Regional electricity sales forecasting

REGIONAL ELECTRICITY

SALES FORECASTING

by

Adrian Paul Woods

A Master's Thesis

Submitted in partial fulfilment of the requirements
for the award of

Master of Philosophy of the
Loughborough University of Technology

7 July 1987

P R E F A C E

This Master of Philosophy degree was conceived to improve *forecasts* of electricity sales in the *East Midlands Electricity Board Area.* The brief was to concentrate on forecasting, and to examine the possibility of using East Midland economic data for the forecasts. The entire topic of "electricity sales forecasting" is too large to be covered by a Master of Philosophy Degree. Several theses have been submitted for the degree of Doctor of Philosophy covering only the forecasting of domestic electricity sales. I decided to cover a less well documented area - that of forecasting Non-Domestic electricity sales. Of non-domestic sales only industrial and commercial sales are worthy of econometric models. The problems encountered when forecasting industrial and commercial sales are discussed. Due to the two year time limit I was only able to develop and estimate an industrial sales model. The application of the industrial models to the commercial sector is straightforward.

This is the *first* work to cover the subject of forecasting electricity sales for the individual electricity board region. It therefore covers completely new ground. I hope it will indicate some of the problems of regional forecasting, and suggest to others whether this route is worthwhile for them, or not.

The need for adequate forecasts of electricity sales at EMEB are explained, together with a brief outline of electricity tariff principles. The method of forecasting electricity sales at East Midlands Electricity Board (EMEB) are discussed, and some of the more relevant existing UK literature is reviewed. The literature considers industrial sales forecasting; there is little worthwhile published work on commercial sales forecasting. An important part of any forecasting exercise is to understand the data used. A detailed analysis of the data is provided. Then a general model is formulated followed by an explanation of the estimation technique used. The next section gives the results of estimating the various models. The main points and lessons are then summarised.

My thanks go to the many people who have helped me to complete this project. I am particularly grateful to EMEB for their financial support, and to Gill Noon and Lesley Jackson for their clerical help. Whilst EMEB have sponsored the degree I should make it clear that all views expressed in the thesis are my own and not necessarily those of the Board. I owe a particularly debt of gratitude to Tom Weyman-Jones at Loughborough University for his technical help, guidance, and especially the encouragement he has given me, without which the project would have been so much more difficult. And I must also thank Sue for her understanding and the many hours spent making drinks and meals for me whilst I worked. Unlike me, she has nothing to show for the extra work I created for her.

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INTRODUCTION

1.1 REASONS FOR FORECASTING

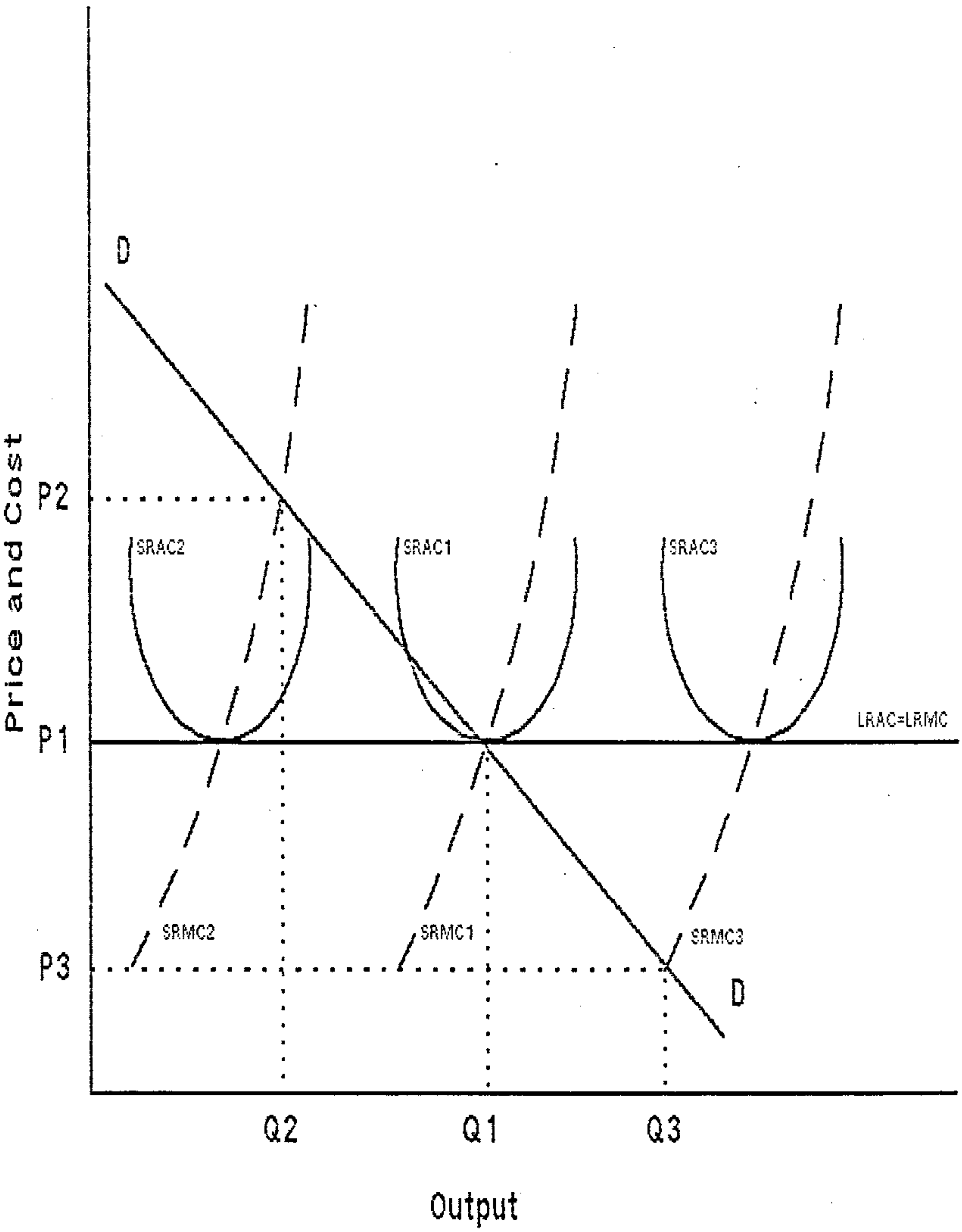
Electricity demand forecasting is *vital* to the investment and pricing decisions of the Electricity Supply Industry (ESI). Efficient allocation of resources in the economy requires prices everywhere to be set at marginal cost[1]. These marginal costs should be derived from the optimum total cost curve. That is, demand must be met at the minimum cost. This requires the optimum mix of plant, machinery and labour to be used to meet each demand. Accurate forecasts are required to ensure the optimum mix of plant in the future since installation of plant and machinery, and the training of labour takes time. Society benefits from accurate forecasts.

The following sections on Marginal Cost Pricing, Tariffs, Financial Targets, and System Planning and Design are a brief and simple guide to why forecasts are needed.

1.2 MARGINAL COST PRICING

The Electricity Supply Industry (ESI) is a Public Enterprise for several reasons. Firstly, it is a natural monopoly, with massive economies of scale. Second, government control of the future investment of such an industry is important to the nations future wealth. If sufficient capacity did not exist to supply *all* the electricity demanded, then the future growth of the economy may be inhibited. Thirdly, the government can use its influence to redistribute income in the manner it sees fit, by preferring certain groups. The government can exert its influence by suggesting lower prices to industry, for example, to help British firms to compete in international markets. Or, also in the recent past, the government effectively limited domestic consumers' standing charge to no more than 50% of their electricity bill. Such value judgements are

FIGURE 1.1 - LRMC Pricing



strictly the domain of governments. It is not allowed, in law, for the ESI to make such judgements.

To maximise profit a monopolist restricts output and raises price above marginal cost. Public control of an enterprise ensures that price can be set at marginal cost, and that the industry acts in the public interest.

The Central Electricity Generating Board (CEGB) sets its Bulk Supply Tariff (BST) at LRMC[2]. It has used LRMC pricing since the 1960s when Ralph Turvey was Chief Economist at the Electricity Council. If forecasts are correct and the optimum mix of plant is used to meet each demand then Short-Run Marginal Cost (SRMC) will equal LRMC. Forecasts are rarely perfect, and when they are not, LRMC pricing will not give a social optimum based on the set of *Paretian* value judgements[3]. Consider figure 1.1. The LRAC curve is the envelope of the SRAC curves. It represents the minimum cost of supplying a given demand when all inputs can be varied. If there are no economies of scale the LRMC will be a straight line and Long-Run Average Cost (LRAC) will equal LRMC. The demand curve is DD. Optimum welfare in a "first-best" economy[4] occurs where SRMC=LRMC=P_1 at Q_1. At this level of output demand is satisfied at minimum cost. If previous forecasts of demand were too low and insufficient capacity existed to meet demand of Q_1 at minimum cost P_1 we might be on the SRAC curve $SRAC_2$. To bring demand and supply into equilibrium a price of P_2 would have to be charged. Conversely, if demand was overestimated and the firm was operating on the $SRAC_3$ curve, price would have to be set at P_3 to utilize resources as efficiently as possible and to maximise social welfare. This assumes no externalities.

1 INTRODUCTION

For welfare maximisation the following must hold in a *first-best* economy:

1 price should be set at SRMC;
2 optimum capacity and demand have to be accurately forecast;
3 at the optimum SRMC=LRMC=P, the cost of meeting demand is minimised, and social welfare maximised;
4 if SRMC > LRMC capacity should be expanded, and if LRMC > SRMC capacity should be contracted.

Given some future demand that must be met, LRMC of generation consists of :

1 the annuitized cost of the extra generation and transmission capacity installed to meet that demand;
2 the cost of generating the incremental load;
3 additional manning and maintenance costs;
4 additional rates;
5 additional administrative costs.

When delivered to the customer the LRMC also consists of :

1 the annuitized cost of the incremental distribution capacity to deliver the energy;
2 transmission and distribution losses.
3 additional Area Board manning and maintenance costs;
4 additional Area Board local authority rates;
5 the additional Area Board administrative costs;

The ESI aims for LRMC pricing in two stages. The Central Electricity Generating Board (CEGB) calculate their LRMC and simplify this into their Bulk Supply Tariff (BST). Theoretically, LRMC's can be calculated for each of the 17520 half hours in the year; in practice the BST presently contains 26 different unit rates, a peak rate, and a series of demand and service charges. Appendix I is a copy of the latest BST. The BST charges vary by season, day of the week, and time of day. Area boards should in turn attempt to pass on their own marginal costs so that each consumer pays the cost which the Board incurs to supply the consumer with electricity. In an uncertain world LRMC is difficult to determine. If LRMC is the cost of the incremental load then there are as many LRMC's as there are conceivable increments in load. *The estimate of LRMC is therefore dependent upon the forecast.*

Accurate forecasts are *critical* to the Electricity Supply Industry (ESI) to optimise investment and therefore supply consumers at minimum cost. When price is equal to marginal cost in a first-best economy, resources are allocated optimally - and social welfare is maximised.

