.29	
D.W. 2.28		D.W.= 1.58		D.W. = 1.96	

Note: Standard errors of parameter estimates are given in parantheses.

The estimates of the disturbance terms (u_c, u_l, and u_e) were then used to obtain the Zellner's two-stage least squares estimates (Estimation procedure is explained in Section 3.2). The results of the second stage of estimation are reported in Table 5, whereas the computer output is in Appendix H.

Table 5. Parameter estimates for the modified model
(Two stage least squares)

Equation 16 a Parameter	Estimate	Equation 16 b Parameter	Estimate	Equation 16 c Parameter	Estimate
α_1	- 0.3649	β_1	- 0.1404	γ_1	- 0.1213
α_2	- 0.2246^x	β_2	- 0.0673^{xx}	γ_2	- 0.0798^x
	(0.075)		(0.054)		(0.027)
α_3	0.9421^x	β_3	0.9723^x	γ_3	0.8586^x
	(0.020)		(0.066)		(0.092)
R^2 = 0.99		R^2 = 0.92		R^2 = 0.90	
F =1188.		F =138.		F =108.	
D.W. = 2.31		D.W. = 1.60		D.W. = 1.98	

Note: Standard errors of the parameter estimates are given in paratheses.
x/ Significant at 99.5 % level
xx/ Significant at 75 % level

Comparing the results in Table 4 and Table 5, it is observed that application of the two-stage least squares procedure has resulted in a significant reduction in the estimated coefficient estimator variances as compared with those of single equation least squares. The computer program written for the second stage prints out only the parameter estimates, and the statistical tests of the model are done manually. The results of the statistical analysis are summarized below, where the details are given in Appendix K.

R^2 values of the three equations are quite large, indicating that most of the total variation in the market shares are explained by the full set of explanatory variables. In other words, excluding cross-prices has not influenced the explanatory power of the model.

All F values are greater than the critical values, so the model as a whole is a significant estimator of the fuel shares.

Durbin-Watson values also indicate the absence of serial correlation among the residuals.

All coefficients have the correct sign, and, except β_2, they are significant at 99.5 % level or better. Thus, one can conclude that price elasticities are not zero and the responsiveness of the relative fuel shares to changes in fuel prices is consistently significant. For example, as the relative price of coal (to petroleum) increases, a reduction in the relative share of coal will be observed. Similarly, as the relative price of lignite declines, a large proportion of lignite is forthcoming. This is mainly due to the substitution of coal/lignite for petroleum, which is used for heating purposes in residences, and for process and space-heating purposes in the industrial sector.

In the model, the short-run coefficients (α_2, β_2, γ_2) indicate the usage response, whereas changes in the owner-ship of energy-using capital are included in the calculated long-run coefficients (coefficients of the lagged dependent variables: α_3, β_3 and γ_3)

Comparing the short-run coefficients to the long-run coefficients (0.2246 to 0.9421, 0.0673 to 0.9723, and 0.0798 to 0.8586 for equations 1, 2 and 3 respectively) and considering their standard errors ; it is observed that effect of the existing stock of energy using goods is greater than the effect of a price change. In other words, long run price effects are more dominant

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in the energy market. This fact can be attributed to the long investment periods involved in changing the energy using stocks of the industrial sector.

It is not surprising that short-run elasticities are relatively small. This analysis covers all energy using sectors except electricity generation (namely, residential, industrial, agriculture and transportation sectors). And the model reflects the effect of price changes to the energy demand without differentiating between the sectors. But all fuels are not perfect substitutes in all sectors. For example, in transportation sector, lignite can not be substituted for petroleum. Most of the interfuel substitution occurs in the residential and industrial sectors, where the total energy consumption in these two sectors constitute approximately 78 per cent[11] of the total energy consumption in Turkey.

On the other hand, estimates of the model having only lagged shares or only price ratios as dependent variables, have resulted in insignificant estimates. Lagged shares or prices alone, can not explain the changes in the market shares. That is, relative prices are effective both in the short and long run.

The lagged dependent variable coefficient value of 0.9723 in the second equation (as compared to 0.9421 in the first and 0.8586 in the third equations) suggests that the speed of adjustment to price changes of lignite users is somewhat smaller than that of coal and electricity users. That means, it is more difficult to make changes in the stocks of lignite using capital. At the same time, short-run price coefficient of lignite(β_2) is least significant, indicating that lignite prices are less effective than prices of other fuels, in the short-run.

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11/ State Planning Organization
5th 5 year Development Plan Special Committe Pre-Report on Energy.

Considering the market shares of fuels over the years 1955-1982 (See: Figure 4), it is expected that the greatest substitution is between charcoal and petroleum. The estimation results are in line with this expectation: Relative share of coal is more responsive to the changes in its relative price than that of electricity and lignite. (Comparing 0.2246 (α_2) to 0.0798 (β_2) and 0.0673 (γ_2))

4.3. MARKET SHARE FORECASTS

This section presents forecasts of market shares of the four main fuel types for the period 1983-1990. In order to make forecasts, future values of the exogenous variables in the model must be projected. The exogonous variables are relative prices. The uncertainty of future price values makes it necessary to follow a scenario approach and to develop several scenarios of energy prices to investigate the sensitivity of future demand to changes in the prices of substitute fuels.

The forecasting period is chosen to be 1983 - 1990. Extending the forecasting period would lead to misleading results, because uncertainties are greater in the long run, both for prices and alternative fuels. For example, it is very difficult to forecast prices of ten years later. On the other hand, it is expected that new alternatives such as geotnermal energy will come into the picture in the long run.

4.3.1. FUTURE SCENARIOS

The scenarios of energy prices are based on the following assumptions:

1. During the forecasting period, petroleum price will increase continually. And, since it is dependent on exchange rates, petroleum price will increase at higher rates than the price of other fuels.
2. Lignite and coal prices will decrease relative to petroleum and electricity prices.

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3. Electricity price will depend on the prices of other fuels which are used in theormoelectric production. As the share of hydropower in electricity production increases, it is expected that electricity price will decrease relative to the petroleum price.

4. In other words, with real prices:
   - Petroleum price will increase,
   - Coal price will remain stable,
   - Lignite price will decrease or remain stable,
   - Electricity price will remain stable, or increase at the same rate with petroleum or increase at a slower rate than petroleum.

Based on the above assumptions eight alternative scenarios are developed. In all of these scenarios, it is assumed that rate of change in the relative prices will not differ from year to year.

Among the eight scenarios, Scenarios 2 to 7 can be considered as the most probable ones. Assuming higher change rates of prices would not be reliable. In the following scenarios, only Scenario 1 assumes sharp declines in relative prices. On the other hand, Scenario 8 is based on the assumption that relative prices will not change during the estimation horizon. Of course, it is possible to develop many other scenarios by using different rates.

The scenarios are presented below. Here, the figures at the right-hand side show the relative price trends where P_c, P_l, P_e and P_p stand for price of coal, lignite, electricity and petroleum, respectively. The actual relative prices for 1982 are:

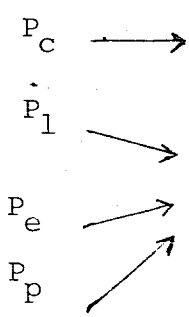
$$\frac{P_c}{P_p} = 0.3496 \qquad \frac{P_l}{P_p} = 0.1466 \qquad \frac{P_e}{P_p} = 0.6650$$

<u>SCENARIO 1</u> — <u>Price trends</u>

P_c / P_p decreases by 20 % every year

P_l / P_p decreases by 30 % every year

P_e / P_p decreases by 10 % every year



<u>SCENARIO 2</u>

P_c/P_p	decreases by 10 % every year
P_l/P_p	decreases by 20 % every year
P_e/P_p	decreases by 5 % every year

P_c →
P_l ↘
P_e ↗
P_p ↗

<u>SCENARIO 3</u>

P_c/P_p	decreases by 10 % every year
P_l/P_p	decreases by 20 % every year
P_e/P_p	remains constant over the years

P_c →
P_l ↘
P_e ↗
P_p ↗

<u>SCENARIO 4</u>

P_c/P_p	decreases by 10 % every year
P_l/P_p	decreases by 20 % every year
P_e/P_p	decreases by 10 % every year

P_c →
P_l ↘
P_e →
P_p ↗

<u>SCENARIO 5</u>

P_c/P_p	decreases by 10 % every year
P_l/P_p	decreases by 10 % every year
P_e/P_p	decreases by 5 % every year

P_c →
P_l →
P_e ↗
P_p ↗

SCENARIO 6

P_c / P_p	decreases by 10 % every year	$P_c \rightarrow$
P_l / P_p	decreases by 10 % every year	$P_l \rightarrow$
P_e / P_p	remains constant over the years	$P_e \nearrow$
		$P_p \nearrow$

SCENARIO 7

P_c / P_p	decreases by 10 % every year	$P_c \rightarrow$
P_l / P_p	decreases by 10 % every year	$P_l \rightarrow$
		$P_e \rightarrow$
P_e / P_p	decreases by 10 % every year	$P_p \nearrow$

SCENARIO 8

P_c / P_p, P_l / P_p, P_e / P_p remain constant over the years.

4.3.2. FORECASTING RESULTS

Once the future prices are projected, obtaining forecasts of fuel shares is a straight forward process. One needs only to rewrite equations 16 (a-c). Denoting the right hand sides of Eq. 16 a as A, of Eq. 16 b as B and of Eq. 16c as C, it follows that:

$$S_p = 1 / \left(1 + \exp (A) + \exp (B) + \exp (C) \right)$$

$$S_c = S_p x \exp (A)$$

$$S_l = S_p x \exp (B)$$

$$S_e = S_p x \exp (C)$$

where $S_p + S_c + S_l + S_e = 1$.

The share estimations ar obtained by the following procedure.

$$\frac{S_c}{S_p} = \exp \quad (A)$$

$$\frac{S_1}{S_p} = \exp \quad (B)$$

$$\frac{S_e}{S_p} = \exp \quad (C)$$

That is, $S_p = 1 \Big/ \left(1 + \frac{S_c}{S_p} + \frac{S_1}{S_p} + \frac{S_e}{S_p} \right)$

and $S_c = S_p \times \frac{S_c}{S_p}$

$$S_1 = S_p \times \frac{S_1}{S_p}$$

$$S_e = S_p \times \frac{S_e}{S_p}$$

The forecasting results based on the above scenarios are presented in Appendix L. Table 6 shows the summary of results, the actual figures for 1982 are also presented, for comparison.[12/]

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12/ Published data for 1983 was not available at the time of this study.

Table 6. Summary of the forecasting results

1982 actual shares (%) :

S_p = 56.08 S_c = 9.49 S_1 = 11.84 S_e = 22.59

Market Share (%) / Scenario	1986				1990			
	S_p	S_c	S_1	S_e	S_p	S_c	S_1	S_e
1	50.00	11.37	14.13	24.50	38.37	19.87	18.77	22.99
2	51.73	9.74	14.00	24.53	44.88	12.38	18.33	24.41
3	52.17	9.81	14.12	23.90	45.96	12.68	18.78	22.58
4	51.32	9.65	13.89	25.14	43.79	12.09	17.88	26.24
5	52.17	9.81	13.28	24.74	46.47	12.82	15.44	25.27
6	52.61	9.90	13.39	24.10	47.63	13.14	15.82	23.41
7	51.75	9.73	13.17	25.35	45.30	12.50	15.05	27.15
8	54.01	8.36	12.89	24.74	52.58	7.59	14.00	25.83

Considering the results of the alternative scenarios, one might expect that different pricing policies would result in different structure of energy demands. That is, relative shares in the energy market are sensitive to relative fuel prices. Thus, validity of forecasts depends on the accuracy of assumptions.

Scenarios 1, 2 and 8 differ substantially, Scenario 1 assumes reductions of considerable amounts in the prices of coal, lignite and electricity (20, 30 and 10 per cent respectively) relative to the petroleum. Scenario 2 also assumes continuous reductions in relative prices but at smaller rates (10, 20 and 5 per cent). On the other hand, in scenario 8, it is assumed that relative prices will remain constant in the next eight years.