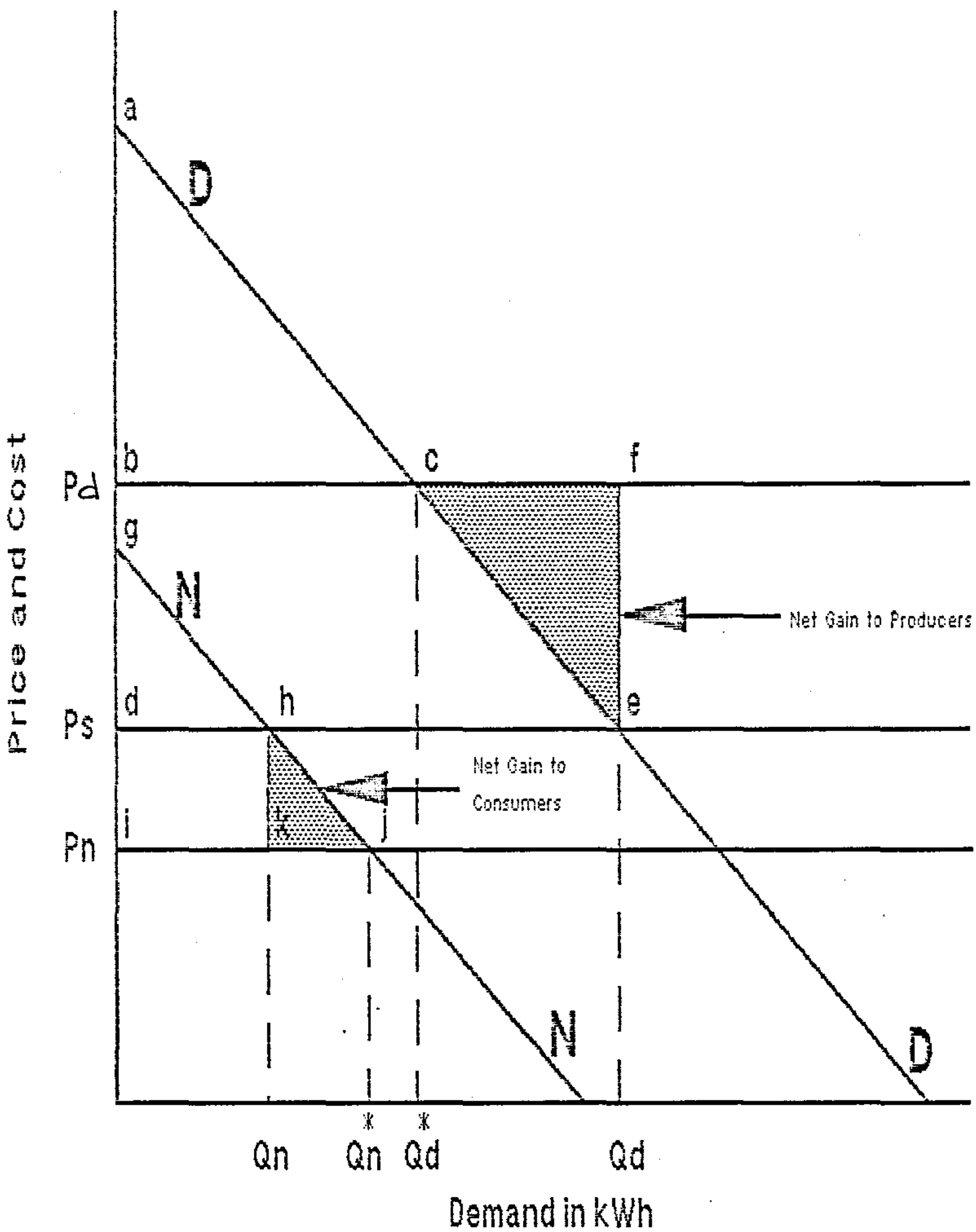
1.3 TARIFFS

"Marginal cost pricing in electricity means a tariff structure such that the cost to any consumer of changing the level or pattern of his consumption equals the cost to the electricity supply industry of his doing so. This can be achieved more or less closely according to whether the tariff structure is more or less complicated."[5]

To reflect the true cost to the ESI of consumers' marginal KW requires tariffs to be designed thus:

1 a connection charge to represent the capital cost of connecting the premises to the supply;
2 a charge for administration, meter reading, billing and so forth;
3 a contribution to overheads and repairs;
4 a charge for the fuel used to generate the energy requirement (this should be grossed up for transmission and distribution losses);
5 a charge to represent his contribution to capacity costs at each part of the system.

FIGURE 1.2 - Consumer Surplus and Tariff Complexity



In practice this is too complicated to understand and too costly to administer. A compromise is therefore found between the cost of administering tariffs and strict marginal cost pricing. For welfare maximisation this compromise should be chosen to maximize the sum of consumer and producer surpluses.

Consider for example the choice of tariff for households. Initially the tariff is single rate with a standing charge to cover the cost of metering, billing and so on. The weighted average marginal cost of supplying domestic consumers is Pd in the day and Pn at night. The weighted average marginal cost over 24 hours is Ps. The demand curves in this hypothetical case are assumed to be linear, DD for day and NN for night consumption. Demand would be Qs on the single rate tariff for consumption in the day and Qn at night. This is shown in Figure 1.2.

Suppose now that we introduce separate prices for day and night consumption. In the day a price of Pd will cause demand to fall to Q_d^*. Consumers' surplus will fall from ade to abc. The ESI will be better off by bdef since they were previously selling Qd units at a loss of bd. The net effect is to increase the sum of consumers' and producer's surpluses by cef.

Similarly, if we charge the weighted average marginal costs for night units, Pn, then demand will increase to Q_n^*. Consumers' surplus will increase from dgh to gij, giving a net increase of dhij. The surplus to the ESI will be reduced by dhik. The net increase in consumers' and ESI's surpluses at night will be hjk.

If the sum of consumers' and ESI's surpluses by moving to a dual unit rate tariff exceeds the cost of additional metering then the two part tariff increases welfare.

Mathematically, if:

$$\frac{(Ps-Pn)(Q_n^*-Q_n)}{2} + \frac{(Pd-Ps)(Q_d^*-Qd)}{2} > \text{additional metering cost}$$

then consumers would benefit from the introduction of the tariff.

Consumers with similar demand characteristics are aggregated into classes, and tariffs of appropriate complexity are constructed which summarise the marginal costs which these consumers impose upon the system. There is more than one tariff for each premises class. The best tariff for a consumer depends on their load shape and the voltage at which the supply is taken.

The ESI calculate "Yardsticks", giving the incidence to each element of the BST for each type of customer. Establishing a load shape for each type of customer is therefore important in forecasting. Costs and revenues can be forecast more accurately when forecasts are disaggregated by class of customer and tariff type.

Retail electricity tariffs reflect Long-Run Marginal Costs by passing onto consumers the CEGB's Bulk Supply Tariff (BST) and Area Board costs as accurately as possible given the practical limitation of tariffs. Both sales of electricity to customers and Area Board purchases of electricity from the CEGB need to be forecast; these differ because of electrical losses, and theft.

Elasticities of demand are *crucial* to the efficient choice of tariff complexity, and forecasts of load shape and losses are required to assess the difference between costs and revenue.

1.4 FINANCIAL TARGETS

Cost and revenue estimates can be made when the forecast of load shape, energy consumption by tariff type within premises class, and losses are complete. If forecasting is perfect and there are constant returns to scale, prices are set equal to marginal costs and Average Cost (AC) will equal Average Revenue (AR). The Government, who make the social welfare decisions, may decide this is not acceptable. In practice the Government sets financial constraints on the ESI. These are :

1 INTRODUCTION

1 The Financial Target

This is specified in terms of a net rate of return on current assets valued on a Current Cost Accounting basis for the period covered by the Target. It is the proportion of operating profit to the total net assets employed (total fixed assets + current assets - current liabilities) for all operations. The rate of return is agreed between the Government and the industry prior to the period to which the Target relates. Financial Targets normally take precedence over the External Finance Limit (EFL), although in more recent times the government's use of Cash Limits has elevated the importance of the EFL.

2 The External Financing Limit

This is the cash which must be paid to the Government each year. The Government sets it, in consultation with the ESI, consistent with the Performance Objective, and the financial target. It allows for the money needed in the year for capital investment.

3 The Performance Objective

The purpose of these is to impose a steady downward pressure on costs. They aim to measure output in terms of input. A Performance Objective could, for example, focus on reducing the amount of staff or capital per unit of output. The Performance Objective is there to encourage managerial efficiency, and reduce added cost per unit sold.

If the financial constraint is inviolable and binding, some prices will have to diverge from marginal costs. This will give a welfare loss. This loss of welfare may be outweighed, however, by gains in managerial efficiency as a result of having to meet the target.

1.5 REASONS FOR NOT USING MARGINAL COST PRICING

For marginal cost pricing to be in the national interest :

1 the prices of complements and substitutes for electricity must be priced at marginal cost;
2 there should be no externalities;
3 consumers must be well informed and rational;
4 the distribution of wealth and income must be acceptable;
5 goods and services for which electricity is an important input should be priced at marginal cost;
6 the prices of goods and services used in electricity production should be priced at marginal cost.

The ESI can help in (3) by informative advertising and advising how to use electricity efficiently. The Government decide what is acceptable in (4) and can suggest that the ESI adjust their prices accordingly. The other conditions are not fulfilled in practice but we can choose a second-best solution. This might include adjusting the price of electricity to compensate for imperfections elsewhere. This would require extensive knowledge and be very complex. If the ESI did not price at marginal cost they would be perpetuating sub-optimal pricing. It may therefore be the best policy for the ESI to ignore these externalities and imperfections of pricing, which it would be better to tackle more directly.

1.6 SYSTEM PLANNING AND DESIGN

Plant must be physically installed to deliver the energy to consumers and overhead lines, substations, manpower and so forth must be also planned to meet their requirements. The aggregate of Area Board forecasts provides background for CEGB and Electricity Council who also forecast electricity requirements for, amongst other reasons, planning construction of new power stations. This need is more medium term and looks seven years ahead - the time taken to plan and build a new power station (although with the current controversy over nuclear power stations such as Sizewell B, the lead times on nuclear stations are longer). The capital requirements of the Board for investment in the distribution network are important for determining the EFL and Financial Target (see above), besides the physical installation of capacity to meet consumers' demand. Precise forecasts are required to ensure optimal investment and a satisfactory level of service.

1.7 TIME SCALE OF THE FORECASTS

Forecasts are required for three distinct time scales :

1 short-term - less than two years, for tariffing, targets, and manpower and equipment planning.
2 the medium term - aimed at installation of the transmission and distribution network.
3 the longer term - more pertinent to power station building.

In addition forecasts are constantly monitored, and revised where necessary, so that the financial implications are evident - although tariff revisions are not common in mid year. Financial targets are frequently spread over several years; but the tariffs for the next year will be formulated well before the financial out-turn of the current year is known.

1.8 AREA OF STUDY

Industrial and commercial sales have been chosen for study in preference to domestic sales because there is inadequate data on the ownership of electricity-consuming durables by households in the Board's area. Most of the rigorous studies of domestic electricity consumption[6] have called upon these ownership levels. Many studies of domestic electricity consumption have been published but there are only a few studies of industrial electricity consumption and virtually no studies of commercial sales of electricity. No studies of industrial or commercial electricity sales at an Area Board level have been published for the United Kingdom, although some studies of domestic electricity sales have used cross-section (Area Board) data. Narrowing down electricity sales to a particular geographical area creates many problems. There is no published economic data which relates specifically to the area covered by an Area Board. The collection of data which applies to the East Midlands Electricity Board (EMEB) area is therefore an essential part of the study. The data available for the models is more limited and less precise than the data used for national models. Regional data is less frequent than national data and one is often left with the choice of interpolating using national data or sacrificing degrees of freedom in the models by using annual data.

The electricity forecasting requirements of Area Boards is embodied in the (normally) annual Load Forecasts submitted to Electricity Council, the central co-ordinating body of Area Boards. Although this study centralises upon energy sales the Load Forecasts need demands (in the electrical sense), losses, the Basic and Peak requirements on the CEGB and forecasts for load management customers as stated in the Bulk Supply Tariff (BST). Load shape, electrical losses, peak and basic demands, total energy used, and price elasticity are all important. This study concentrates on the price elasticity of demand, and total energy demand for industrial and commercial consumers.