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Although there are wide variations between these three scenarios, in the first four years the shares do not differ very much. In 1986, share of petroleum declines to 50 per cent, 51.73 per cent and 54.01 per cent, in scenarios 1, 2 and 8 respectively.

But when we look at 1990 figures, we see significant variations among the scenarios. In scenario 1, petroleum share which is 56.08 percent in 1982, decreases by 32 per cent (to 38.37 per cent), in scenario 2, decreases by 20 per cent (to 44.88 per cent), and in scenario 3 decreases only by 6 per cent (to 52.58 per cent).

This fact can be best explained by the long term effects of prices. In the early years of the forecasting period, effects of the new pricing policies are not evident. In these years, pricés of the previous periods are effective. But as the new policies are applied in a consistent manner, they begin to influence the energy market after a few years.

Results of scenaris 8 indicate that, the market structure will not differ significantly unless the current pricing policy change. Petroleum will continue to be the dominant energy source by a market share of 52.58 per cent. Domestic fuels such as lignite and coal will not be preferred to imported petroleum. Of course, such a case is not desirable.

But when relative prices change significantly, as in the case of scenario 1, then transitions of considerable amounts from petroleum to the other fuels are observed. Petroleum looses 32 per cent of its share (declines from 56.08 to 38.37 per cent), while coal share increases by 109 per cent (increases from 9.49 to 19.87 per cent), and lignite share increases by 59 per cent (increases from 11.84 to 18.77 per cent). Electricity share increases only by 1 per cent, because it has the highest relative price (0.67) in 1982, and the lowest rate of relative price reduction during the forecasting period

As long as the change rates of relative prices are concerned, there are not great differences between scenarios 2 to 7. But one can derive many implications by comparing the results of these scenarios.

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In every scenario, relative prices decrease at constant rates, but the market shares increase at increasing rates. This is mainly due to the long-term effect of prices. Reductions in prices influence both the demand of the current year and of the future years. As the relative price reductions continue in a consistent manner, their influence on the energy demand becomes greater in the later years of the forecasting period.

As explained in Section 4.2., coal is the most responsive fuel to price changes. Since all scenarios assume that (real) coal price will remain constant over the years, it is expected that coal share will increase at the highest rate as the relative price of petroleum increases. And, this is precisely the pattern that evolves: The share of coal is 9.49 per cent in 1980, and it reaches to 12.38, 12.68, 12.09, 12.82, 13.14 and 12.50 per cent in 1990, in scenarios 2 to 7 respectively (increasing by 27 - 38 per cent).

When there is a continuous decline in the relative price of lignite to petroleum, lignite share increases continually, too. This is the result of substitution of lignite for petroleum. Although the price elasticity of lignite is not as high as the elasticity of coal, we see transitions of considerable amounts from petroleum to lignite. Lignite share, which is 11.84 per cent in 1982, reaches to approximately 18 per cent in 1990, when its relative price decreases by 20 per cent. (Scenarios 2, 3 and 4). It becomes approximately 15.5 per cent, when its relative price decreases by 10 per cent (Scenarios 5, 6 and 7).

When lignite price remains constant in real terms (Scenarios 5, 6 and 7), in addition to transitions from petroleum to lignite and coal, a transition to electricity is also observed.

Electricity is the least price responsive fuel. This fact may be attributed to the limited end uses that are available for substitution. In almost all scenarios, electricity share changes very slightly over the eight years of forecasting horizon. In scenarios 3 and 6, electricity price changes at the same rate with petroleum. In these cases, in the early years, we observe a transition from petroleum to electricity arising from relatively low price of electricity. But in the later years, electricity begins to loose its share because of the long-term effect of continuously increasing electricity prices.

Electricity price is mostly effected by the prices of other fuels which are used in thermoelectric production. If the share of hydroelectricity in total electricity production increases, as it is planned by the Turkish Electricity Authority, relative price of electricity will decline significantly. And, this will lead to increasing share of electricity as in the case of scenarios 7 and 8.

Scenario 7 is based on the assumption that, prices of coal, lignite and electricity will all decrease by 10 per cent, relative to petroleum. In that case, transitions from petroleum involve mainly the substitution of coal for petroleum, secondly of lignite and thirdly of electricity (In eight years, coal share increases by 32 per cent, lignite share by 27 per cent and electricit share by 20 per cent).

V. CONCLUSIONS

The results of this study imply that, preference of users among the alternative fuels is sensitive to the relative prices of fuels. Observing that current period fuel prices are significant variables effecting energy demand, one may suggest that prices can be good instruments in shaping the structure of the energy market. In Turkey, energy prices are under the control of the government, and applying consistent pricing policies may lead to a market structure with desired percentages of shares.

Influence of the pricing policies becomes more evident in the long run, because long-run prices are more effective in the energy market. That is, energy demand mostly depends on the existing stock of energy-using capital. Energy using goods have long amortization periods (especially in the industrial sector), and changing the stocks involves long investment periods. Therefore, responses of users to price changes become more significant after a few years of time lag.

Estimation results indicate that coal demand is more sensitive to price changes than lignite and electricity. As the price of coal relative to petroleum declines, a significant increase in the relative share of coal is indicated. That is, degree of substitubility between coal and petroleum is the greatest among all fuels.

Eight alternative scenarios are developed with different sets of assumptions. The common point of these assumptions is that, growth rate of petroleum price will be the greatest among the prices of all fuels. The results show that forecasts vary depending on the assumptions used. Thus, validity of forecasts depends on the accuracy of assumptions.

Based on these forecasts, major conclusions may be summarized as follows: Petroleum demand will continue to decline as long as its relative price continues to increase. Assuming that most probable scenarios are the second to seventh (See: Section 4.3.1.), petroleum share will decline from 56 per cent to 44-47 per cent in eight years. In 1990, coal share will be 12-13 per cent, whereas lignite share is 15-18 per cent and electricity share is 23-27 per cent. It may also be possible to reduce the petroleum share to 38 per cent as in the case of scenario 1.

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But, if the relative prices remain stable over the years as it is assumed in scenario 8, the decline in petroleum share will be very insignificant. It will continue to be the dominant fuel in the market. Therefore, changing the price trends of energy-use seems to be a necessity.

The objective of the national policy must obviously be to reduce the dependence on imported energy (that is, petroleum). In order to shape the energy demand, a new pricing policy should be developed. Since the changes in usage patterns involve long lead times, these policies should be applied consistently over the years.

A suitable pricing policy may lead the users to prefer domestic substitutes for petroleum (such as coal and lignite). But, in order to support this pricing policy, difficulties in supplying the substitute fuels should also be resolved. Consumers should be able to reach the fuel they need, at the right place and at the right time. For this reason, production of coal, lignite and hydroelectricity should increase so that the increasing demand for these fuels can be supplied.

Results of this study can be used for translating the forecasts of market shares to quantities. This requires the total market demand to be known or forecasted. For that purpose, another econometric relationship should be established between the total energy demand and the number of relevant explanatory factors such as national income. Although such an attempt has not been made in this study, knowing the forecasts of market share percentages for each type of fuel and the forecast of the total energy demand, quantity demand for each fuel can be forecasted. Thus, supply policies can be developed in order to meet the forecasted demand.

Although the results of this study are reliable, it might be possible to get more accurate results if the data were more reliable. It has been fairly difficult to solve the inconsistencies between the data obtained from several official sources. Therefore, establishing an energy data bank becomes a necessity for more healthy analyses.

This study has not been done on sectoral basis because of the lack of sectoral energy-use data. It is believed that, a study on disaggregated basis by individual sectors (industrial, residential, etc.) may lead to results which reflect the substitution relationships better. Because, degree of substitubility between fuels differs from sector to sector. For example, transition between coal and petroleum involved in the industrial sector is not similar to that in the transportation sector.

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It is appropriate to recomm further work carried on sectoral basis reflecting the behavior of energy users more accurately. Using relative costs rather than relative prices may also lead to more accurate results. In this study it is assumed that energy is available to fulfill demand at the stated prices. Therefore it may also be recommended to build a supply side into the model, and thus considering the supply availability of alternative fuels. New alternatives, as they come into the picture should be included into the model, too.

Nevertheless, it is felt that the model developed in this study reflects the competitive interactions among the alternative fuels very well. And, it can be used to forecast the future consumption of individual fuels. Taking into account both short-run and long-run responses to prices, considering all fuels simultaneously and paying close attention to the estimation technique, the model provides a better understanding of the energy market in Turkey.

APPENDICES

APPENDIX A

CONVERSION FACTORS

Source: State Planning Organization
5th 5 year Development Plan Special Committe Pre-Report on Energy.

	Specific heat (kcal/kg)	Tons of coal[15] equivalent
1 ton Bituminous coal	6,100	0.87
1 ton Lignite	3,000	0.43
1 ton Crude-oil	10,500	1.50
1 ton Fuel-oil	10,185	1.455
1 ton Gasoline, Diesel-oil	11,340	1.62
10^3 kwh Electricity (hydro, geotermal or nuclear)	2,500[13]	0.36
10^3 m^3 Natural gas	8,900[14]	1.27
1 ton Firewood	3,000	0.43
1 ton Animal and Vegetable waste	2,300	0.33
1 Mwh Solar	860[13]	0.123

13/ kcal/kwh

14/ kcal/m^3

15/ In international standards, specific heat of coal is 7000 kcal/kg.

APPENDIX B

ENERGY CONSUMPTION DATA

B. 1. ANNUAL CONSUMPTION DATA

Source: State Planning Organization 2-5th 5 year Development Plans Special Committe Reports on [illegible] and State Institute of Statistics, Statistical Yearbooks of Turkey 1958 - 1983.

Year	Coal (1000 tons)	Lignite (1000 tons)	Petroleum[16] (1000 tons)	Electricity (1000 kwh)
1955	3.500	1.633	1.201	1.347.250
1956	3.718	2.150	1.274	1.544.838
1957	4.011	2.734	1.423	1.757.039
1958	4.074	2.895	1.469	1.961.540
1959	3.937	2.718	1.536	2.170.491
1960	3.898	2.710	1.938	2.395.720
1961	3.689	2.588	2.126	2.585.364
1962	3.983	3.337	2.699	3.059.274
1963	4.229	3.335	2.976	3.406.316
1964	4.511	4.140	3.650	3.780.695
1965	4.489	4.381	3.959	4.236.812
1966	4.842	4.683	4.724	4.727.157
1967	4.550	4.645	5.446	5.269.226
1968	4.513	5.343	6.231	5.847.000
1969	4.798	5.602	7.256	6.515.000
1970	4.677	5.791	7.661	7.058.000
1971	4.671	6.414	9.046	8.289.266
1972	4.630	6.613	10.031	9.527.261
1973	4.572	7.793	12.240	10.530.083
1974	4.965	9.336	12.154	11.358.701
1975	4.746	10.159	13.950	13.491.661
1976	4.332	10.908	15.116	16.078.892
1977	5.057	12.109	17.365	17.945.000
1978	4.634	13.522	17.114	18.967.600
1979	4.901	14.085	15.008	19.984.000
1980	4.556	15.801	15.434	20.968.000
1981	4.452	16.738	15.282	22.753.100
1982	4.974	17.657	16.087	24.381.200

16/ Crude Oil Equivalent

B.2. CONSUMPTION OF [illegible]LS IN THERMOELECTRIC PRODUCTION

Source : State Institute of Statistics
Turkish Statistical Yearbooks 1958-1983

Year	Coal (1000 tons)	Lignite (1000 tons)	Petroleum (1000 tons)
1955	556	188	36
1956	607	330	36
1957	657	544	37
1958	633	441	39
1959	619	500	40
1960	642	570	77
1961	701	332	84
1962	905	487	107
1963	604	506	127
1964	875	892	122
1965	844	866	123
1966	961	1.085	140
1967	773	862	411
1968	755	1.026	369
1969	941	913	615
1970	986	1.122	787
1971	978	1.187	1.058
1972	1.039	1.166	1.248
1973	1.118	1.490	1.647
1974	1.130	2.114	1.571
1975	1.098	2.593	1.657
1976	1.069	3.381	1.567
1977	1.012	3.910	2.142
1978	1.046	5.019	1.989
1979	891	6.001	1.457
1980	731	5.128	1.518
1981	787	6.932	1.546
1982	778	7.015	1.678

B.3. ANNUAL CONSUMPTION EXCLUDING THERMOELECTRIC PRODUCTION

(In terms of original units.)

Year	Coal (1000 tons)	Lignite (1000 tons)	Petroleum (1000 tons)	Electricity (10^3 kwh)
1955	2.944	1.445	1.165	1.347.250
1956	3.111	1.820	1.238	1.544.838
1957	3.354	2.190	1.386	1.757.039
1958	3.455	2.454	1.430	1.961.540
1959	3.318	2.218	1.496	2.170.491
1969	3.256	2.140	1.861	2.395.720
1961	2.988	2.256	2.042	2.585.364
1962	3.078	2.850	2.592	3.059.274
1963	3.625	2.829	2.849	3.406.316
1964	3.636	3.248	3.528	3.780.695
1965	3.645	3.515	3.836	4.236.812
1966	3.881	3.598	4.584	4.727.157
1967	3.777	3.783	5.035	5.269.226
1968	3.758	4.317	5.862	5.847.000
1969	3.857	4.689	6.641	6.515.000
1970	3.691	4.669	6.874	7.058.000
1971	3.693	5.227	7.988	8.289.266
1972	3.591	5.447	8.783	9.527.261
1973	3.454	6.303	10.593	10.530.083
1974	3.835	7.222	10.583	11.358.701
1975	3.648	7.566	12.293	13.491.661
1976	3.263	7.527	13.549	16.078.892
1977	4.045	8.199	15.223	17.945.000
1978	3.588	8.503	15.125	18.965.600
1979	4.010	8.084	13.551	19.984.000
1980	3.825	10.673	13.916	20.968.000
1981	3.665	9.806	13.736	22.753.100
1982	4.196	10.642	14.409	24.381.200

B.4. ANNUAL CONSUMPTION EXCLUDING THERMOELECTRIC PRODUCTION

(In terms of 10 kcal.)

Year	Coal	Lignite	Petroleum	Electricity	Total
1955	17.958.400	4.335.000	12.232.500	3.368.125	37.894.025
1956	18.977.100	5.460.000	12.999.000	3.862.095	41.298.195
1957	20.459.400	6.570.000	14.553.000	4.392.598	45.974.998
1958	21.075.500	7.362.000	15.015.000	4.903.850	48.356.350
1959	20.239.800	6.654.000	15.708.000	5.426.228	48.028.028
1960	19.861.600	6.420.000	19.540.500	5.989.300	51.811.400
1961	18.226.800	6.768.000	21.441.000	6.463.410	52.899.210
1962	18.775.800	8.550.000	27.216.000	7.648.185	62.189.985
1963	22.112.500	8.487.000	29.914.500	8.515.790	69.029.790
1964	22.179.600	9.744.000	37.044.000	9.451.738	78.419.338
1965	22.234.500	10.545.000	40.278.000	10.592.030	83.649.530
1966	23.674.100	10.808.300	48.132.000	11.817.893	94.432.293
1967	23.039.700	11.363.300	52.867.500	13.173.065	100.443.565
1968	22.923.800	12.984.800	61.551.000	14.617.500	112.077.100
1969	23.527.700	14.094.300	69.730.500	16.287.500	123.640.000
1970	22.515.100	14.053.800	72.177.000	17.645.000	126.390.900
1971	22.527.300	15.710.900	83.874.000	20.723.165	142.835.365
1972	21.905.100	16.559.400	92.221.500	23.818.153	154.504.153
1973	21.069.400	19.284.700	111.226.500	26.325.208	177.905.808
1974	23.393.500	22.178.200	111.121.500	28.396.753	185.089.953
1975	22.252.800	23.290.800	129.076.500	33.729.153	208.349.253
1976	19.904.300	23.156.900	142.264.500	40.197.230	225.522.930
1977	24.674.500	25.161.200	159.841.500	44.862.500	254.539.700
1978	21.886.800	25.895.100	158.812.500	47.419.000	254.013.400
1979	24.461.000	24.515.900	142.285.500	49.960.000	241.222.400
1980	23.332.500	32.744.400	146.118.000	52.420.000	254.614.900
1981	22.356.500	30.144.700	144.228.000	56.882.750	253.611.950
1982	25.595.600	31.926.000	151.294.500	60.953.000	269.769.100

B.5. MARKET SHARES OF FUELS

Year	Coal (%)	Lignite (%)	Petroleum (%)	Electricity (%)
1955	47.39	11.44	32.28	8.89
1956	45.95	13.22	31.48	9.35
1957	44.50	14.29	31.66	9.55
1958	43.58	15.23	31.05	10.14
1959	42.14	13.85	32.71	11.30
1960	38.34	12.39	37.71	11.56
1961	34.46	12.79	40.53	12.22
1962	30.19	13.75	43.76	12.30
1963	32.03	1[illegible].29	43.34	12.34
1964	28.28	1[illegible].43	47.24	12.05
1965	26.58	12.61	48.15	12.66
1966	25.07	11.45	50.97	12.51
1967	22.94	11.30	52.64	13.12
1968	20.45	11.59	54.92	13.04
1969	19.03	11.40	56.40	13.17
1970	17.81	11.12	57.11	13.96
1971	15.77	11.00	58.72	14.51
1972	14.17	10.73	59.69	15.41
1973	11.84	10.84	62.52	14.80
1974	12.64	11.98	60.04	15.34
1975	10.68	11.18	61.95	16.19
1976	8.83	10.26	63.08	17.83
1977	9.69	9.88	62.80	17.63
1978	8.62	10.19	62.52	18.67
1979	10.14	10.16	58.99	20.71
1980	9.16	12.86	57.39	20.59
1981	8.82	1[illegible]	56.90	22.43
1982	9.49	11.84	56.08	22.59

APPENDIX C

ENERGY PRICES

C.1. AVERAGE PRICE [illegible] COAL AND LIGNITE

Source: Turkish Coal Enterprises
Annual Reports 1956-1983

Year	Coal (TL/Ton)	Lignite (TL/Ton)
1956	39.06	32.47
1957	39.06	32.47
1958	41.41	32.77
1959	84.64	48.99
1960	115.70	58.88
1961	115.70	58.88
1962	119.17	60.06
1963	120[illegible]	60.06
1964	121.56	60.96
1965	121.56	60.96
1966	125.21	60.96
1967	148.75	64.06
1968	167.05	62.50
1969	180.05	68.18
1970	174.69	65.38
1971	227.12	89.04
1972	295.08	115.30
1973	286.81	116.90
1974	286.50	104.80
1975	288.49	104.41
1976	280.56	98.96
1977	444.05	119.91
1978	1244.50	273.90
1979	1791.33	478.43
1980	5681.[illegible]	1134.20
1981	8070.[illegible]4	1857.63
1982	11669.59	2406.24

C.2. WEIGHTED AVERAGE PRICE OF PETROLEUM

Source: Turkish Petroleum Works
Statistics Department

Year	TL/10^3 kcal[17]
1956	0.0280
1957	0.0280
1958	0.0320
1959	0.0387
1960	0.0471
1961	0.0473
1962	0.0473
1963	0.0573
1964	0.0592
1965	0.0591
1966	0.0591
1967	0.0632
1968	0.0651
1969	0.0651
1970	0.0735
1971	0.0890
1972	0.0917
1973	0.0917
1974	0.1522
1975	0.1643
1976	0.2643
1977	0.2120
1978	0.3773
1979	1.0565
1980	2.4300
1981	4.0422
1982	5.4722

17/ In computing the averages, convesion factors in Appendix A are used.

C.3. AVERAGE PRICE OF ELECTRICITY

Source: State Institute of Statistics
Turkish Statistical Yearbooks 1958-1983

Year	Krş/Kwh
1956	17.10
1957	17.70
1958	17.60
1959	23.80
1960	25.81
1961	26.41
1962	27.07
1963	28.28
1964	29.08
1965	29.00
1966	29.57
1967	32.36
1968	34.30
1969	35.33
1970	37.98
1971	42.84
1972	45.95
1973	51.25
1974	63.18
1975	74.40
1976	75.00
1977	89.10
1978	126.70
1979	176.15
1980	482.95
1981	686.37
1982	909.75

C.4. FUEL PRICES

(In terms of TL/10^3 kcal)

Year	Coal	Lignite	Petroleum	Electricity
1956	0.0064	0.0108	0.0280	0.0684
1957	0.0064	0.0108	0.0280	0.0708
1958	0.0068	0.0109	0.0320	0.0704
1959	0.0139	0.0163	0.0387	0.0952
1960	0.0190	0.0196	0.0471	0.1032
1961	0.0190	0.0196	0.0473	0.1056
1962	0.0195	0.0200	0.0473	0.1083
1969	0.0198	0.0200	0.0573	0.1131
1964	0.0199	0.0203	0.0592	0.1163
1965	0.0199	0.0203	0.0591	0.1160
1966	0.0205	0.0203	0.0591	0.1183
1967	0.0244	0.0214	0.0632	0.1294
1968	0.0274	0.0208	0.0651	0.1372
1969	0.0295	0.0227	0.0651	0.1413
1970	0.0286	0.0218	0.0735	0.1519
1971	0.0372	0.0297	0.0890	0.1714
1972	0.0484	0.0384	0.0917	0.1838
1973	0.0470	0.0390	0.0917	0.2050
1974	0.0470	0.0349	0.1522	0.2527
1975	0.0473	0.0348	0.1643	0.2976
1976	0.0460	0.0330	0.1643	0.3000
1977	0.0728	0.0400	0.2120	0.3564
1978	0.2040	0.0913	0.3773	0.5068
1979	0.2937	0.1595	1.0565	0.7046
1980	0.9314	0.3781	2.4300	1.9318
1981	1.3231	0.[illegible]192	4.0422	2.7455
1982	1.9130	0.8021	5.4722	3.6390