NOTES TO CHAPTER 1

1 Welfare economics is beyond the scope of this work but a good book to read on the subject and its relevance to the Public Sector is Rees (1984)

2 It has ben suggested that the CEGB do not price at LRMC - see Slater and Yarrow (1983)

3 Rees, p. 29.

4 Rees, p. 31.

5 Turvey (1968)

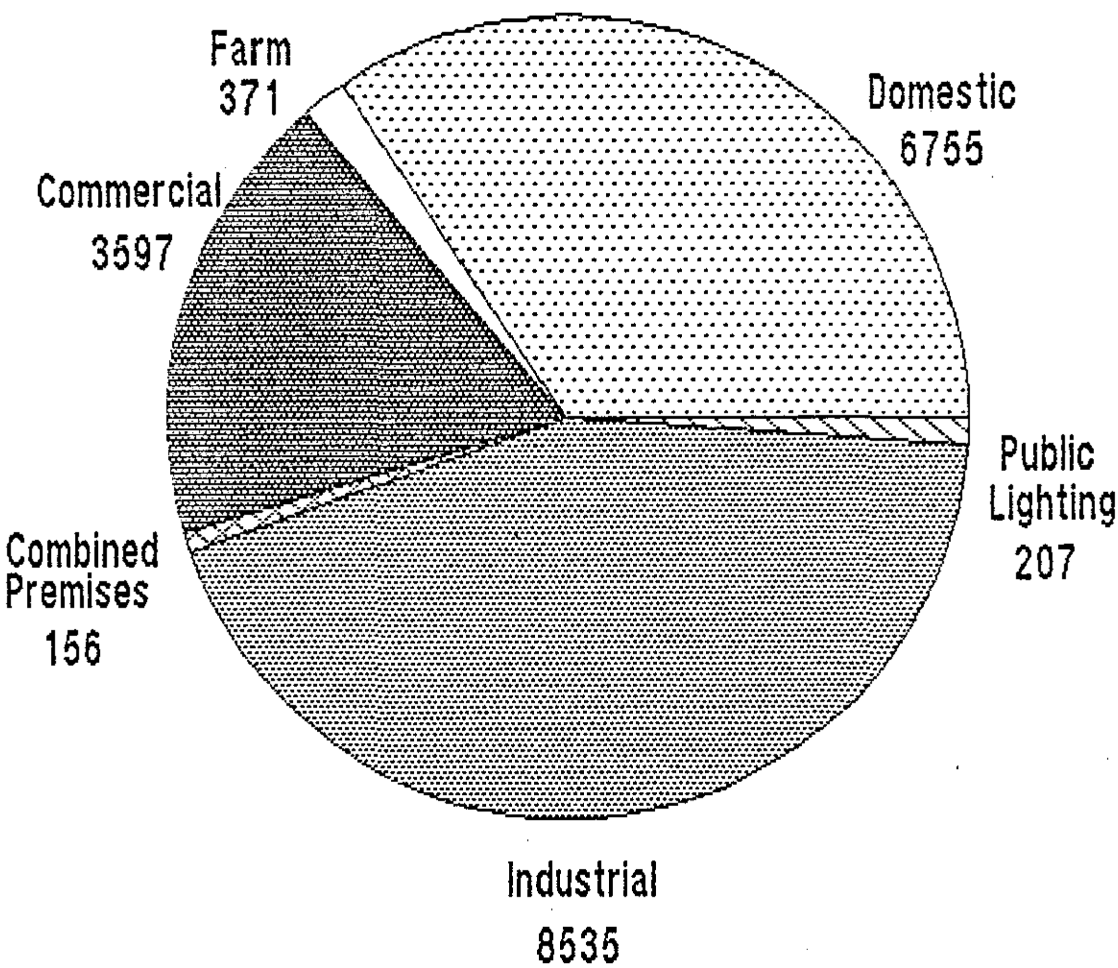
6 Ruffell (1977), Pierson (1982), Tomlinson (1983).

TABLE 2.1 EMEB Electricity Sales 1985/86

Class	Sales (GWh)	Percentage
Domestic	6755	34.4
Farms	371	1.9
Commercial	3597	18.3
Combined Premises	156	0.8
Industrial	8535	43.5
Public Lighting	207	1.1
Total Sales	19621	100.0

FIGURE 2.1

EMEB Electricity Sales 1985/86



CHAPTER 2

PRESENT LOAD FORECASTING METHODS

The units forecast provides the starting point for the "Autumn Load Estimates", the main forecasting task of the year. Electricity sales are forecast at standard weather; and historic data is corrected to standard weather for forecasting and comparison of one year with another. Standard weather is *average* weather conditions. Correction of total sales to standard weather sales is performed at Electricity Council but the split of the weather correction amongst premises classes is done at Area Board level and is based upon experience. When considering the performance of a forecast it makes most sense to compare the original forecast with the standard weather out-turn since the weather cannot be forecast satisfactorily.

Table 2.1 gives the split of electricity sales by premises class for 1985/86, and figure 2.1 shows a pie chart of sales.

In 1985/86 Domestic, Commercial and Industrial sales together accounted for 96.2 % of the Board's total sales and most effort is put into forecasting these classes.

2.1 DOMESTIC

Domestic sales are probably the most difficult to explain and forecast. Econometric models have been used but have not met with as much success over the last decade at EMEB as they did previously. A *Build-Up* model (explained later) is currently used.

Domestic Sales are determined by :

1 consumers' stock of appliances;
2 usage of appliances;
3 loading of the appliances;

4 the price of electricity;
5 the price of other fuels;
6 the price of other goods;
7 consumers' disposable income;
8 the number of domestic customers;
9 marketing effort.

Domestic sales are forecast by tariff type. Three significant tariffs exist :

1 Unrestricted Domestic;
2 Economy 7;
3 Restricted Hour Tariff.

For forecasting purposes Economy 7 day units are treated as unrestricted.

2.1.1 Unrestricted Domestic

Two types of model exist for forecasting domestic unrestricted sales :

1. Econometric Models

Various single equation econometric models have been used such as :

$$UD = \beta_0 + \beta_1.CE + \beta_2.P_t$$

$$UD = \beta_0 + \beta_1.CE + \beta_2.P_{t-1}$$

Where UD = Unrestricted domestic consumption
CE = Consumers' expenditure
P = A relative price variable for electricity against competing fuels

The above model has also been specified in per capita form and forecasts of domestic customers derived from population studies and past trends.

To be strictly correct, personal disposable income should be used instead of consumers' expenditure; however, forecasts of consumers' expenditure are more readily available and is perhaps a better measure of *permanent income*, representing the ability of consumers to add to their stock of appliances over time - and so increase electricity sales. The price variable has been more successful in the past than it is today; this is partly because less people now use direct acting space heating, and are less likely to heat water on the unrestricted domestic tariff. Therefore, the degree of competition from other fuels on the unrestricted tariff is limited mostly to the cooking load with some water heating and direct acting space heating. Econometric models have lacked success because they do not account for the demand for electricity being a derived demand from the ownership and characteristics of electrical appliances. The demand for unrestricted electricity is the sum of the individual demand curves for electricity associated with the ownership of appliances, and the utilisation and acquisition of these appliances, which will be influenced by the price of electricity. The electricity required by these appliances will depend on their efficiency. This efficiency will vary over time. New appliances are mostly more efficient than older ones. It is very difficult to construct a technical variable to represent these changing efficiencies. For these reasons the "Build-Up" model (described below) has recently been favoured. Early econometric models worked because people were in the process of acquiring a range of electrical appliances; the consumers' expenditure variable related their ability to acquire them. Establishments[1] are now closer to saturation and the increased efficiency of new appliances is now a dominant feature of domestic sales.

2. The Build-Up Model

The *build-up* model consists of three matrices. The first, A, gives the ownership level of appliances held by consumers. B gives the mean annual consumption of each appliance. The product of these two matrices gives a third matrix, C, showing the mean annual consumption of each appliance for the "average" customer. This is multiplied by the total number of EMEB customers to give the total contribution to domestic electricity sales of each type of appliance. A copy of the domestic *Build-Up* model is included as appendix II.

Mean Unrestricted Domestic Electricity Sales per Customer (C) = A.B

where : A is an i by y matrix of ownership levels

B is an i by y matrix of average consumptions for each appliance

C is the product of A and B

i is the number of different appliances

n is the number of customers on unrestricted tariffs

y is the number of years data

Aggregate consumption on unrestricted tariffs is therefore C.n.

The *build-up* model avoids some of the criticisms of the econometric models. The ownership levels of domestic appliances is determined by market research. The mean consumption of these appliances is estimated by load research and other, mostly ad hoc methods. When multiplied out this gives the consumption of the "average" customer. The main advantage of this method is that it pin-points the areas of growth and contraction. If we know, for example, that lights will become more efficient over the forecast period we can allow for this directly. There are some problems with this method. Market research is costly and so is load research. Much of the available data is unreliable; confidence limits on ownership levels are poor at an Area Board level. With a sample size of 300, and at the 50 % ownership level, 95 % confidence limits suggest the true ownership level could be in the range of 42 % to 58 % ! The average consumption of appliances depends not only on the rating of appliances but also upon their usage throughout the year, and in some cases upon the weather. It is extremely difficult to model use of appliances; this is related to the price of electricity, disposable income, and the ownership of other appliances (one does not normally use the television and stereo simultaneously.) The build-up model, therefore, is better for predicting domestic demand in the long-run rather than the short-run since it fails to relate to short-run economic conditions. Presently, ownership levels are forecast by trend fitting, bearing in mind saturation levels, and establishments in other Area Boards with higher incomes and other different characteristics. Estimates of the efficiency of the future stock of appliances can be guessed from the efficiency of new appliances and their likely replacement rates. With sufficient load research data on the pattern of consumption, the build-up approach could give an insight into the domestic load shape, enabling forecasts to be made of the changing domestic load shape. This is important for tariffing since it enables the Board to reflect marginal costs more closely in its tariffs.

A more thorough treatment of the domestic build-up model is given by Ruffell (1977), Pierson (1982), and Tomlinson (1983).

2.1.2 Economy 7 Night Units and Restricted Hour Tariff

Competition from other fuels is more pertinent to off-peak tariffs. No econometric model currently exists for this market - mostly because there is insufficient historic data on these relatively new tariffs. Data is interrupted by changes in the structure of the tariff or a change in emphasis on the marketing of the tariff. The forecast for sales on off-peak tariffs is, therefore, largely judgmental - using the experience of other boards and previous tariffs of a similar nature, and taking account of other relevant factors such as marketing and price. This guesstimate is broken down into average consumption per customer and the number of customers on the tariff, together with an estimate of the net new load sold for use on the tariff. There are problems determining the number of storage heaters sold to EMEB consumers, for example, since the Board is not a monopoly supplier of storage heaters to EMEB customers. Estimates of the average electricity used by storage heaters is also required.

The forecast of consumption on the various domestic tariffs is then summed to give a forecast for the total consumption of electricity by domestic consumers.

2.2 Commercial

Large commercial customers may be on high or low voltage Maximum Demand Tariffs; these tariffs consist of an energy charge, a standing charge, and a charge for the highest MD recorded in a half hour in the months of November to March inclusive, and a monthly authorised supply capacity charge representing the highest demand a customer is authorised to make on the system. Smaller customers may choose the less complex General Purpose (including Economy Seven) tariff. Commercial consumption is forecast as an aggregate across all tariffs and types of customer at present. This is then disaggregated by tariff type for revenue estimating. Disaggregated approaches have been limited to time trending each sector of commercial sales for the short-term, and use of "a priori" information.

Commercial customers are mostly in the service industries. Gross Domestic Product at constant factor cost (GDP) has been the main economic variable used to forecast commercial sales - on the assumption that the level of services a country enjoys is related to the wealth of the country. The models used for this sector have taken various forms such as :

$$C = \beta_0 + \beta_1.GDP$$

$$C = \beta_0 + \beta_1.GDP + \beta_2.PL$$

where C = commercial consumption
GDP = gross domestic product at constant factor cost
PL = lagged price variable

The price variable uses average prices but should really be specified as marginal price. Price is inversely related to quantity if average prices are used because of the standing charge. This point is expanded in chapter 4.3.