A P P E N D I X   D

TWO-STAGE LEAST SQUARES PROGRAM

D.1. FLOWCHART OF THE TWO-STAGE LEAST SQUARES PROGRAM

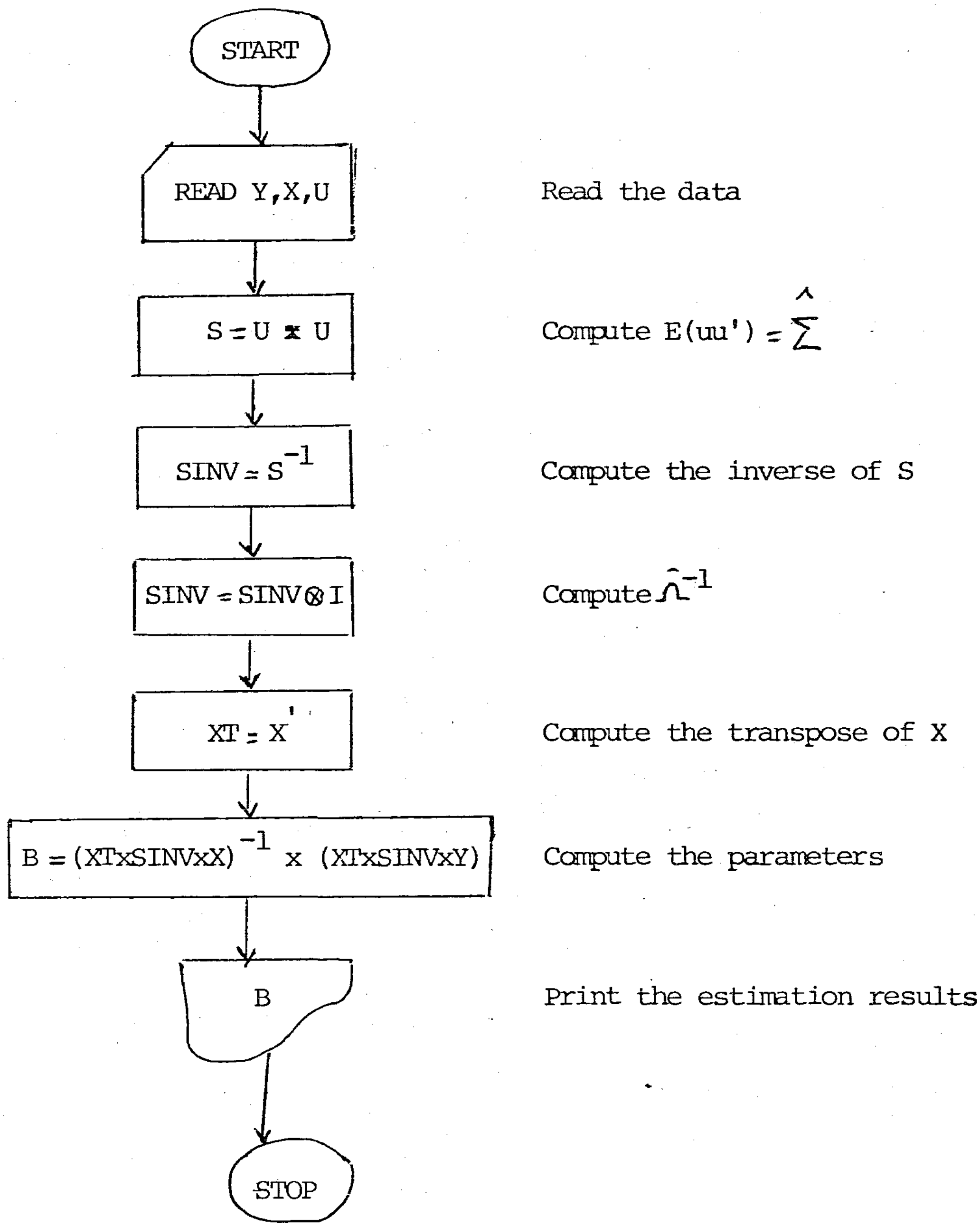
Symbols:

X : Matrix of independent variables

Y : Array of dependent variables

U : Matrix of residuals

B : Array of parameter estimates



D.2. LIST OF THE TWO-STAGE LEAST SQUARES PROGRAM

```
      DIMENSION X( [illegible]
      DIMENSION B(9,1),Z1(9,81),Z2(9,9),Z4(9,1),V(7),JC(10),DAT(27,12)
      READ(5,58) M,N,L
   58 FORMAT(3I2)
      NM=N*M
      DO 46 I=1,N
      READ(5,45)(DAT(I,J),J=1,12)
   45 FORMAT(4F6.2,4F7.4,4F6.2)
   46 CONTINUE
      CALL OUT(DAT,N,12,27,12)
      DO 56 I=1,NM
      DO 57 J=1,L
      X(I,J)=0.
   57 CONTINUE
   56 CONTINUE
      DO 42 I=1,N
      X(I,1)=1.
      X(I,2)=DAT(I,5)/DAT(I,8)
      X(I,3)=DAT(I,9)/DAT(I,12)
      Y(I,1)=DAT(I,1)/DAT(I,4)
      II=N+I
      X(II,4)=1.
      X(II,5)=DAT(I,6)/DAT(I,8)
      X(II,6)=DAT(I,10)/DAT(I,12)
      Y(II,1)=DAT(I,2)/DAT(I,4)
      KI=2*N+I
      X(KI,7)=1.
      X(KI,8)=DAT(I,7)/DAT(I,8)
      X(KI,9)=DAT(I,11)/DAT(I,12)
      Y(KI,1)=DAT(I,3)/DAT(I,4)
   42 CONTINUE
      CALL OUT(X,NM,L,81,9)
      DO 33 I=1,NM
      Y(I,1)=ALOG(Y(I,1))
      DO 34 J=2,L
      IF((J.EQ.4).OR.(J.EQ.7))GO TO 34
      IF(X(I,J).EQ.0.) GO TO 34
      X(I,J)=ALOG(X(I,J))
   34 CONTINUE
   33 CONTINUE
      WRITE(6,35)
   35 FORMAT(/////,10X,,MATRIX X IN LOGARITHMIC FORM,)
      CALL OUT(X,NM,L,81,9)
      WRITE(6,36)
   36 FORMAT(/////,10X,,Y IN LOGARITHMIC FORM,)
      CALL OUT(Y,NM,1,81,1)
      DO 12 I=1,N
      READ(5,*)(U(I,J),J=1,M)
   12 CONTINUE
      DO 16 J1=1,M
      DO 17 J2=1,M
      S(J1,J2)=0.
      DO 18 I=1,N
      S(J1,J2)=S(J1,J2)+U(I,J1)*U(I,J2)
   18 CONTINUE
      S(J1,J2)=S(J1,J2)/(N-3)
   17 CONTINUE
   16 CONTINUE
      WRITE(6,25)
   25 FORMAT(/////,10X,,MATRIX S,)
      CALL OUT(S,M,M,3,3)
      V(1)=1.
      CALL GJR(S,3,3,M,M,$19,JC,V)
      GO TO 20
   19 WRITE(6,21)
   21 FORMAT(/////,,INVERSE OF S CAN NOT BE COMPUTED,)
      STOP
   20 WRITE(6,26)
   26 FORMAT(/////,10X,,INVERSE OF S,)
      CALL OUT(S,M,M,3,3)
      DO 37 IR=1,M
      IRNEW=(IR-1)*N
      DO 38 IK=1,M
      IKNEW=(IK-1)*N
      DO 39 I=IRNEW+1,IRNEW+N
      DO 40 J=IKNEW+1,IKNEW+N
      IF((I-IRNEW).EQ.(J-IKNEW)) SINV(I,J)=S(IR,IK)
      IF((I-IRNEW).NE.(J-IKNEW)) SINV(I,J)=0.
   40 CONTINUE
   39 CONTINUE
   38 CONTINUE
```

```
   37 CONTINUE
      WRITE(6,41)
   41 FORMAT(/////,10X,'SINV')
      CALL MXTRN(X,XT,NM,L,81,9)
      WRITE(6,27)
   27 FORMAT(/////,10X,'TRANSPOSE OF X')
      CALL OUT(XT,L,NM,9,81)
      CALL MXMLT(XT,SINV,Z1,L,NM,NM,9,81)
      WRITE(6,28)
   28 FORMAT(/////,10X,'XT * SINV')
      CALL OUT(Z1,L,NM,9,81)
      CALL MXMLT(Z1,X,Z2,L,NM,L,9,81)
      WRITE(6,29)
   29 FORMAT(/////,10X,'XT * SINV * X')
      CALL OUT(Z2,L,L,9,9)
      V(1)=1.
      CALL GJR(Z2,9,9,L,L,$24,JC,V)
      GO TO 23
   24 WRITE(6,47)
   47 FORMAT(/////,10X,'INVERSE OF XT*SINV*X  CAN NOT BE COMPUTED')
      STOP
   23 WRITE(6,30)
   30 FORMAT(/////,10X,'INVERSE OF XT*SINV*X')
      CALL OUT(Z2,L,L,9,9)
      CALL MXMLT(Z1,Y,Z4,L,NM,1,9,81)
      WRITE(6,31)
   31 FORMAT(/////,10X,'XT * SINV * Y')
      CALL OUT(Z4,L,1,9,1)
      CALL MXMLT(Z2,Z4,B,L,L,1,9,9)
      WRITE(6,51)
   51 FORMAT(/////,10X,'RESULTS OF THE ESTIMATION')
      CALL OUT(B,L,1,9,1)
      STOP
      END
A RT,S ZEL*ZEL.S1
```

```
ZEL*ZEL(1).S1
      SUBROUTINE OUT(A,NR,NC,NROW,NCOL)
      DIMENSION A(NROW,NCOL)
       DO 32 I=1,NR
       WRITE(6,31)(A(I,J),J=1,NC)
   31 FORMAT(/,10X,9F12.4)
   32  CONTINUE
      RETURN
      END
APRT,S ZEL*ZEL3.MAIN
```

APPENDIX E

THE ORIGINAL MODEL-COMPUTER OUTPUT

VARIABLES

LNSRCP = $\ln(Sc/Sp)$

LNSRLP = $\ln(S_l/Sp)$

LNSREP = $\ln(Se/Sp)$

LNPRCP = $\ln(Pc/Pp)$

LNPRLP = $\ln(P_l/Pp)$

LNPREP = $\ln(Pe/Pp)$

```
ENERGY+SSS(1).P33
RUN NAME        MARKET SHARES MODEL
VARIABLE LIST   PC,PL,PP,PL,SC,LAGC,SL,LAGL,SP,LAGP,SE,LAGE
INPUT MEDIUM    CARD
INPUT FORMAT    FIXED(4F7.4,8F6.2)
N OF CASES      27
COMPUTE             SRCP=SC/SP
COMPUTE             SRLP=SL/SP
COMPUTE             SREP=SE/SP
COMPUTE             LRCP=LAGC/LAGP
COMPUTE             LRLP=LAGL/LAGP
COMPUTE             LREP=LAGE/LAGP
COMPUTE             PRCP=PC/PP
COMPUTE             PRLP=PL/PP
COMPUTE             PREP=PE/PP
COMPUTE           LNSRCP=LN(SRCP)
COMPUTE           LNSRLP=LN(SRLP)
COMPUTE           LNSREP=LN(SREP)
COMPUTE           LNLRCP=LN(LRCP)
COMPUTE           LNLRLP=LN(LRLP)
COMPUTE           LNLREP=LN(LREP)
COMPUTE           LNPRCP=LN(PRCP)
COMPUTE           LNPRLP=LN(PRLP)
COMPUTE           LNPREP=LN(PREP)
REGRESSION      VARIABLES=LNSRCP,LNSRLP,LNSREP,LNLRCP,LNLRLP,LNLREP,
                LNPRCP,LNPRLP,LNPREP/
                REGRESSION=LNSRCP WITH LNPRCP,LNLRCP (2) RESID=0/
                REGRESSION=LNSRLP WITH LNPRLP,LNLRLP (2) RESID=0/
                REGRESSION=LNSREP WITH LNPREP,LNLREP (2) RESID=0/
STATISTICS      ALL
READ INPUT DATA
0.0064 0.0108 0.0280 0.0684 45.95 47.39 13.22 11.44 31.48 32.28 09.35 08.89
0.0064 0.0100 0.0280 0.0708 44.50 45.95 14.29 13.22 31.65 31.48 09.55 09.35
0.0068 0.0102 0.0320 0.0704 43.58 44.50 15.23 14.29 31.05 31.65 10.14 09.55
0.0139 0.0163 0.0387 0.0952 42.14 43.58 13.85 15.23 32.71 31.05 11.30 10.14
0.0190 0.0190 0.0471 0.1032 38.34 42.14 12.39 13.85 37.71 32.71 11.56 11.30
0.0190 0.0196 0.0473 0.1056 34.46 38.34 12.79 12.39 40.53 37.71 12.22 11.56
0.0195 0.0200 0.0473 0.1083 30.19 34.46 13.75 12.79 43.76 40.53 12.30 12.22
0.0198 0.0200 0.0573 0.1131 32.03 30.19 12.29 13.75 43.34 43.76 12.34 12.30
0.0199 0.0203 0.0592 0.1163 28.28 32.03 12.43 12.29 47.24 43.34 12.05 12.34
0.0199 0.0203 0.0591 0.1160 26.58 28.28 12.61 12.43 48.15 47.24 12.66 12.05
0.0205 0.0203 0.0591 0.1183 25.07 26.58 11.45 12.61 50.97 48.15 12.51 12.66
0.0244 0.0214 0.0632 0.1294 22.94 25.07 11.30 11.45 52.64 50.97 13.12 12.51
0.0274 0.0200 0.0651 0.1372 20.45 22.94 11.59 11.30 54.92 52.64 13.04 13.12
0.0295 0.0227 0.0651 0.1413 19.03 20.45 11.40 11.59 56.40 54.92 13.17 13.04
0.0286 0.0218 0.0735 0.1519 17.81 19.03 11.12 11.40 57.11 56.40 13.96 13.17
0.0372 0.0297 0.0890 0.1714 15.77 17.81 11.00 11.12 58.72 57.11 14.51 13.96
0.0484 0.0384 0.0917 0.1838 14.17 15.77 10.73 11.00 59.69 58.72 15.41 14.51
0.0470 0.0390 0.0917 0.2050 11.84 14.17 10.84 10.73 62.52 59.69 14.80 15.41
0.0470 0.0349 0.1522 0.2527 12.64 11.84 11.98 10.84 60.04 62.52 15.34 14.80
0.0473 0.0348 0.1643 0.2976 10.68 12.64 11.18 11.98 61.95 60.04 16.19 15.34
0.0460 0.0330 0.1643 0.3600 08.83 10.68 10.26 11.18 63.08 61.95 17.83 16.19
0.0728 0.0400 0.2120 0.3564 09.69 08.83 09.88 10.26 62.80 63.08 17.63 17.83
0.2040 0.0913 0.3773 0.5068 08.62 09.69 10.19 09.88 62.52 62.80 18.67 17.63
0.2937 0.1595 1.0565 0.7046 10.14 08.62 10.16 10.19 58.99 62.52 20.71 18.67
0.9314 0.3781 2.4300 1.9318 09.16 10.14 12.86 10.16 57.39 58.99 20.59 20.71
1.3231 0.6192 4.0422 2.7455 08.82 09.16 11.88 12.86 56.90 57.39 22.43 20.59
1.9130 0.8021 5.4722 3.6390 09.49 08.82 11.84 11.88 56.08 56.90 22.59 22.43
FINISH
ABRUPT PRINTS
```

FILE NONAME (CREATION DATE = 14 MAR 84)

VARIABLE	MEAN	STANDARD DEV	CASES
LNSRCP	[illegible]9697	[illegible]	27
LNSRLP	[illegible]4349	[illegible]3361	27
LNSREP	[illegible]2538	[illegible]560	27
LNLRCP	[illegible]5896	[illegible]8345	27
LNLRLP	[illegible]4155	[illegible]3436	27
LNLREP	[illegible]2579	[illegible]1401	27
LNPRCP	[illegible]0388	[illegible]2406	27
LNPRLP	[illegible]2335	[illegible]3621	27
LNPREP	[illegible]5502	[illegible]4084	27

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * *   VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. LNSPCP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNPREP
LNLRCP
LNPRCP
LNPRLP

			ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
MULTIPLE R	.99417		REGRESSION	4.	16.89991	4.22498	467.66849
R SQUARE	.98838		RESIDUAL	22.	.19875	.00903	
ADJUSTED R SQUARE	.98626						
STANDARD ERROR	.09505						

------------ VARIABLES IN THE EQUATION ------------

VARIABLE	B	BETA	STD ERROR B	F
LNPREP	[illegible]	-.10124	.11550	3.029
LNLRCP	.94344	.97083	.05101	239.144
LNPRCP	.30988	.09794	.14199	4.763
LNPRLP	-.17930	-.07962	.22387	.595
(CONSTANT)	[illegible]			

------------ VARIABLES NOT IN THE EQUATION ------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. LNSPCP

SUMMARY TABLE

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
LNPREP	.63531	.40361	.40361	.63531	.20101	-.10124
LNLRCP	.99230	.98467	.58105	.99018	.94341	.97083
LNPRCP	.99399	.98801	.00334	.35796	.30988	.09194
LNPRLP	.99417	.98838	.00037	.73461	.17830	.07962
(CONSTANT)					2.12172	

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 2

DEPENDENT VARIABLE.. LNSPLP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNPREP
LNLRLP
LNPRCP
LNPRLP

MULTIPLE R	.96482
R SQUARE	.93088
ADJUSTED R SQUARE	.9183
STANDARD ERROR	.09605

ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
REGRESSION	4.	2.73377	.68344	74.07345
RESIDUAL	22.	.20298	.00923	

------------ VARIABLES IN THE EQUATION ------------

VARIABLE	B	BETA	STD ERROR B	F
LNPREP	.29640	.23867	.17859	2.743
LNLREP	-.73155	-.79923	.19565	54.532
LNPRCP	-.32165	-.23027	.12983	6.138
LNPRLP	-.27632	.29826	.17758	2.430
(CONSTANT)	-.21286			

------------ VARIABLES NOT IN THE EQUATION ------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION.

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 2
REGRESSION LIST 2

DEPENDENT VARIABLE.. LNSRLF

SUMMARY TABLE

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
LNPREP	.41825	.17494	.17494	.41825	.19640	.23867
LNCRLP	.95457	.91120	.73625	.95216	.78165	.79923
LNPRCP	.96035	.92325	.0_205	.49104	.32165	.23027
LNPRLP	.96482	.93088	.00763	.52518	.27682	.29825
(CONSTANT)					.21288	

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 4
REGRESSION LIST 5

DEPENDENT VARIABLE.. LNSREP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNPMEP
LNLREP
LNPRCP
LNPRLP

MULTIPLE R	.95240	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	.90707	REGRESSION	4.	.57395	.14349	53.68430
ADJUSTED R SQUARE	.89017	RESIDUAL	22.	.05880	.00267	
STANDARD ERROR	.05470					

- - - - - - - - - - VARIABLES IN THE EQUATION - - - - - - - - - -

VARIABLE	B	BETA	STD ERROR B	F
LNPREP	-.13540	-.35448	.07145	3.591
LNLREP	.78475	.70183	.09839	63.125
LNPRCP	-.14152	-.12841	.04933	8.241
LNPRLP	-.03292	.07641	.07298	.203
(CONSTANT)	.29464			

- - - - - - - - - - VARIABLES NOT IN THE EQUATION - - - - - - - - - -

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

FILE NONAME (CREATION DATE = 14 MAR 84)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST [illegible]
REGRESSION LIST 3

DEPENDENT VARIABLE.. LNSREP

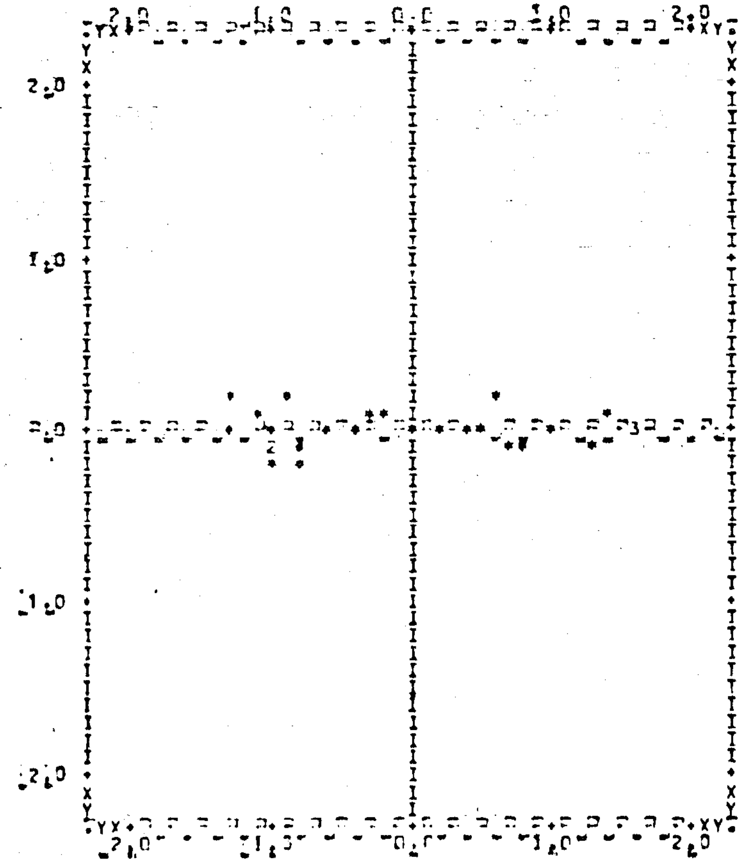
SUMMARY TABLE

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
LNPREP	.67242	.45215	.45215	.67242	.13540	.1354[illegible]
LNLREP	.931[illegible]9	.86709	[illegible]	.90525	.78[illegible]75	.270[illegible]8
LNPRCP	.95195	.9062[illegible]	.03912	.33613	.14162	.2[illegible]84[illegible]
LNPRLP	.95240	.9070[illegible]	.00086	.523[illegible]8	.03292	.0764[illegible]
(CONSTANT)					.29464	

FILE NONAME (CREATION DATE = 14 MAR 84)

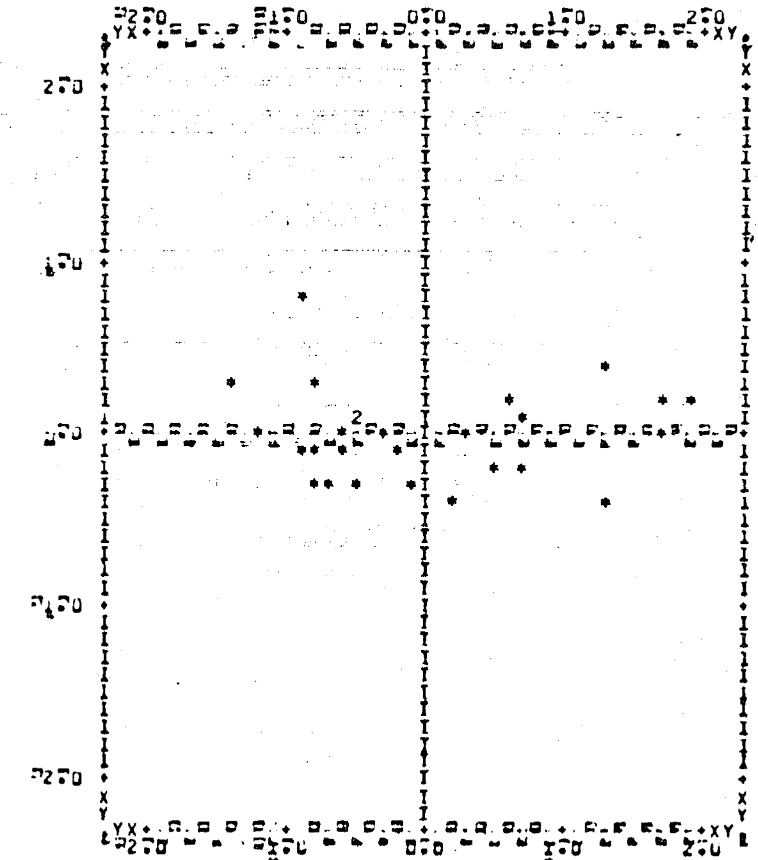
* * * * * * * PLOT: STANDARDIZED RESIDUAL (DOWN) - PREDICTED STANDARDIZED DEPENDENT VARIABLE (ACROSS) * * * * * * *

DEPENDENT VARIABLE: LNSRCP VARIABLE LIST 1 REGRESSION LIST 1



ROWS,COLUMNS Y: VALUES OUTSIDE (-3.0,3.0)