Forecasts of sales on off-peak tariffs are then made, but as with domestic off-peak sales these are largely subjective - due to insufficient historic data. Factors such as the likely relative price of off-peak electricity vis a vis gas and oil are, of course, taken into account. Unrestricted commercial sales are then calculated as the difference between total commercial sales and sales on off-peak tariffs.

The forecast of commercial sales has many problems. Each sub-sector of commercial sales has a different relationship between its output and its electricity input. The relationship between commercial sales of electricity and GDP will therefore change over time. Firstly, the proportion of GDP which is created in the service sector is increasing at a fast rate. As GDP has increased, therefore, a larger percentage increase in the services sector has been seen. This implies that the relationship between commercial sales and GDP is not linear, because a large part of GDP is the more static industrial sector. Secondly, the changing mix of commercial consumers will change the relationship between aggregate commercial sales and aggregate commercial output. Lastly, some account must be taken of energy conservation measures, which will vary according to commercial sector.

An ideal system would also account for end usage within each sector. For example if we expect lighting to be more efficient we need to know the lighting load to allow for the resultant decline in sales for lighting in a similar way to the domestic *build-up model.*

Consumers' expenditure has been used as an alternative to GDP for the independent variable. Sales to Shops, Warehouses, Public Houses, Offices, Hotels and Boarding Houses, Entertainments, and Department Stores are dependent upon how much consumers have to spend on their services. An increase in the demand for shops, for example, is likely to result in an increase in the sales of electricity to shops. An economy with a high income per capita is also likely to spend more money on entertainment and leisure. For sales to Public Buildings, H.M. Forces, and Education, however, Government Expenditure is the most relevant economic variable. As Government financial pressure is applied to these establishments their requirement for electricity is depressed, and the relationship between expenditure of these establishments on fuel and light and other factors will be distorted. Sales to the latter category, however, accounted for only 22 % of total commercial billed units in 1983/84. Again, these aggregate demand relationships miss some of the subtleties of reality. Commercial premises are becoming more electricity intensive; offices are acquiring a large number of electric appliances as the real price of new technology equipment falls. Photocopiers and computers, for example, are becoming commonplace, and new technology is not confined to offices. A time variable could be included in the equation for commercial sales to reflect the growing stock of commercial appliances. It was expected that the time variable would cause problems with multicollinearity but this does not seem to be the case. A simple time variable cannot hope to cope with the complexities of the changes occurring over time. These include the changing mix in consumption of the sectors, energy conservation measures, and competition with other fuels, besides a growing stock of appliances. This is recognised but the time variable has been used whilst reliable alternative data is compiled. The lack of true explanatory power of the time variable makes it difficult to put much faith in a model using it, but the results can be used if they are interpreted with caution.

2.3 INDUSTRIAL

Industrial and commercial tariffs are similar but very large users can choose a Load Management tariff. These pass on to the customer the Board's cost saving as a result of the customer reducing his load when this is required by the CEGB. In practise many of these large customers are visited and their future energy requirements are discussed. These customers accounted for 13 % of industrial sales in 1985/86.

The industrial model is similar to the commercial model. An aggregate approach has been taken in the main with a typical model being :

$$IS = \beta_0 + \beta_1.IIP + \beta_2.STKS$$

where IS = industrial sales of electricity

IIP = national index of industrial production

STKS = ratio of industrial stocks to finished output

Industrial models used IIP instead of regional Gross Domestic Product because the industrial production proportion of GDP is changing with time.

Similar problems exist to those encountered in the commercial sector. The problems of sector mix is even more relevant in the industrial sector. The shake-out of the old heavy industries implies a declining elasticity of industrial sales with respect to industrial production. In addition to the declining elasticity due to "structural" effects, firms are becoming more efficient in their use of electricity. Many firms now have specialists in energy management and energy conservation. Firms are continually investing in more efficient plant and machinery, and new firms are often less energy intensive than established ones. For these reasons a simple relationship between industrial production and industrial sales will result in a mis-specification error giving biased and inconsistent estimates of the true slope. In this case it can be seen that the forecast would overstate the true growth of industrial sales. To overcome this problem, a time variable has been tried in an attempt to represent the changing structure of East Midlands Industry and improved efficiency of plant and machinery. Meanwhile, the precise nature of these effects is being examined in more detail. If we do not expect the structural and efficiency characteristics to persist we can allow for this by holding time at its present level or introducing judgement into the value for the time variable. Although this is a weak approach it does produce a less biased estimate of the IIP coefficient. In addition to these problems the IIP measures national industrial production, which, of course, increases the inherent errors of the estimates.

Some of the above problems can be overcome with a more disaggregated approach. Even though this might explain the past quite well, it might not be much use in forecasting unless each sector can be separately modelled and related to pertinent economic variables. It must also be possible to forecast these variables. If not, the errors in the disaggregated approach could exceed those in the aggregate approach. A detailed disaggregated approach had not been used at EMEB prior to this thesis.

Some of the regression residuals will be due to the economic cycle. In times of slack demand, plant utilisation rates will be lower. Any fixed consumption, such as lighting or heating, will constitute a larger proportion of the total; thus, at low levels of activity, the elasticity of industrial sales with respect to output will be higher. Thus the relationship between IIP and industrial sales will be non-linear. A variable which measures capacity utilisation should be included in the regression. The CBI quarterly trends survey asks questions about capacity utilisation. This could be included in the model, although only national data is available. Quarterly data could also help pick out the economic cycle, and provide more degrees of freedom for the model.

NOTES TO CHAPTER 2

1 Establishments are the stock of appliances currently owned by households.

CHAPTER 3

LITERATURE SURVEY

This chapter presents three illustrative and important studies of *industrial electricity sales*. Most UK studies concentrate on industrial electricity sales. There is little worthwhile published literature on commercial sales, although there is some useful unpublished work at Electricity Council. Wigley and Vernon (1983) estimated elasticities for "other industry" (excluding Iron and Steel, and Energy industries). The equation used is one of two equation set, but is similar to those I use later, except that it is the share of "useful electricity demand in total useful energy". The price elasticity is -0.247 in the short-run, and -0.49 in the long-run. Annual data was used from 1954 to 1979.

3.1 HANKINSON AND RHYS (1983)

This study provides a good understanding of some of the basic problems of forecasting aggregate industrial electricity sales. The model " uses simple arithmetic procedure to separate changes in industrial structure and industrial electricity intensity" and concludes that "a *disaggregated approach* is needed."

The Hankinson and Rhys study is similar to that of Kouvaritakis (1983). Hankinson and Rhys start with a simple model in double-log form which implies a constant elasticity of electricity consumption with respect to industrial output.

$$\text{Log } E_t = \beta + \beta \text{LogIIP}_t + e_t$$

where: E_t = seasonally adjusted electricity consumption in period t

IIP_t = seasonally adjusted industrial output in period t (excluding North Sea oil and gas)

e_t = random error in period t

TABLE 3.1 - The Changing Elasticity of industrial electricity consumption with respect to industrial output

	Regression constant	Regression co-efficient	R^2	Durbin-Watson
1955Q1-1960Q4	-0.27	2.3	0.88	0.44
1960Q1-1966Q4	0.87	1.7	0.92	0.72
1965Q1-1970Q4	1.58	1.33	0.95	1.17
1970Q1-1975Q4	2.90	0.67	0.92	1.48
1975Q1-1980Q4	2.34	0.97	0.42	0.37

The model used quarterly data from 1955 to 1980. Results from this simple model are poor and are shown in table 3.1

The regression co-efficients for this simple model are unstable and the Durbin-Watson statistic is poor; this suggests there are factors unaccounted for by the model.

Consumption data for England and Wales is used but the IIP (excluding North Sea Oil and Gas) is for the U.K. The industrial structure has changed over the period covered by the study and so has the electricity intensity of the individual industries. It is suggested that changes in electricity intensity may arise due to increases or decreases in the end-use, changes in efficiency, increases in the use of electricity to replace other fuels (or vice versa), or the development of new electric technology.

Three effects are distinguished by Hankinson and Rhys.

Defining variables thus :

TC_b = total industrial electricity consumption in base year b
TC_{ib} = electricity consumption by the i th industry in year b
IIP_b = index of industrial output in year b
IIP_{ib} = index of output for the i th industry in year b
TC_t = total industrial electricity consumption in year t
IIP_t = index of industrial output in year t
IIP_{it} = index of output of the i th industry in year t

These effects are :

1 Overall Level of Production (Effect A)

This assumes that only output influences electricity consumption and that a simple proportional relationship exists between electricity consumption and industrial output thus :

TABLE 3.2 - The effect of changes in output, structure and electricity intensity on industrial electricity consumption.

Period	Effect A, total output (GWh) (% total growth)	Effect B, industrial structure (GWh) (% total growth)	Effect C, electricity intensity (GWh) (% total growth)	Actual Growth in total consumption
68-71	1957 (31.0)	589 (9.3)	3778 (59.7)	2.6
68-74	6550 (74.8)	3282 (37.5)	-1074(-12.3)	1.8
68-77	3619 (25.8)	4934 (33.2)	5482 (39.1)	1.8
68-80	-1002 (-9.4)	2461 (23.1)	9189 (86.3)	1.1

$$\text{Effect A} = \frac{TC_b.IIP_t}{IIP_b} - TC_{tb}$$

2 Structural Change (Effect B)

This is measured by multiplying consumption for each industry group in the base year by the growth in output of each industry. The result is then summed across industries - then the total base year consumption scaled up by the growth in total output is subtracted.

$$\text{Effect B} = \sum_{i=1}^{n} \frac{TC_{ib}.IIP_{it}}{IIP_{ib}} - \frac{TC_b.IIP_t}{IIP_b}$$

3 Electricity Intensity (Effect C)

This is the difference between the actual consumption and the total derived by multiplying the base year consumption by the growth in sector output.

$$\text{Effect C} = TC_t - \sum_{i=1}^{n} \frac{TC_{ib}.IIP_{it}}{IIP_{ib}}$$

These effects were calculated for several periods. The results are given in table 3.2

This approach is used to quantify the three main factors causing changes in electricity demand. The simple regression only identifies the output change. The growing significance of the structure and intensity effects after the mid - 1970's is evident from table 3.2. The negative electricity intensity effect was probably the result of the three day week. Table 3.3 shows the calculated contribution of each industry group to both structural and intensity effects of industrial electricity consumption.

TABLE 3.3 - The impact of individual industries on the growth in electricity consumption over the period 1968 - 1980.

	Changes in electricity consumption arising from:	
Industry group	Effect B, industrial structure (GWh)	Effect C, electricity intensity (GWh)
Iron and Steel	-4101	2973
Chemicals	4559	-3414
Food, Drink and Tobacco	14	1635
Coal Mining	-717	2032
Bricks, pottery, glass and cement	-55	680
Vehicles and aircraft	-70	1443
Mechanical engineering	25	-64
Textiles	-515	154
Gas and water	1683	-2068
Metal Goods	-28	880
Paper and printing	118	53
Electrical engineering	365	-798
Non-ferrous metals	-55	4260
Other industry	1238	1423
All industry	2461	9189

Hankinson and Rhys suggest adjusting the dependent variable to account for effect B and re-estimating the equation. They conclude that "there is no obvious economic variable" which adequately reflects the intensity effects and they subsequently adopt a simple time trend to represent intensity. Hankinson and Rhys found the price of other fuels, labour, and capital to be weak explanatory variables. Table 3.4 shows the results of the re-estimated model. Model I is the simple model. Model II has the adjusted dependent variable. Model III has the adjusted dependent variable and a time trend to represent intensity. Table 3.4 shows improvements in Durbin-Watson and more stable regression co-efficients with these amendments. The methods of Hankinson and Rhys are simple but show clearly the major factors causing changes in the proportion of industrial electricity consumption per unit of output. These are :

1 Changes in industrial output;
2 Changes in industrial structure;
3 Changes in electricity intensity (including changes due to price, different products being made, and process changes).

3.2 BAXTER AND REES (1968)

Baxter and Rees tried to construct "models based on accepted economic principles" and use them to examine "the significant influences on electricity demand".

They identify two approaches to modelling industrial electricity demand. One is to estimate the total demand of industry for energy and then to determine electricity's share of the total. The other, which Baxter and Rees used, is to regard all fuels as the input to a Cobb-Douglas type production function.

TABLE 3.4 - Comparison of regression results of the original model with the model using the dependent variable adjusted for industrial structure, and the modified model including a time trend

Time period	Model	IIP (t value)	Time trend (t value)	R^2	D-W
1970Q1-1975Q4	I	0.674 (7.62)		0.923	1.48
	II	0.545 (6.24)		0.907	1.63
	III	0.626 (7.30)	-0.021 (-2.37)	0.929	2.07
1971Q1-1976Q4	I	0.585 (3.67)		0.797	0.75
	II	0.537 (4.62)		0.855	1.46
	III	0.539 (4.59)	0.011 (0.78)	0.86	1.52
1972Q1-1977Q4	I	0.370 (1.83)		0.746	0.66
	II	0.457 (3.16)		0.816	1.31
	III	0.678 (4.13)	0.054 (2.26)	0.855	1.78
1973Q1-1978Q4	I	0.410 (1.73)		0.608	0.55
	II	0.506 (2.63)		0.694	0.83
	III	1.039 (6.74)	0.137 (5.67)	0.882	2.17
1974Q1-1979Q4	I	1.210 (2.93)		0.603	0.58
	II	1.056 (2.97)		0.634	0.70
	III	0.928 (5.87)	0.191 (9.32)	0.932	2.44
1975Q1-1980Q4	I	0.968 (3.37)		0.420	0.37
	II	0.772 (3.02)		0.467	0.44
	III	0.887 (9.20)	0.211 (11.38)	0.929	2.30

At the time of their study electricity consumption was rising faster than industrial output (i.e. the elasticity was greater than unity). In the short-run a less than proportionate increase was expected by Baxter and Rees, because of the fixed element of electricity consumption used for lighting, heating, and so forth. In the long-run, a proportionate increase might be expected as firms vary all their inputs to meet the change in demand. Three long-run effects were identified which might cause a more than proportionate increase in electricity consumption per unit of output.

Baxter and Rees had three models designed to test for each of these effects which are :

1 Relative price movements may favour use of electricity in place of other fuels or labour.
2 Technological change may favour electricity use in place of other fuels or labour.
3 There may be increasing or decreasing *returns to scale*. This is difficult to determine since in the long-run electricity is related to output through plant and machinery . The relationship between output and electricity use will therefore depend on how the capital stock varies as output varies - and the electricity using characteristics of the incremental capital stock.

Model I

This is a Cobb-Douglas type production function with inputs of labour, capital, coal, gas, oil, and electricity. It takes the form:

(1) $Q=a_0x_1{}^{a1}x_2{}^{a2}...x^{aK}$

Total costs of production are:

(2) $C=p_1x_1+p_2x_2...p_Kx_K$

Assuming that firms are cost minimisers and minimising (2) subject to (1) gives the first order conditions for a constrained cost minimum :

$$(3) \quad p_1 - La_1a_0x_1^{a-1}x_2^{a2}\ldots x_K^{aK}=0$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$p_K - La_Ka_0x_1^{a1}x_2^{a2}\ldots x_K^{aK-1}=0$$

$$Q=-a_0x_{1a1}x_2^{a2}\ldots x_K^{aK}=0$$

where L = the lagrangean multiplier associated with (1)

Q = total output

x_i = input i

C = total costs of production

p_i = the price associated with input i

If electricity is the K'th variable then solving the system of (K+1) equations in (K+1) unknowns for x_K will give the demand function for electricity as :

$$(4) \quad x_K = b_0p_1^{b1}p_2^{b2}\ldots p_K^{bK}Q^{bK+1}$$

Therefore *the demand function for electricity is an exponential function of the k input prices, and output.*

This model lays emphasis on *relative prices.*

Model II

This is complementary to model I but emphasises the effect of changes in fuel technology. Time trends are often used to represent this. Baxter and Rees dismissed time trends as economically unsound. They can also cause problems of multicollinearity. Instead they used the amount of coal consumed by an industry as a surrogate for technology. This also creates problems, especially when included with price variables which includes the price of coal. The variation in coal price may be causing the change in use of coal - it may not be changes in technology. For this model electricity

TABLE 3.5 - List of equations and variables.

Dependent Variables	Specific Independent Variables. Symbol	Meaning	Equation Form	Equation number and set of independent variables used in that equation
I D_t (Electricity consumption in KWh)	1. Q_t	Index of production	Exponential	(1) $Q_t;T_t$
	2. T_t	Temperature		(2) $Q_t;T_t;(P/F)_t$
	3. $(P/F)_t$	Price of electricity Price index of all other fuels		(3) $Q_t;T_t;(P/W)_t$
	4. t	Time		(3a) $Q_t;T_t;t$
	5. $(P/W)_t$	Price of electricity Average wage-rates		
II Z_t (electricity consumption in coal equivalent tons)	1. Q_t	As above	Linear	(4) $Q_t;T_t;C_t;C_{t-1}$
	2. T_t	As above		(5) $Q_t;T_t;C_t;C_{t-1};t$
	3. C_t	Coal consumption		(6) $Q_t;T_t;C_t$
	4. C_{t-1}	As Above		(7) $Q_t;T_t;C_t;(M/Q)_t$
	5. t	As above		(8) $(I/Q)_t;T_t;C_t$
	6. $(M/Q)_t$	Numbers employed Index of production		
	7. $(I/Q)_t$	Gross fixed capital formation Index of production		
III $(D/Q)_t$ (consumption ratio)	1. T_t	As above	Exponential	(9) $T_t;(M/Q)_t$
	2. $(P/F)_t$	As above		(10) $T_t;(I/Q)_t$
	3. $(P/W)_t$	As above		(11) $T_t;(P/F)_t$
	4. $(M/Q)_t$	As above		(12) $T_t;(P/W)_t$
	5. $(I/Q)_t$	As above		

consumption was converted to Coal Equivalent Tons (CET) for comparison of coal and electricity consumption.

Model III

The third model assumes constant elasticity of electricity consumption with respect to output. Variations from this are assumed to be caused by changes in relative prices, and changes in labour and capital intensity.

(5) $D_t = y_t Q_t \quad (t=1,2,\ldots n)$

where D_t = electricity demand in time t
Q_t = output in time t

and:

(6) $y_t = f(Y_{t1}, Y_{2t}, \ldots Y_{mt})$

where Y_{mt} are relative prices, and labour and capital intensities.

Table 3.5 shows the equations estimated and variables used. Desirable economic properties of equations sometimes had to be sacrificed to give statistically acceptable results. In model I the fuel price relative was included separately from the wage relative (equations 2 and 3). The correlation which exists between these two may be greater than the correlation of each with the dependent variable. Equation (1) was estimated to show the effect of the price variables; and equation 3a to compare the economic significance of the of the price variables.

The second group of equations are model II, which uses coal consumption as a surrogate for technological change. Lags were experimented with in these equations and equation (5) tested for the significance of a time trend. Output was included in all equations. Equations (7) and (8) included employment-output and investment-output ratios respectively to isolate the effects of changes in capital and labour intensity.

Data

Quarterly time-series were used from 1954-1964 giving 44 observations. The data is seasonally unadjusted to avoid smoothing of the effects under examination. Seasonal dummies were used in all equations. The inclusion of temperature with the seasonal dummies greatly reduces the significance of the temperature coefficient as most of the temperature response is included with the seasonal dummy. A lagged dependent variable was used by Baxter and Rees to represent the time taken by the dependent variable to move to its equilibrium level following the change in the independent variables. The *partial adjustment* model used has an implicit geometrically declining lag structure. Baxter and Rees made three criticisms of their model:

1 it emphasises the current value of the independent variable (which might not be appropriate);
2 the same lag distribution is given for each independent variable;
3 the assumptions underlying OLS estimation will break down - this is *not* a valid criticism of the partial adjustment model but would be valid if the model was constructed with a Koyck transformation.

TABLE 3.6 - Comparison of Explanatory Power of the Variables.

Variable / Equation	Q_t	log Q_t	T_t	log T_t	log $\frac{P}{F}_t$	log $\frac{P}{W}_t$	t	C_t	C_{t-1}	$\frac{M}{Q}_t$	log $\frac{M}{Q}_t$	$\frac{I}{Q}_t$	log $\frac{I}{Q}_t$	log D_{t-1}	Z_{t-1}	log $\frac{D}{Q}_{t-1}$
1		9		1										16		
2		12		6	7									16		
3		6		5		7								16		
4	9		8					7	4						15	
5	9		4				5	9	0						10	
6	10		7					13							15	
7	8		7					11		6					15	
8			7					8				5			16	
9				5							1					16
10				4									7			16
11				4	8											16
12				7		5										16

The analysis was performed for each of the industry groups commonly used by the Electricity Supply Industry (ESI).

Equations are compared by goodness of fit and comparison of the size and significance of the parameters amongst industries. It is inappropriate, however, to compare linear and logarithmic models on the basis of goodness of fit - this requires the Box-Cox technique. Baxter and Rees analysed each of their equations across industry group and ranked their equations according to: mean R^2; mean standard error of equation; lowest standard deviation of R^2; lowest S.D. of S.E. of equations. The equations ranked highest on R^2 are also ranked highest on S.E. of equation; they also have the lowest S.D. implying a greater consistency across industry groups. Equations based on model I perform slightly better than those based on model II. Model II is subject to considerable measurement error of the variables (using coal as a surrogate for technology) but performs well regardless. Equations based on model III are consistently inferior on the above criteria. Baxter and Rees do not conclude which set of equations would be best for forecasting but they do suggest that equations (2) and (6) have the highest general levels of significance of the parameters in their respective groups. This can be seen in table 3.6 which shows the number of industries in which the parameters of the variables were significant at the 0.95 level. Output, Q, and coal consumption, C, are the most common significant determinants of electricity demand - apart from the lagged dependent variable which is not shown in their results. The time variable in equation (5) is not significant in many cases which suggests intercorrelation with Q and C. The only other variables with fairly general explanatory power are the price variables and the I/Q variable in the consumption ratio equation. The Q variable falls in significance when the P/W variable is introduced. A similar effect is observed on C_t when C_{t-1} is introduced.

TABLE 3.7 - Elasticities

Industry group	D,Q	D,P/F	D,P/W	Z,I/Q	Z,M/Q	Z,C	Z,t	λ	D,T	Mean S.E.%
Food, Drink, Tobacco	2.571	-0.415*	-1.046	2.493	-2.541	-0.056*	0.348	0.632	-0.273*	3.1
Chemicals	0.821	-1.069	-1.096*	-1.607*	-8.312	0.237*	0.291	0.448	-0.140*	2.4
Non-Ferrous Metals	1.310	-0.843*	-2.543	-0.103*	2.367*	0.031*	0.173	0.246	-0.101*	3.6
Iron and Steel	1.507	-2.257*	-2.722	-0.378	-3.581	-0.397	0.146*	0.115	-0.163*	2.5
Engineering	0.944	-0.588	-0.712	-0.473*	2.206	-0.156	0.002*	0.490	-0.216	2.7
Vehicles	1.216	-1.428*	-1.280*	-0.144*	-0.127*	-1.285	0.216*	0.200	-0.251	3.5
Shipbuilding	-0.615*	-0.904*	-1.354	-0.305*	1.090*	-0.182	0.203*	0.033	-0.369	4.5
Metals nes	0.647	-2.277	-2.705	-2.064	-4.266*	0.239	0.202	0.185	-0.265	3.3
Textiles	1.307	-1.651	-1.432	0.570*	-2.536*	-0.403	0.090*	0.148	-0.184	1.9
10 Leather & Fur	0.301*	-2.532*	-2.193	0.046*	0.056*	-0.901	0.307*	0.213	-0.205	7.0
11 Clothing	0.612*	-2.444*	-1.194*	0.403*	-0.151*	-0.790	0.216	0.118	-0229*	4.5
12 Timber	0.182*	-3.181*	-2.623*	0.143	0.593	-0.788	0.079*	0.084	-0.260*	5.1
13 Bricks	0.721	-0.738	0.722*	0.507*	0.657*	-0.235	0.153*	0.674	-0.061*	2.1
14 Paper	0.746	-1.083	-0.793*	-0.854	2.732*	-0.275	0.050	0.423	-0.079*	1.9
15 Other Manufacturing	1.206	-1.207*	-0.857*	0.364*	5.007	-0.156*	0.239*	0.279	-0.326	4.2
16 Mining & Quarrying	-1.954	-2.017	-1.307*	-0.025*	0.052*	0.383*	-0.025	-0.122*	-0.085*	1.4

Table 3.7 summarises the elasticities obtained by Baxter and Rees. These elasticities were taken from the "best" equations for each industry. They can be classified according to :

1 Those with a significant index of production variable greater than one. Two of these have significant fuel price elasticities and three have significant price-wage relatives. Three of the four industries with insignificant coal consumption variables are in this group. No other significant variable exists to explain the growth in electricity consumption for each unit of output. It is argued that this indicates the importance of the capital-stock effect. In "Iron and Steel" and "Vehicles" the coal variable indicates the importance of technological change.