DEPENDENT VARIABLE: LNSRLP VARIABLE LIST 1 REGRESSION LIST 2

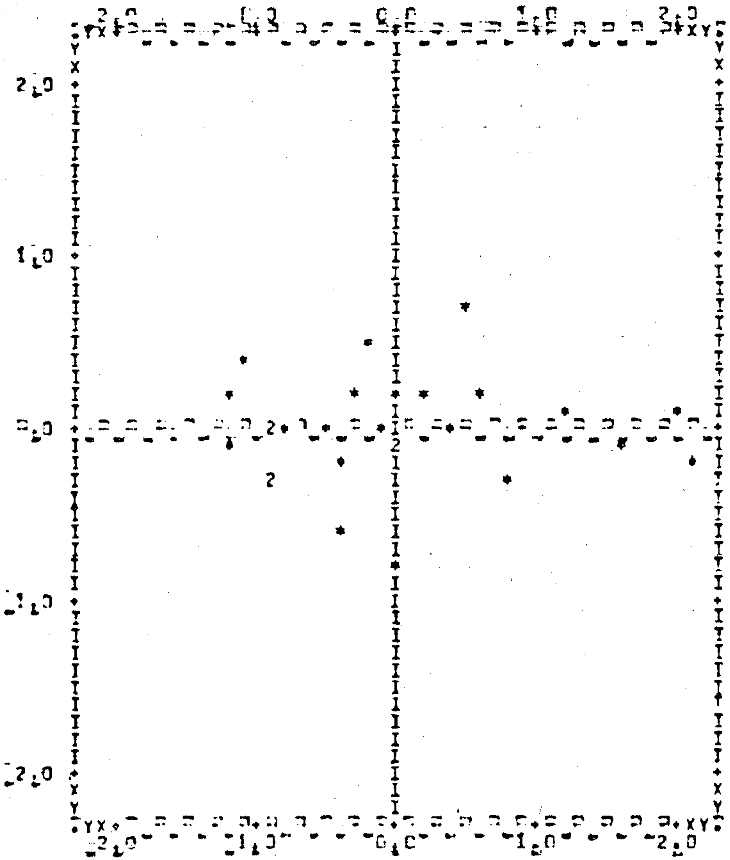


ROWS,COLUMNS X: VALUES IN (-3.0,-2.05) OR (2.05,3.0)

FILE NONAME (CREATION DATE = 14 MAR 84)

* * * * * * * PLOT: STANDARDIZED RESIDUAL (DOWN) - PREDICTED STANDARDIZED DEPENDENT VARIABLE (ACROSS) * * * * * * *

DEPENDENT VARIABLE: LNSREP VARIABLE LIST 1
REGRESSION LIST 5



ROWS,COLUMNS Y: VALUES OUTSIDE (-3.0,3.0) ROWS,COLUMNS X: VALUES IN (-3.0,-2.05) OR (2.05,3.0)

APPENDIX F

STATISTICAL ANALYSIS OF THE ORIGINAL MODEL

1. Statistical Significance of the Model

Statistical significance of the regression equations is tested through 'F test' :

$F(5,22)_{\alpha=0.05} = 2.70$

Equation 3a : $F^{*} = 467.67 > 2.70$
Equation 3b : $F^{*} = 74.07 > 2.70$
Equation 3c : $F^{*} = 53.68 > 2.70$

We accept that, equations 3(a-c) are significant estimators of fuel shares.

2. Statistical Significance of the Parameters

Sitatistical significance of the parameters can be tested by 't test'.

$$t^{*} = \frac{\beta}{\text{Standard error of } \beta}$$

β_{C1} : $t^{*} = 2.183 > t_{22,0.025}$	Significant at 97.5 % level
β_{C2} : $t^{*} = 0.834 > t_{22,0.25}$	" " 75 % "
β_{C3} : $t^{*} = 1.740 > t_{22,0.05}$	" " 95 % "
β_{C4} : $t^{*} = 15463 > t_{22,0.005}$	" " 99.5 % "
β_{L1} : $t^{*} = 2.477 > t_{22,0.025}$	" " 97.5 % "
β_{L2} : $t^{*} = 1.559 > t_{22,0.01}$	" " 90 % "
β_{L3} : $t^{*} = 1.656 > t_{22,0.01}$	" " 90 % "

β_{L4} : $t^{*} = 7.385 > t_{22,0.005}$ Significant at 99.5 % level
β_{e1} : $t^{*} = 2.871 > t_{22,0.005}$ " " 99.5 % "
β_{e2} : $t^{*} = 0.451 > t_{22,0.40}$ " " 60 % "
β_{e3} : $t^{*} = 1.895 > t_{22,0.05}$ " " 95 % "
β_{e4} : $t^{*} = 7.945 > t_{22,0.005}$ " " 99.5 % "

3. Statistical Analysis of the Residuals

H_0 : Residuals are serially correlated

H_1 : Residuals are indegendent of each other

Durbin-Watson: $$D.W^{*} = \frac{\sum_{t=2}^{n} (u_t - u_{t-1})}{\sum_{t=1}^{n} u_t^2}$$

$\alpha = 0.05$ $n = 27$ $K = 4$: $D.W_L = 1.10$ $D.W_u = 1.75$

Equation 3_a : $D.W^{*} = 2.61 > D.W_u$

Equation 3_b : $D.W^{*} = 2.36 > D.W_u$

Equation 3_c : $D.W^{*} = 2.33 > D.W_u$

So, we reject the null hypothesis, and conclude that the residuals are independent of each other.

A P P E N D I X   G

THE MODIFIED MODEL - SPSS OUTPUT

```
SEMIN

* * * UNIVAC 1106 -- BOGAZICI UNIVERSITESI KOMPUTER MERKEZI --ISTANBUL LEV. 36R2B-BUR   SITE * BUI106    TURKIYE * * *
   RUNID * SEMIN          USER ID *              PART NUMBER * 00      INPUT DEVICE * BIMT0a         OUTPUT DEVICE * PR2
   FILE NAME * SS                         CREATED AT:  11:25:48 DEC 14,1983            PRINTED AT:  11:28:06 DEC 14,1983
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890**SEQ NO. 21
ASPSS*SPSS.SPSS
SPSS 6.03   NOVEMBER 4, 1976

          SPACE ALLOCATION FOR THIS RUN..

            TOTAL AMOUNT REQUESTED                              9000 WORDS

            DEFAULT TRANSPACE ALLOCATION                        1125 WORDS

              MAX NO OF TRANSFORMATIONS PERMITTED         37
              MAX NO OF RECODE VALUES                    150
              MAX NO OF ARITHM.OR LOG.OPERATIONS         300

            RESULTING WORKSPACE ALLOCATION                      7875 WORDS

      1.     RUN NAME         MARKET SHARES MODEL
      2.     VARIABLE LIST    PC,PL,PP,PE,SC,LAGC,SL,LAGL,SP,LAGP,SE,LAGE
      3.     INPUT MEDIUM     CARD
      4.     INPUT FORMAT     FIXED(4F7.4,8F6.2)

              ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

              VARIABLE  FORMAT  RECORD     COLUMNS

              PC        F 7. 4     1        1-   7
              PL        F 7. 4     1        8-  14
              PP        F 7. 4     1       15-  21
              PE        F 7. 4     1       22-  28
              SC        F 6. 2     1       29-  34
              LAGC      F 6. 2     1       35-  40
              SL        F 6. 2     1       41-  46
              LAGL      F 6. 2     1       47-  52
              SP        F 6. 2     1       53-  58
              LAGP      F 6. 2     1       59-  64
              SE        F 6. 2     1       65-  70
              LAGE      F 6. 2     1       71-  76

THE INPUT FORMAT PROVIDES FOR  12 VARIABLES.  12 WILL BE READ
IT PROVIDES FOR  1 RECORDS (,CARDS,) PER CASE.  A MAXIMUM OF   76 ,COLUMNS, ARE USED ON A RECORD.

      5.     N OF CASES        27
      6.     COMPUTE             SRCP=SC/SP
      7.     COMPUTE             SRLP=SL/SP
      8.     COMPUTE             SREP=SE/SP
      9.     COMPUTE             LRCP=LAGC/LAGP
     10.     COMPUTE             LRLP=LAGL/LAGP
     11.     COMPUTE             LREP=LAGE/LAGP
```

```
12.   COMPUTE         PRCP=PC/PP
13.   COMPUTE         PRLP=PL/PP
14.   COMPUTE         PREP=PE/PP
15.   COMPUTE         LNSRCP=LN(SRCP)
16.   COMPUTE         LNSRLP=LN(SRLP)
17.   COMPUTE         LNSREP=LN(SREP)
18.   COMPUTE         LNLRCP=LN(LRCP)
19.   COMPUTE         LNLRLP=LN(LRLP)
20.   COMPUTE         LNLREP=LN(LREP)
21.   COMPUTE         LNPRCP=LN(PRCP)
22.   COMPUTE         LNPRLP=LN(PRLP)
23.   COMPUTE         LNPREP=LN(PREP)
24.   REGRESSION      VARIABLES=LNSRCP,LNSRLP,LNSREP,LNLRCP,LNLRLP,LNLREP,
25.                   LNPRCP,LNPPLP,LNPREP/
26.                   REGRESSION=LNSRCP WITH LNPRCP,LNLRCP (2) RESID=0/
27.                   REGRESSION=LNSRLP WITH LNPRLP,LNLRLP (2) RESID=0/
28.                   REGRESSION=LNSREP WITH LNPREP,LNLREP (2) RESID=0/
29.   STATISTICS      ALL

***** REGRESSION PROBLEM REQUIRES    360 WORDS WORKSPACE, NOT INCLUDING RESIDUALS *****

30.   READ INPUT DATA
```

FILE NONAME (CREATION DATE = 14 DEC 83)

VARIABLE	MEAN	STANDARD DEV	CASES
LNSKCP	-.9697	.8110	27
LNSKLP	-1.4348	.3361	27
LNSKEP	-1.2538	.1560	27
LNLKCP	-.8896	.8345	27
LNLKLP	-1.4156	.3436	27
LNLKEP	-1.2679	.1401	27
LNPKCP	-1.0388	.2406	27
LNPKLP	-1.2335	.3621	27
LNPKEP	.5502	.4084	27

FILE NONAME (CREATION DATE = 14 DEC 83)

CORRELATION COEFFICIENTS

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	LNSRCP	LNSRLP	LNSREP	LNLRCP	LNLRLP	LNLREP	LNPRCP	LNPRLP	LNPREP
LNSRCP	1.00000	.93274	-.00956	.99018	.94482	.10460	-.35796	.73461	.63531
LNSRLP	.93274	1.00000	.28160	.90933	.95216	.35510	-.49104	.52518	.41826
LNSREP	-.00956	.28160	1.00000	-.07117	.20725	.90535	-.33613	-.52398	-.67242
LNLRCP	.99018	.90933	-.07117	1.00000	.94002	.07521	-.28808	.78605	.68905
LNLRLP	.94482	.95216	.20725	.94002	1.00000	.33451	-.30554	.60814	.50083
LNLREP	.10460	.35510	.90535	.07521	.33451	1.00000	-.17544	-.34399	-.53902
LNPRCP	-.35796	-.49104	-.33613	-.28808	-.30554	-.17544	1.00000	.20950	.02988
LNPRLP	.73461	.52518	-.52398	.78605	.60814	-.34399	.20950	1.00000	.88357
LNPREP	.63531	.41826	-.67242	.68905	.50083	-.53902	.02988	.88357	1.00000

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. LNSPCP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNLRCP
LNPRCP

			ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
MULTIPLE R	.99309		REGRESSION	2.	16.86321	8.43160	859.41685
R SQUARE	.98623		RESIDUAL	24.	.23546	.00981	
ADJUSTED R SQUARE	.98508						
STANDARD ERROR	.09905						

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
LNLRCP	.94092	.96734	.02431	1495.512
LNPRCP	-.26723	-.07929	.08431	10.047
(CONSTANT)	-.41098			

------------------ VARIABLES NOT IN THE EQUATION ------------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. LNSRCP

SUMMARY TABLE

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
LNLRCP	.99018	.98046	.98046	.99018	.94002	.96734
LNPRCP	.99309	.98623	.00576	-.35796	-.26723	-.07929
(CONSTANT)					-.41098	

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 2

DEPENDENT VARIABLE.. LNSPLP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNLPLP
LNPPLP