2 Those with a significant index of production variable less than unity; in each case the fuel price relative is significant. In "Chemicals" the elasticity of the M/Q variable is high and significant; the P/W variable proved insignificant - which suggests a labour substitution effect due to technological change. In the other industries the significance of the coal elasticity may be partly due to substitution because of relative price movements; the results do not distinguish between these two effects.

3 Those with non-significant index of production elasticities. These industries: "Shipbuilding"; "Leather and Fur"; "Clothing and Timber", had low or negative growth rates over the period. These industries also had non-significant fuel-price elasticities. In each case the coal variable is significant so improved technical efficiency may have contributed to the growth in electricity consumption of these industries. The P/W variable is significant for "Shipbuilding", and "Leather and Fur". This suggests that modernisation of plant and substitution of electricity for labour account for the growth of electricity consumption in these industries despite low output growth.

The poor results on the significance of the parameters in the consumption ratio model (model III) indicate the inappropriateness of the assumption that the elasticity of electricity consumption with respect to output is unity. The coefficients are more significant in those industries where the estimated elasticity of electricity consumption with respect to output is close to unity.

Baxter and Rees recognise that multicollinearity and positive autocorrelation are present - partly due to the inclusion of a lagged dependent variable. The effect is to reduce the t-value on some of the parameter estimates and so to reduce the apparent statistical significance of some coefficients.

The output variable was more significant in capital intensive than labour intensive industries; this is probably due to the low growth of the labour-intensive industries which gives less significant output coefficients. The coal variable was more significant in labour-intensive industries - this is probably a result of the technologies employed in these industries.

The poor significance of price variables is attributed to the demand for electricity being a derived demand. The price of fuel or labour is just one consideration when changing your method of production. The total cost of employing the alternate technology is more relevant. A strong correlation exists between the fuel price variable and time; the fuel price relative may have been acting as a simple time trend. Baxter and Rees suggest a fuel price relative which accounts for the fuels used in each industry in place of the aggregate index which they used and blamed for the low level of significance of the price coefficients. The importance of the mix of firms within each broad industrial group may lead to inaccurate output elasticities due to the weighting of the sub-industries in the index of production, with no equivalent weighting of electricity consumption. It is not clear whether marginal price is used for the analysis or just average price. If average price is used, price will be inversely related to quantity, as discussed in chapter 4.3.

Baxter and Rees conclude that "*electricity demand is highly responsive to output and fuel technology but relatively unresponsive to price*"; and that further research is needed on the derivation of an appropriate fuel price index for each industry.

3.3 BELL (1973)

Bell's study covered 1955-1970. He attempted to explain why the output elasticity of electricity consumption fell from 3.1:1 in the period 1955-1961 to 1.57:1 during 1961-1970. Three causes were examined : peaks and troughs in the economic cycle; changes in industrial structure; other economic factors based on the Baxter and Rees study above. Bell does not mention whether he uses seasonally adjusted data or not.

1 The Economic Cycle

To measure the *pressure of demand* Bell used deviations about the trend of IIP. These were calculated by regressing IIP against time thus :

$$I_t = \log \beta + \beta t + e_t$$

where I_t = IIP
t = time trend
e_t = random error

The residual is in log form and can be used as a measure of cyclic economic activity. This *pressure of demand* variable, J, gives a significant and negative coefficient in the equation below:

$$\log C_t = \text{seasonal constants} + \beta_1.\log I_t + \beta_2.\log J_t + e_t$$

where C_t = electricity sales to industry
I_t = IIP
J_t = pressure of demand variable

TABLE 3.8 - The influence of the pressure of demand variable on elasticity

Time Period	elasticity			
	Simple Equation	I_t	J_t	R^2
Early...............	2.21068	2.33834	-1.50728	0.995
Late................	1.58988	1.76299	-0.64081	0.991
Overall.............	2.05118	2.08534	-0.30815	0.972

This indicates that electricity consumption per unit of output is less in a boom than in a recession. This is consistent with economic theory, since some electricity usage, such as lighting and heating, is fixed in the short-run regardless of output and will thus be a larger proportion of total consumption when output is low. Table 3.8 compares the elasticities obtained from the simple equation relating industrial consumption to IIP and the equation modified with the pressure of demand variable.

Bell elaborated on this simple economic cycle variable with a capacity utilisation variable. This was based on an idea suggested by Pearce and Taylor (1968). Similar results to the previous analysis were obtained. A five year moving average of the elasticity was obtained in order to gain some idea of the trend. This was then to be extrapolated to give an idea of the future elasticity.

2 Industrial Structure

Changes in Structure can affect the elasticity of total electricity consumption with respect to the IIP. Bell therefore modified the industrial consumption figures to eliminate the effect of changes in industrial structure. He selected the year with the latest known output weights from the Census of Production as the base year. Each industry's percentage of the IIP for that year is calculated. These percentages are then applied to the IIP for any year to give the percentage points of the IIP accounted for by each industry in that year. The sum across industries of this adjusted index and the consumption ratio is the electricity consumption *if there had been no change in structure.* In mathematical notation this is :

TABLE 3.9 - Electricity consumption with constant industrial structure.

	1955-61	1961-1970
	Percentage	Change p.a.
Actual consumption	5.6	4.6
Actual "elasticity"	2.43	1.59
Adjusted consumption	5.6	4.5
Adjusted "elasticity"	2.43	1.56

$$M_t = \Sigma A_i.\frac{C_t}{IIP_t}$$

where M_t = Total sales to industry with unchanged industrial structure

A_i = Base year proportion of IIP of industry i

IIP_t = Index of industrial production

C_t = Industrial electricity consumption

The elasticity of electricity production with respect to output was re-estimated using the adjusted dependent variable. Table 3.9 shows the elasticity with constant industrial structure. It is evident that changes in structure had only a small effect on the declining elasticity. Bell tested the effect of private generation to see if this was causing the decline in elasticity. He estimated the simple equation using public supply sales - then using public supply sales plus private generation . The results indicate that a declining elasticity is still evident in most industries.

3 Other Effects

The effects of other economic variables was examined along similar lines to the Baxter and Rees study. These factors are technological advance, the price of labour, capital, and competing fuels. A summary of the equations used and results obtained is given in table 3.10. A lagged dependent variable was included in the equations like the Baxter and Rees study. This was subsequently dropped due to problems with multicollinearity which caused non-significance of other independent variables .

TABLE 3.10 - Regression Results

			Independent Variables							
Equation		Dependent	(N/I)	I	t	(PE/PW)	(PE/PT)	V	(V/I)	R^2
Number	Period	Variable								
1	Early	C		0.831	0.005					.995
	Late			0.881	0.003					.986
	Total			0.697	0.005					.992
2	Early	C		1.423		-1.096*				.929
	Late			1.232		-0.730ns				.976
	Total			1.406		-0.966				.978
3	Early	C		1.029			-1.096			.974
	Late			1.588			-0.224ns			.967
	Total			1.735			-0.709			.984
4	Early	(C/I)					-0.595		0.504	.948
	Late						-0.358ns		0.635	.616
	Total						-0.284		1.015	.907
5	Early	(C/I)	-1.510							.775
	Late		-0.594							.877
	Total		-1.155							.881
6	Early	(C/I)							1.000	.919
	Late								0.606	.612
	Total								1.177	.903
7	Early	C				-0.687		0.763		.991
	Late					-1.715		0.465		.946
	Total					-0.926		0.783		.985
								(V_{t-3})		
8	Early	C		0.880		-0.330		0.581		.993
	Late			0.948		-0.820		0.203		.979
	Total			0.830		-0.630		0.447		.992

Bell reasoned that direct output effects should, ā priori, equal unity and he experimented with a time trend to represent factors other than direct output effects. The results are shown in equation (1) of table 3.10. This suggests that changes in output elasticity over time is not due to changes in the direct link between output and electricity consumption; the change in elasticity is due to a combination of other factors. Bell found that relative prices were not very significant but like Baxter and Rees, blames the inadequacy of the fuel price measure for its failure to identify price effects. Equation (5) indicates that labour productivity has been leading to more efficient use of electricity. The reason for this is not clear, however, since the electricity/wages relative is not significant. Equation (6) indicates that declining elasticity is the result of capital investment. It is not clear whether this is due to more efficient plant and machinery, or whether other inputs are benefitting at the expense of electricity since the price relative is not significant. There is therefore no firm conclusion that electricity is losing out to other fuels as a result of capital investment - so it is possible that machinery is becoming more efficient. In equation (7) the coefficients of V_t and (PE/PW) fall over time. This suggests that electricity consumption in absolute terms may be growing due to capital investment which leads to substitution of electricity for labour. The new equipment is more efficient in its use of electricity, however, which gives a declining elasticity (which is still significantly above unity).

Bell concludes that the declining elasticity is not caused by structural change or cyclical influences but by capital investment where the new equipment is more efficient in the use of electricity.

3.4 LITERATURE SURVEY SUMMARY

Hankinson and Rhys argue that there are three effects to look out for: the level of production, structural change, and electricity intensity. Baxter and Rees explain the economic theory behind many models of electricity sales and make an important point - that further research is needed on the derivation of an appropriate fuel price index for each industry. This point was made in 1968, but the problem remains unresolved. An alternative explanation for the failure of the fuel price variable is the lack of adequate variation in the prices of fuels over the period studied. Bell examines the idea that changing output elasticity is the result of changes in capacity utilisation, and in investment in new technology. These are just some of the problems to confront my models in later chapters.

CHAPTER 4

DATA

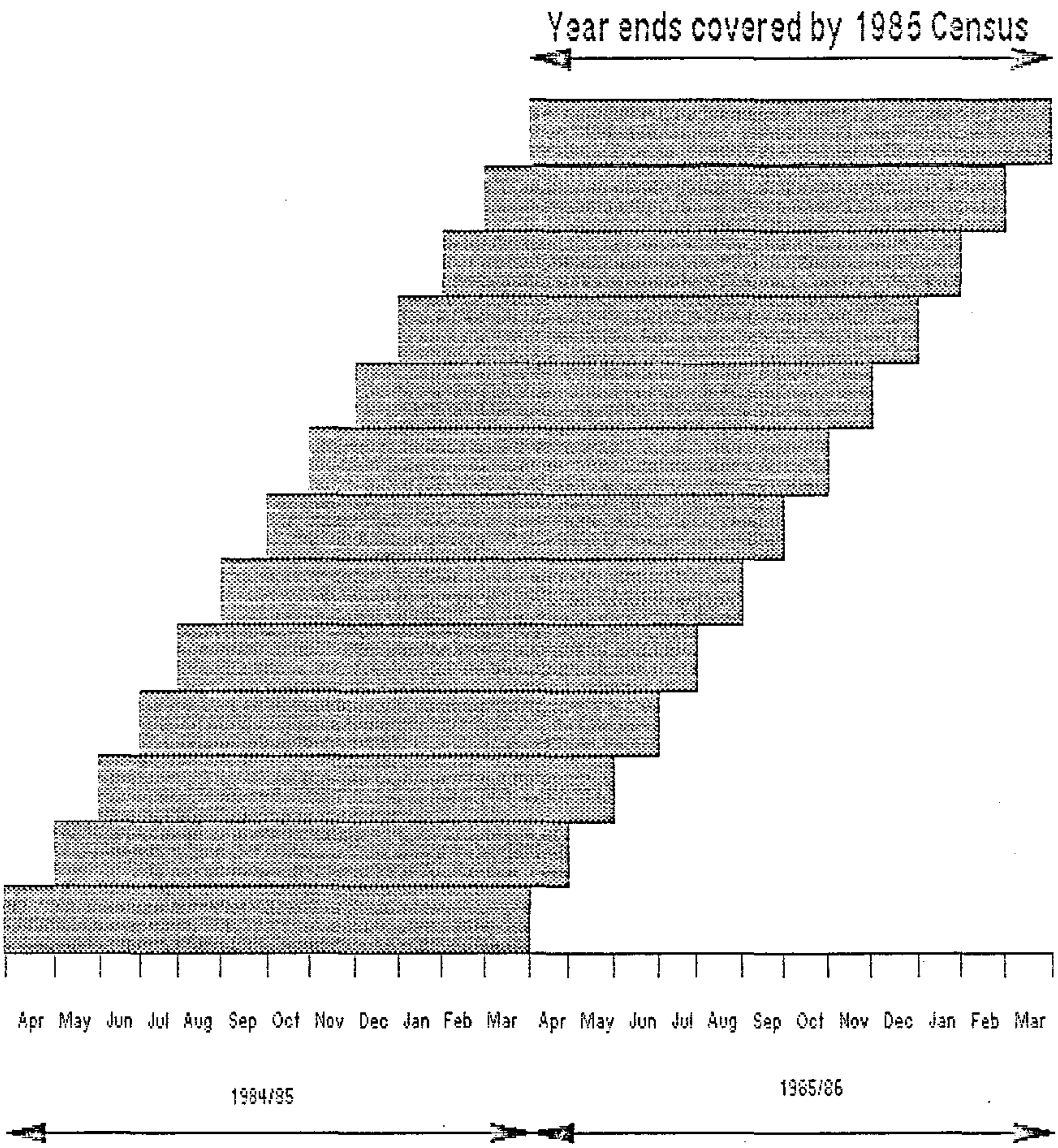
Regional data is scarce and the detail in the data is poor. This creates forecasting and econometric problems which are additional to those discussed in the national forecasting problems of the literature survey. Regional data is rarely available quarterly, except for employment statistics. The regional forecaster is frequently faced with the choice of using poor annual data and losing degrees of freedom in the econometric model, or reverting to national data which is available quarterly. This chapter outlines the nature of the data available and shows some of the problems with the data. Understanding the data is essential for complete comprehension of the estimation results.

4.1 INDUSTRIAL OUTPUT DATA

National data can be used in the models but regional data is preferable. UK IIP data may give an indication of industrial activity in the East Midlands but some serious estimation problems may result from using UK output data against EMEB industrial electricity sales (specification error - see chapter 6.3). An index of industrial output of the East Midlands is preferred for the reasons below.

1 Industrial output may be growing at a different rate in the East Midlands. This will give biased[1] parameter estimates at best. If the ratio of national to regional growth rates changes then parameter estimates will also be inconsistent[1]. Parameters estimates will also be inefficient[1], since the additional variation between National and East Midlands output is introduced. For example, output from the Continental Shelf is included in National output statistics. This has been growing during the period under study but very little of the related output growth is in the East Midlands. Output elasticity in the

FIGURE 4.1 - Period Covered by 1985 Census of Production



East Midlands would therefore be understated if national output measures are used.

2 The mix of industries in the East Midlands and the UK is changing. These industries have different output elasticities so the aggregate output elasticity will be changing over time. If this is not included in the models, then again the output parameter estimate will be biased, inconsistent, and inefficient. The composition of output in the East Midlands must be known so that this can be corrected.

Unadjusted output data is preferred to seasonally adjusted data since seasonal adjustment will inevitably smooth out some of the detail which the models are designed to examine. Seasonality can be examined within the models.

Using East Midland Industrial output data has many drawbacks. The data is derived from the Annual Census of Production. This covers each firm's annual output but it may be anywhere in a 23 month timeslot. The Business Statistics Office ask for a firm's output in their accounts for the 12 months ended in the financial year. Some firms accounts may end in April 1985 and would cover output from 1st May 1984 to 30th April 1985. Another firm's accounts may end in March 1986 and cover output from 1st April 1985 to 31st March 1986. Both sets of output would be included in the 1985 Census of Production, since both year ends occur in the financial year 1985/86. In practice, accounting years normally end in either December or March.

An illustration of the period covered by the Annual Census of Production Regional Tables is given in figure 4.1.

Even a comparison of the Census of Production data for East Midlands with the United Kingdom is fraught with difficulties. The proportion of year ends falling in a certain month is likely to be different in the East Midlands to the United Kingdom - due to a different mix of companies, having different accounting years. A comparison of the East Midlands with the United Kingdom may therefore be comparing output over different time periods.

Census of Production data gives net and gross value added in £ 000's at current values. Gross value added is the most appropriate measure of output since the net figure takes account of capital consumption. The main problem is finding a suitable deflator to adjust output at current prices to a volume index of output. What might at first seem a relatively simple problem has many pitfalls. The simplest solution is to use the deflator for the UK economy. This is inappropriate for two reasons:

1 The national IIP is a weighted average of the output of all sectors. Since the East Midlands does not have a national "mix" the implied national deflator is unsuitable.

2 Deflators for several broad industry groups are available: however, even if allowance was made for the East Midlands mix the producer price index deflator would be different for each industry in the East Midlands: prices may differ between regions; and the mix of industries within each broad category would also distort the true picture. Producer Price Indices (PPI) are unavailable regionally. Furthermore, only a few firms participate in the production of the PPI. These are mostly large firms situated in the south of the country. The prices of the output of larger firms is likely to differ from the price of smaller firms.

Attempts to construct an East Midlands IIP using Census of Production data and UK PPI's have been only moderately successful. Comparison of output in the East Midlands with the United Kingdom has been limited to informed judgement. It has not been possible to construct an East Midlands output statistic which is ideal for econometric modelling. Even if there are no problems with the Census of Production data, or with Producer Price Indices, there are additional problems. The data which is available covers the East Midlands Standard Region, not the East Midlands Electricity Board region. And there are no regional forecasts of IIP available for forecasting electricity sales. Again, judgement and some adjustment of UK IIP data for the EMEB mix of industries is the best path open for forecasting at present. The mix problem can be overcome, however, by modelling each industry within the industrial sector. This is the approach I have taken.

The Business Statistics Office at Newport can provide the Census of Production data at current cost for EMEB Trade Codes, and for the EMEB geographical area. This overcomes more of the problems. However, the cost to EMEB of obtaining this data is several thousand pounds. It is probably not worth spending this much money on data until suitable PPI's are found for the East Midlands.

Even if these problems are overcome, the data is still annual, not quarterly. I have interpolated the "annual" East Midlands IIP using quarterly UK data and deflated by a UK PPI.

4.2 EMEB SALES DATA

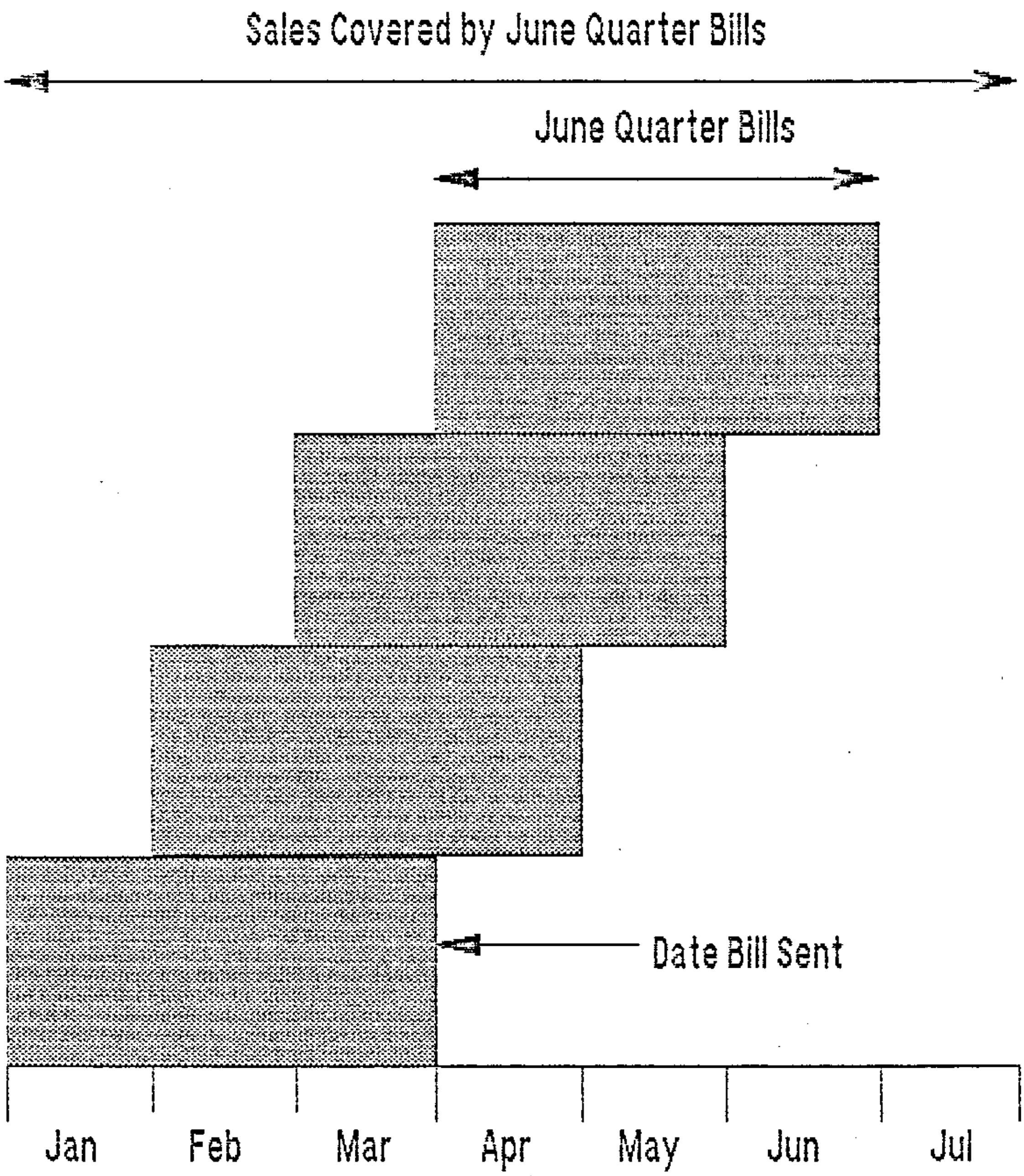
Electricity sales is the dependent variable in the models. One of the main problems of using quarterly data is to discover how much electricity was actually consumed by customers in the quarter. The correct classification of consumers into suitable groups for forecasting is also a major achievement.

4.2.1 Converting Billed Units into Units Sold.

Electricity sales are derived from the amount of energy for which customers are *billed*. Customers are normally billed either monthly or quarterly according to their tariff. Large industrial and commercial consumers are billed on monthly tariffs. There is little problem converting electricity billed into electricity sold for these customers.