MULTIPLE R	.95453	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	.91121	REGRESSION	2.	2.67601	1.33801	123.15788
ADJUSTED R SQUARE	.90382	RESIDUAL	24.	.26074	.01086	
STANDARD ERROR	.10423					

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
LNLPLP	.98206	1.00414	.07493	171.759
LNPPLP	-.07933	-.06548	.07111	1.245
(CONSTANT)	-.14243			

------------- VARIABLES NOT IN THE EQUATION -------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 2

DEPENDENT VARIABLE.. LNSRLP

SUMMARY TABLE

VARIABLE	MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
LNLRLP	.95216	.90661	.90661	.95216	.98206	1.00414
LNPRLP	.95458	.91121	.00460	.52518	-.07033	-.08548
(CONSTANT)					-.14243	

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 3

DEPENDENT VARIABLE.. LNSREP

VARIABLE(S) ENTERED ON STEP NUMBER 1.. LNPREP
LNLREP

MULTIPLE R	.93118	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	.86709	REGRESSION	2.	.54866	.27433	78.29863
ADJUSTED R SQUARE	.85602	RESIDUAL	24.	.08410	.00350	
STANDARD ERROR	.05920					

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
LNPREP	-.09901	-.25922	.03377	8.597
LNLREP	.85244	.76529	.09848	74.929
(CONSTANT)	-.11853			

------------- VARIABLES NOT IN THE EQUATION -------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

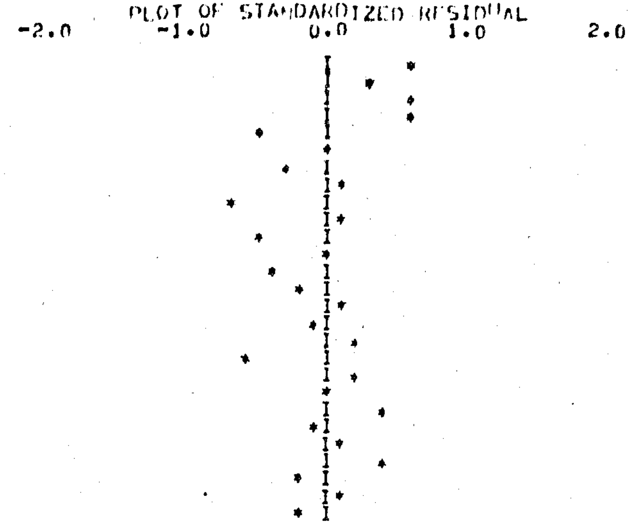
ALL VARIABLES ARE IN THE EQUATION

FILE NONAME (CREATION DATE = 14 DEC 83)

* M U L T I P L E R E G R E S S I O N *

DEPENDENT VARIABLE: LNSREP FROM VARIABLE LIST 1
REGRESSION LIST 3

SEQNUM	OBSERVED LNSREP	PREDICTED LNSREP	RESIDUAL
1	-1.213976	-1.306199	.9222293-01
2	-1.196197	-1.245216	.4701933-01
3	-1.119111	-1.217963	.9887253-01
4	-1.062878	-1.161665	.9874711-01
5	-1.182374	-1.102230	-.8014432-01
6	-1.196068	-1.205950	.9881603-02
7	-1.267121	-1.226596	-.4052557-01
8	-1.256230	-1.267700	.1147025-01
9	-1.366176	-1.256244	-.1099322
10	-1.335874	-1.349878	.1400464-01
11	-1.404709	-1.325991	-.7871769-01
12	-1.389339	-1.386908	-.2430727-02
13	-1.437856	-1.376668	-.6118801-01
14	-1.454528	-1.420942	-.3358591-01
15	-1.408783	-1.430299	.2151617-01
16	-1.397942	-1.384317	-.1362506-01
17	-1.354148	-1.379033	.2488503-01
18	-1.440859	-1.352529	-.8833019-01
19	-1.364547	-1.396971	.3242394-01
20	-1.341934	-1.340539	-.1395196-02
21	-1.263521	-1.322057	.5853607-01
22	-1.270353	-1.247035	-.2331805-01
23	-1.208569	-1.230641	.2207254-01
24	-1.046751	-1.108649	.6189749-01
25	-1.025065	-.9881007	-.3696386-01
26	-.9308960	-.9540308	.2313484-01
27	-.9092719	-.8716642	-.3760775-01



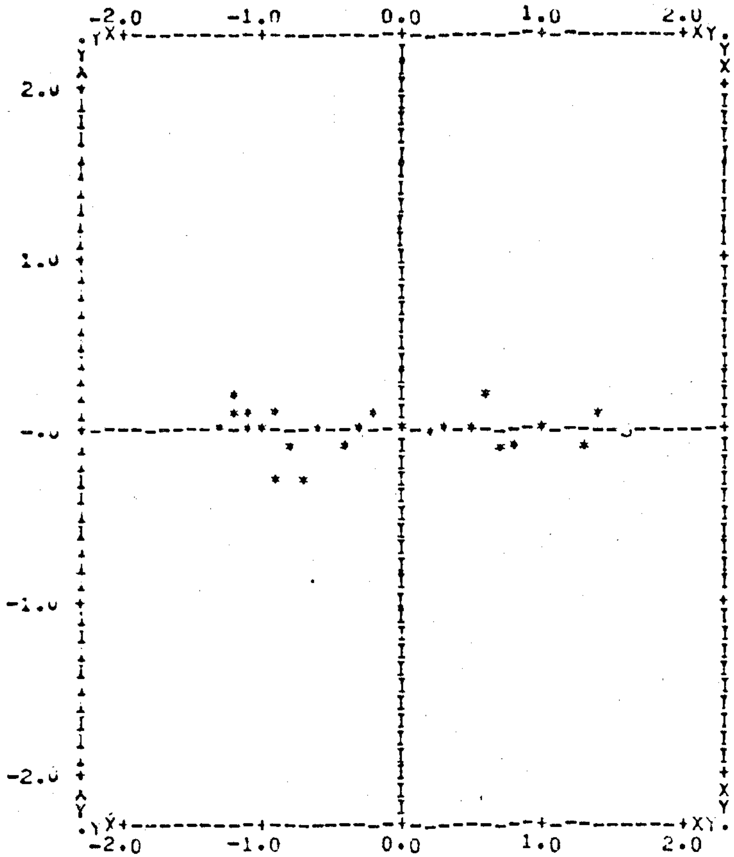
DURBIN-WATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

VARIABLE LIST 1, REGRESSION LIST 1. DURBIN-WATSON TEST 2.27615
VARIABLE LIST 1, REGRESSION LIST 2. DURBIN-WATSON TEST 1.57627
VARIABLE LIST 1, REGRESSION LIST 3. DURBIN-WATSON TEST 1.95727

FILE NONAME (CREATION DATE = 14 DEC 83)

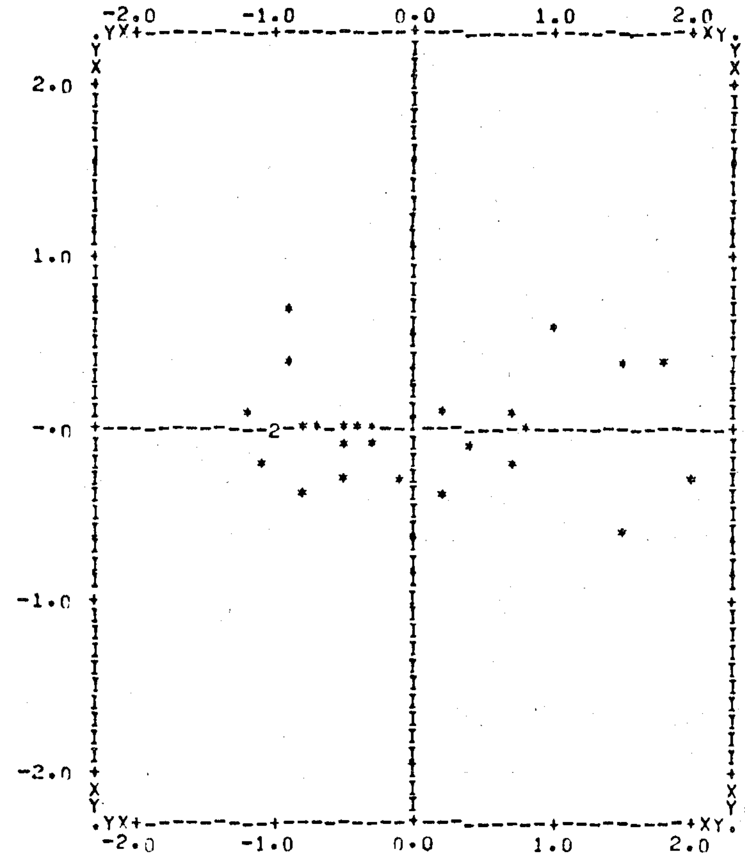
* * * * * * * PLOT: STANDARDIZED RESIDUAL (DOWN) -- PREDICTED STANDARDIZED DEPENDENT VARIABLE (ACROSS) * * * * * * *

DEPENDENT VARIABLE: LNSRCP VARIABLE LIST 1 REGRESSION LIST 1



ROWS,COLUMNS Y: VALUES OUTSIDE (-3.0,3.0)

DEPENDENT VARIABLE: LNSRLP VARIABLE LIST 1 REGRESSION LIST 2

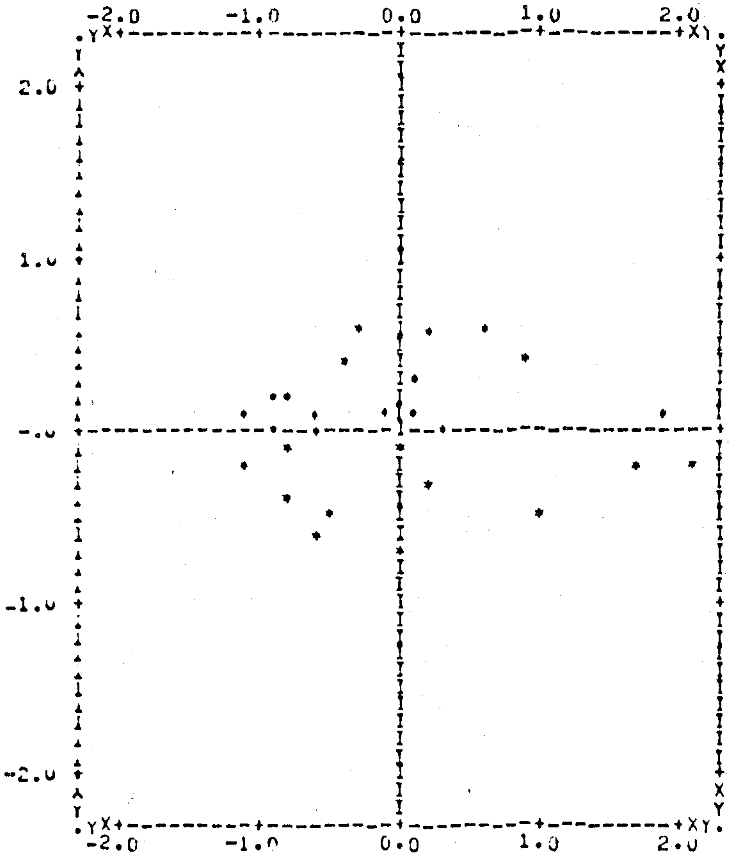


ROWS,COLUMNS X: VALUES IN (-3.0,-2.05) OR (2.05,3.0)

FILE NONAME (CREATION DATE = 14 DEC 83)

* * * * * * * PLOT: STANDARDIZED RESIDUAL (DOWN) -- PREDICTED STANDARDIZED DEPENDENT VARIABLE (ACROSS) * * * * * * *

DEPENDENT VARIABLE: LNSREP VARIABLE LIST 1
REGRESSION LIST 3



ROWS,COLUMNS Y: VALUES OUTSIDE (-3.0,3.0) ROWS,COLUMNS X: VALUES IN (-3.0,-2.05) OR (2.05,3.0)

A P P E N D I X H

THE MODIFIED MODEL
TWO STAGES LEAST SQUARES OUTPUT

			[illegible]	7.7045	8.8446	-33.5167	-18.4410	42.4945
-127.4755	-39.6956	-96.9910	6.4856	-8.1099	-8.9936	34.8164	19.0613	-43.9515

-109.6033	-76.9910	-80.1291	5.5545	-8.2809	-9.4815	29.8181	8.8260	-38.0889
-6.2435	6.4456	5.5545	45.6196	-557.0867	-639.7695	-54.4303	-29.9478	69.0101
7.7045	-8.1099	-8.2809	-557.0867	744.2099	821.9610	67.1415	30.0921	-84.2116
8.8446	-8.9936	-9.4815	-639.7695	821.9610	957.3358	77.1067	38.7584	-98.6055
-33.5167	34.8164	29.8181	-54.4303	67.1415	77.1067	145.6561	80.1405	-184.6715
-18.4410	19.0613	8.8260	-29.9478	30.0921	38.7584	80.1405	67.4912	-105.9369
42.4945	-43.9515	-38.0889	69.0101	-84.2116	-98.6055	-184.6715	-105.9389	236.3890

INVERSE OF XT•SINV•X

.2172	.1779	.0266	.0028	.0026	-.0006	.0051	.0114	.0073
.1779	.1595	.0137	.0008	.0019	-.0011	-.0063	.0050	-.0028
.0266	.0137	.0139	.0017	.0007	.0007	.0107	.0070	.0115
.0028	.0008	.0017	.0464	.0095	.0228	.0216	.0108	.0210
.0026	.0019	.0007	.0095	.0287	-.0183	-.0133	.0041	-.0087
-.0006	-.0011	.0007	.0228	-.0183	.0320	.0262	.0040	.0224
.0051	-.0063	.0107	.0216	-.0133	.0262	.7486	.0961	.6261
.0114	.0050	.0070	.0108	.0041	.0040	.0961	.0662	.1045
.0073	-.0028	.0115	.0210	-.0087	.0224	.6261	.1045	.5391

XT * SINV * Y

-66.4807
63.4961
139.1685
-573.6913
735.7165
858.1145
-72.0229
-55.4374
92.8296

RESULTS OF THE ESTIMATION

$\alpha_1 =$ -.3649
$\alpha_2 =$ -.2246
$\alpha_3 =$ .9421
$\beta_1 =$ -.1404
$\beta_2 =$ -.0673
$\beta_3 =$ .9723
$\gamma_1 =$ -.1213
$\gamma_2 =$ -.0798

$\gamma_3 =$ .8586

RKPT PRINTS

APPENDIX K

STATISTICAL ANALYSIS OF THE MODIFIED MODEL

1. Coefficient of Determination

$Y = a+b_1X_1+b_2X_2$

$$R^2 = \frac{\text{Total explained variation}}{\text{Total variation}} = \frac{\sum_{t=1}^{n} (\hat{Y}_t - \bar{Y})^2}{\sum_{t=1}^{n} (Y_t - \bar{Y})^2}$$

Equation 16_a : $R^2 = 0.99$
Equation 16_b : $R^2 = 0.92$
Equation 16_c : $R^2 = 0.90$

2. Statistical Significance of the Model

$$F^* = \frac{R^2/k}{(1-R^2)/n-k-1}$$

where n = Sample size = 27,
k = No. of parameters = 2

$$F^* = \frac{R^2/2}{(1-R^2)/24}$$

Tabled value : $F(2.24)_{\alpha=0.05} = 6.66$

Equation 16_a : $F^* = 1188. > 6.66$
Equation 16_b : $F^* = 138. > 6.66$
Equation 16_c : $F^* = 108. > 6.66$

We accept that, the equations 16(a-c)are significant estimators of fuel shares.

3. Statistical Significance of the Parameters

$Y = a + b\,X_1 + cX_2$

a) Standard error of the estimate : $s = \sqrt{\dfrac{\sum_{t=1}^{n} (Y_t - \hat{Y}_t)^2}{n-k-1}}$

b) Standard error of the parameters:

$$S_a = \frac{s}{\sqrt{n}}$$

$$S_{b1} = \frac{s}{\sqrt{\sum_{t=1}^{n} (X_{1t} - \bar{X}_1)^2}} \qquad S_{b2} = \frac{s}{\sqrt{\sum_{t=1}^{n} (X_{2t} - \bar{X}_2)^2}}$$

Then, $S_{\alpha 2} = 0.075$ $S_{\beta 2} = 0.054$ $S_{\gamma 2} = 0.027$

$S_{\alpha 3} = 0.020$ $S_{\beta 3} = 0.066$ $S_{\gamma 3} = 0.092$

Statistical significance of the parameters can be tested by "t test":

$$t^* = \frac{b_1}{S_{b_1}}$$

2 : t^* :	$0.225/0.075 = 3.000 > t_{24,0.005}$	Significant at	99.5 % level
3 : t^* :	$0.942/0.020 = 47.100 > t_{24,0.005}$	" "	99.5 % "
2 : t^* :	$0.067/0.054 = 1.240 > t_{24,0.25}$	" "	75 % "
3 : t^* :	$0.972/0.066 = 14.727 > t_{24,0.005}$	" "	99.5 % "
2 : t^* :	$0.080/0.027 = 2.963 > t_{24,0.005}$	" "	99.5 % "
3 : t^* :	$0.859/0.092 = 9.337 > t_{24,0.005}$	" "	99.5 % "

4. Statistical Analysis of the Residuals

H_0 : Residuals are serially correlated

H_1 : Residuals are independent of each other

Durbin-Watson : $$D.W^* = \frac{\sum_{t=2}^{n} (u_t - u_{t-1})}{\sum_{t=1}^{n} u_t^2}$$

$\alpha = 0.05$ $n = 27$ $k = 2$: $DW_L = 1.26$ $DW_u = 1.56$

Equation 16_a : $D.W^* = 2.31 > DW_u$

Equation 16_b : $D.W^* = 1.60 > DW_u$

Equation 16_c : $D.W^* = 1.98 > DW_u$

So, we reject the null hypothesis, and conclude that the residuals are independent of each other.

APPENDIX L
FORECASTING RESULTS

SCENARIO 1

Year	Pc/Pp	Pl/Pp	Pe/Pp
1983	.29	.11	.60
1984	.24	.09	.55
1985	.20	.07	.50
1986	.17	.05	.45
1987	.14	.04	.41
1988	.12	.03	.38
1989	.10	.02	.35
1990	.08	.017	.31

Year	Sp	Sc	Sl	Se
1983	.5504	.0947	.1223	.2326
1984	.5370	.0978	.1271	.2381
1985	.5202	.1042	.1333	.2423
1986	.5000	.1137	.1413	.2450
1987	.4765	.1274	.1505	.2456
1988	.4498	.1451	.1615	.2436
1989	.4188	.1680	.1749	.2383
1990	.3837	.1987	.1877	.2299

SCENARIO 2

Year	Pc/Pp	Pl/Pp	Pe/Pp
1983	.32	.12	.63
1984	.29	.10	.60
1985	.26	.08	.57
1986	.24	.07	.55
1987	.22	.06	.52
1988	.20	.05	.50
1989	.18	.04	.48
1990	.17	.03	.45

Year	Sp	Sc	S_1	Se
1983	.5525	.0929	.1220	.2326
1984	.5423	.0928	.1268	.2381
1985	.5303	.0944	.1330	.2423
1986	.5173	.0974	.1400	.2453
1987	.5029	.1016	.1482	.2473
1988	.4868	.1076	.1578	.2478
1989	.4688	.1154	.1692	.2466
1990	.4488	.1238	.1833	.2441

SCENARIO 3

Year	Pc/Pp	Pl/Pp	Pe/Pp
1983	.32	.12	.67
1984	.29	.10	.67
1985	.26	.08	.67
1986	.24	.07	.67
1987	.22	.06	.67
1988	.20	.05	.67
1989	.18	.04	.67
1990	.17	.03	.67

Year	Sp	Sc	Sl	Se
1983	0.5530	0.0930	0.1222	0.2318
1984	0.5439	0.0930	0.1271	0.2360
1985	0.5332	0.0949	0.1337	0.2382
1986	0.5217	0.0981	0.1412	0.2390
1987	0.5089	0.1029	0.1500	0.2382
1988	0.4945	0.1093	0.1603	0.2358
1989	0.4781	0.1177	0.1725	0.2317
1990	0.4596	0.1268	0.1878	0.2258

SCENARIO 4

Year	Pc/Pp	Pl/Pp	Pe/Pp
1983	.32	.12	.60
1984	.29	.10	.55
1985	.26	.08	.50
1986	.24	.07	.45
1987	.22	.06	.41
1988	.20	.05	.38
1989	.18	.04	.35
1990	.17	.03	.31

Year	Sp	Sc	Sl	Se
1983	.5520	10928	.1219	.2333
1984	.5411	.0925	.1264	.2400
1985	.5279	.0939	.1323	.2459
1986	.5132	.0965	.1389	.2514
1987	.4970	.1004	.1465	.2561
1988	.4792	.1059	.1553	.2595
1989	.4596	.1131	.1659	.2615
1990	.4379	.1209	.1788	.2624

SCENARIO 5

Year	Pc/Pp	P_1/Pp	Pe/Pp
1983	.32	.13	.63
1984	.29	.12	.60
1985	.26	.11	.57
1986	.24	.10	.55
1987	.22	.09	.52
1988	.20	.08	.50
1989	.18	.075	.48
1990	.17	.068	.45

Year	Sp	Sc	S_1	Se
1983	.5528	.0930	.1215	.2327
1984	.5436	.0929	.1249	.2386
1985	.5330	.0948	.1286	.2436
1986	.5217	.0981	.1328	.2474
1987	.5092	.1029	.1376	.2503
1988	.4954	.1095	.1429	.2522
1989	.4806	.1183	.1484	.2527
1990	.4647	.1282	.1544	.2527

SCENARIO 6

Year	Pc/Pp	P_1/Pp	Pe/Pp
1983	.32	.13	.67
1984	.29	.12	.67
1985	.26	.11	.67
1986	.24	.10	.67
1987	.22	.09	.67
1988	.20	.08	.67
1989	.18	.075	.67
1990	.17	.068	.67

Year	Sp	Sc	S_1	Se
1983	.5533	.0931	.1216	.2320
1984	.5451	.0932	.1252	.2365
1985	.5360	.0953	.1293	.2394
1986	.5261	.0990	.1339	.2410
1987	.5154	.1042	.1392	.2412
1988	.5034	.1113	.1452	.2401
1989	.4902	.1207	.1515	.2376
1990	.4763	.1314	.1582	.2341

SCENARIO 7

Year	Pc/Pp	P_l/Pp	Pe/Pp
1983	.32	.13	.60
1984	.29	.12	.55
1985	.26	.11	.50
1986	.24	.10	.45
1987	.22	.03	.41
1988	.20	.08	.38
1989	.18	.075	.35
1990	.17	.068	.31

Year	Sp	Sc	S_l	Se
1983	.5523	.0930	.1213	.2334
1984	.5422	.0927	.1246	.2405
1985	.5305	.0944	.1280	.2471
1986	.5175	.0975	.1317	.2535
1987	.5031	.1017	.1359	.2593
1988	.4875	.1077	.1407	.2641
1989	.4708	.1159	.1454	.2679
1990	.4530	.1250	.1505	.2715

SCENARIO 8

Year	Pc/Pp	P_1/Pp	Pe/Pp
1983-90	.35	.15	.67

Year	Sp	Sc	S_1	Se
1983	.5548	.0917	.1209	.2326
1984	.5494	.0887	.1235	.2384
1985	.5445	.0860	.1262	.2432
1986	.5401	.0836	.1289	.2474
1987	.5360	.0815	.1316	.2509
1988	.5323	.0794	.1344	.2539
1989	.5289	.0776	.1372	.2563
1990	.5258	.0759	.1400	.2583

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