The main problems arise with smaller customers who are billed on quarterly tariffs. Their meters are read once each quarter, and

FIGURE 4.2 - Units Billed and Units Sold



the bill will cover consumption in the preceding quarter. Meters are not read at exactly the end of each quarter, however; this would require too much manpower. Instead, meter reading is continuous throughout the quarter to spread the workload. The bills sent out in any one quarter may cover consumption during the previous six months. In figure 4.2 the bills sent out in the June quarter are those bills sent out from 1st April to 30th June. Bills sent out on 1st April cover consumption from 1st January to 31st March - which is actually sold entirely in the March quarter but billed in the June quarter. Approximately half the sales in the June quarter are billed in that quarter, the rest of the consumption billed relates to the March quarter. Thus quarterly billed data needs adjusting to units sold. This problem is discussed further in appendix III.

Meters may be read ahead or behind schedule. The meter reading cycle may particularly be thrown out of sequence by holidays. The ESI use a standard review period for reporting and once every six years or so this gives an extra week which is deemed to occur in December. Ideally the units billed should be "normalised" by taking account of the number of bills sent out in any period, and allowing for the natural increase in consumers. Unfortunately, the data to do this is currently unavailable.

Additionally, some bills sent out will be estimates of consumption since the Board were unable to get access to read the customers meter. The bias which this introduces is probably small, and should be consistent.

4.2.2 Classification of Consumers.

Allocating customers to classes such as domestic, commercial, combined premises, farms, and industrial may be rather arbitrary. For example, a barbers shop with a flat above it may be classified as a Combined Domestic and Commercial Premise, even if the shop is only open part-time. However, if someone works from home, they may be on a domestic tariff. The two situations are identical but the customers might be classified differently. Similarly, offices may be on an industrial site by the factory in which case they will receive their electricity from the same supply as the factory, and their consumption will be registered on an industrial tariff. Alternatively, if they are remote from the factory they will have their own supply, and their consumption will be recorded on a commercial tariff.

The classes themselves are no longer appropriate for tariffs, but are retained because they are useful for forecasting purposes.

Splitting Commercial and Industrial sales into consumption by EMEB trade code also has problems. MLH codes are allocated to each customer, but there is no detailed analysis to establish the main business of the customer. In some cases a customer is part of a larger company and make components for them. In this case EMEB will code the customer according to what is made on the premises; but government statistics will record the output of the premises under the MLH code of the main company. In the Census of Production data there is no problem with 75% of reporting units. These are single unit businesses making a narrow range of similar commodities. The remaining 25% are multi-unit businesses making a wide range of commodities at various locations throughout the country. Unfortunately, these are the main contributors to economic activity.

MLH codes are normally allocated to each supply when the supply is first installed. No check is made whether the MLH code is still relevant at any future date. If the main business of the company changes, then EMEB's classification of the industry will be incorrect. This is an extensive problem.

Disaggregating the forecast into equations by EMEB Trade Code creates massive additional difficulties. EMEB Trade Codes include MLH codes which do not match the government's industrial orders or the latest SIC codes. This will be most serious when a particular industry within the Trade Code is growing faster than others, and the SIC classifies this industry differently.

Disaggregation also creates problems when trying to determine sales by trade code. The current method of calculating the unbilled does not allow the split of sales by trade code. Units billed are available by Trade Code *or* tariff type. The mix of tariffs across Trade Codes is not known. One cannot, therefore, perform the unbilled calculation for trade codes since the mix of monthly and quarterly billed units is unknown for each trade code. Simplifying assumptions have to be made. Three assumptions can be made, any of which enables the problem to be overcome.

1 The mix of quarterly and monthly billed units is the same for all trade codes.
2 A slight improvement on the above is to assume that the proportion of customers on quarterly billed tariffs and monthly billed tariffs remains constant at today's proportion. An approximate mix of monthly and quarterly billed units can be found - but only for the current year, since EMEB only keeps customers' consumption records on the computer for one complete year. Previous data is kept on microfiche. It would be an enormous task to extract this information.
3 It is reasonable to assume that industrial units billed equal industrial sales. Only 3 % of industrial units are sold on quarterly billed tariffs. The proportion may be greater than this for some industries.

The study only considers industrial sales. Assumption 3 is therefore used. It is reasonably accurate and easiest to compute.

TABLE 4.1 - EMEB TRADE CODES

77	Water and Gas
81	Coal Mining
82	Other Mining and Quarrying
83	Bricks, Pottery, Glass, and Cement
84	Iron and Steel
85	Non-Ferrous Metals
86	Chemicals and Allied Trades
87	Shipbuilding
88	Non-Electrical Engineering
89	Electrical Engineering
90	Vehicles
91	Minor Metal Industries
92	Textiles
93	Leather
94	Clothing
95	Food, Drink, and Tobacco
96	Timber and Furniture
97	Printing, Paper, and Publishing
98	Construction
99	Other

TABLE 4.2 - 1980 SIC CODES

21	Extraction and Preparation of Metalliferous Ore
22	Metal Manufacturing
23	Extraction of Minerals not elsewhere specified
24	Manufacture of Non-Metallic Mineral Products
25	Chemicals
26	Production of Man-Made Fibres
31	Manufacture of Metal Goods Not Elsewhere Specified
32	Mechanical Engineering
33	Manufacture of Office Machinery and Data Processing Equipment
34	Electrical and Electronic Engineering
35	Manufacture of Motor Vehicles and Parts
36	Manufacture of Other Transport Equipment
37	Instrument Engineering
41/42	Food, Drink and Tobacco Manufacturing
43	Textiles
44	Manufacture of Leather and Leather Goods
45	Footwear and Clothing
46	Timber and Wooden Furniture
47	Paper, Paper Products, Printing, and Publishing
48	Processing of Rubber and Plastics
49	Other Manufacturing Industries

TABLE 4.3 - 1968 Industrial Orders

II	Mining and Quarrying
III	Food, Drink, and Tobacco
IV	Coal and Petroleum Products
V	Chemicals and Allied Industries
VI	Metal Manufacture
VII	Mechanical Engineering
VIII	Instrument Engineering
IX	Electrical Engineering
X	Shipbuilding and Marine Engineering
XI	Vehicles
XII	Metal Goods Not Elsewhere Specified
XIII	Textiles
XIV	Leather, Leather Goods, and Fur
XV	Clothing and Footwear
XVI	Bricks, Pottery, Glass, and Cement
XVII	Timber, Furniture, etc.
XVIII	Paper, Printing, and Publishing
XIX	Other Manufacturing Industries

4.3 FORECASTING CLASSES

The main problem in estimating an EM model is getting a consistent run of output data for the EM. Three different classifications of industrial customers need to be matched:

EMEB Trade Codes
1968 SIC Codes
1980 SIC Codes

This is very difficult to achieve. There are 20 EMEB industrial trade codes and 1968 SIC industrial orders. These match fairly closely but are not identical. The change in classification in 1980 created 21 broad manufacturing classifications which vary significantly from the 1968 classification, plus other industrial classes which interfere with the rationalisation of forecasting classes. The classifications for industry are shown in table 4.1, table 4.2, and table 4.3 (only manufacturing is shown for the 1980 SICs.

In this thesis the broad industry groups corresponding to EMEB Trade Codes and Industrial Orders are used. In many cases the sales and output classes cannot be made compatible. This accounts for many of the poor EM output coefficient t-statistics in the regressions. Each of these classes is made up of more detailed classifications. For example, 1968 SIC Order II, Mining and Quarrying, consists of MLH codes 101, 10201, 10202, 103, 104, 10901, 10902, 10903, and 10904. The 5 digit MLH level of classification is also used to code EMEB industrial and commercial consumers. The 1980 and 1968 SIC codes can be matched fairly closely at the detailed level of disaggregation. Unfortunately, neither EMEB sales or EM output is published in this detail. The level of detail in the tables is the level which has to be used without purchasing the detail from the BSO. Table 4.4 compares EMEB trade codes with 1968 Industrial Orders. The close match is visible but in four cases, classes have to be combined to match SIC Codes with Trade Codes. Order II contains consumers from codes 81 and 82; order VI contains codes 84

TABLE 4.4 - EMEB Trade Codes and 1968 Industrial Orders

EMEB Trade Codes (columns) / 1968 Industrial Orders (rows)

	77	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
II		■	■																	
III																■				
IV							■													
V							■													
VI					■	■														
VII									■											
VIII												■								
IX										■										
X								■												
XI											■									
XII												■								
XIII													■							
XIV														■						
XV															■					
XVI				■																
XVII																	■			
XVIII																		■		
XIX																				■
XX																			■	
XXI	■																			

FIGURE 4.6 - 1968 and 1980 SICs

1968 Industrial Orders (columns) / 1980 SICs (rows)

1980 SICs	II	III	IV+V	VI	VII	VIII+XII	IX	X	XI	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
5																	■	
11	■																	
12			■															
13	■																	
14			■															
15			■															
16																		■
17																		■
21	■																	
22			■	■														
23	■																	
24													■					
25			■															
26										■								
31				■		■												
32					■													
33							■											
34							■											
35									■									
36								■	■									
37						■												
41		■																
42		■																
43										■								
44											■							
45												■						
46														■				
47															■			
48																■		
49																■		

TABLE 4.6 - Classification Problems

	Missing Data	Minor Classification Problem	Forecasting Class
II	■		MQ
III			FT
IV + V	■		CH
VI + VIII + XII			MM + IE
VII		■	ME
IX		■	EE
X + XI			VE
XIII	■		TX
XIV	■	■	LE
XV		■	CF
XVI			GC
XVII		■	TF
XVIII			PP
XIX		■	OM
XX	■		Con
XXI	■		UT

and 85; some of trade code 86 is in order IV and some in V; and trade code 91 is split between orders VIII and XII. This reduces the number of classes from 20 to 18.

The reduced set of compatible codes for industrial orders and trade codes can then be compared to 1980 SICs. This is done in table 4.5. Again, some rationalisation of classes is necessary to maintain compatibility. Any 1980 SIC with two or more markers on its line represents a problem, in this case SICs 31, 34, and 35. Combining the orders reduces the number of classes by two, from 18 to 16. The remaining classes are shown in table 4.6.

The process does not stop there. None of the classes below SIC 21 are available in the Annual Census of Production. This eliminates a further four classes. There are now only twelve classes left from 20 which are suitable for forecasting. The Annual Census of Production Regional Tables does not necessarily give a complete set of data even at the most aggregated level used in my work. Sometimes a firm accounts for the whole, or a very large proportion of the output of one industry. An example of this is British Coal. To preserve confidentiality of the output of British Coal, the entry for Coal Mining would be omitted together with the entry for another industry. The output of the Leather industry, and Man-Made Fibres are not available because of this from 1980. This reduces the number of compatible forecasting classes further. There are minor classification errors within some of the ten remaining classes - in orders VII, IX, XV, XVII, and XIX. Only five from of the original 20 classes are matched perfectly for forecasting. These are III, VI+VIII+XII, X+XI, XVI, and XVIII. Using the names used for forecasting these are FT, MM+IE, VE, GC, and PP. Unfortunately, the Cabinet Office supplied adjusted data instead of non-adjusted data for PP (Printing and Publishing) so the results of that model could not always be used, but it is reported in my results (and is always adjusted output data).

The arguments above make bleak reading, but things are not as bad as they seem. It does make an important point though, that the main

TABLE 4.7 - Forecasting Classes

Forecasting Class		Description
✓	IE	Instrument Engineering
✓	FT	Food, Drink, and Tobacco
✗	CH	Chemicals and Allied Trades
	MM	Metal Manufacturing
	ME	Mechanical Engineering
	EE	Electrical Engineering
✓	VE	Vehicles
✗	TX	Textiles
✗	LE	Leather and Leather Goods
	CF	Clothing and Footwear
✓	GC	Bricks, Pottery, Glass, and Cement
	TF	Timber and Furniture
✓	PP	Paper, Printing, and Publishing
	OM	Other Manufacturing

✓ Denotes accurate classification

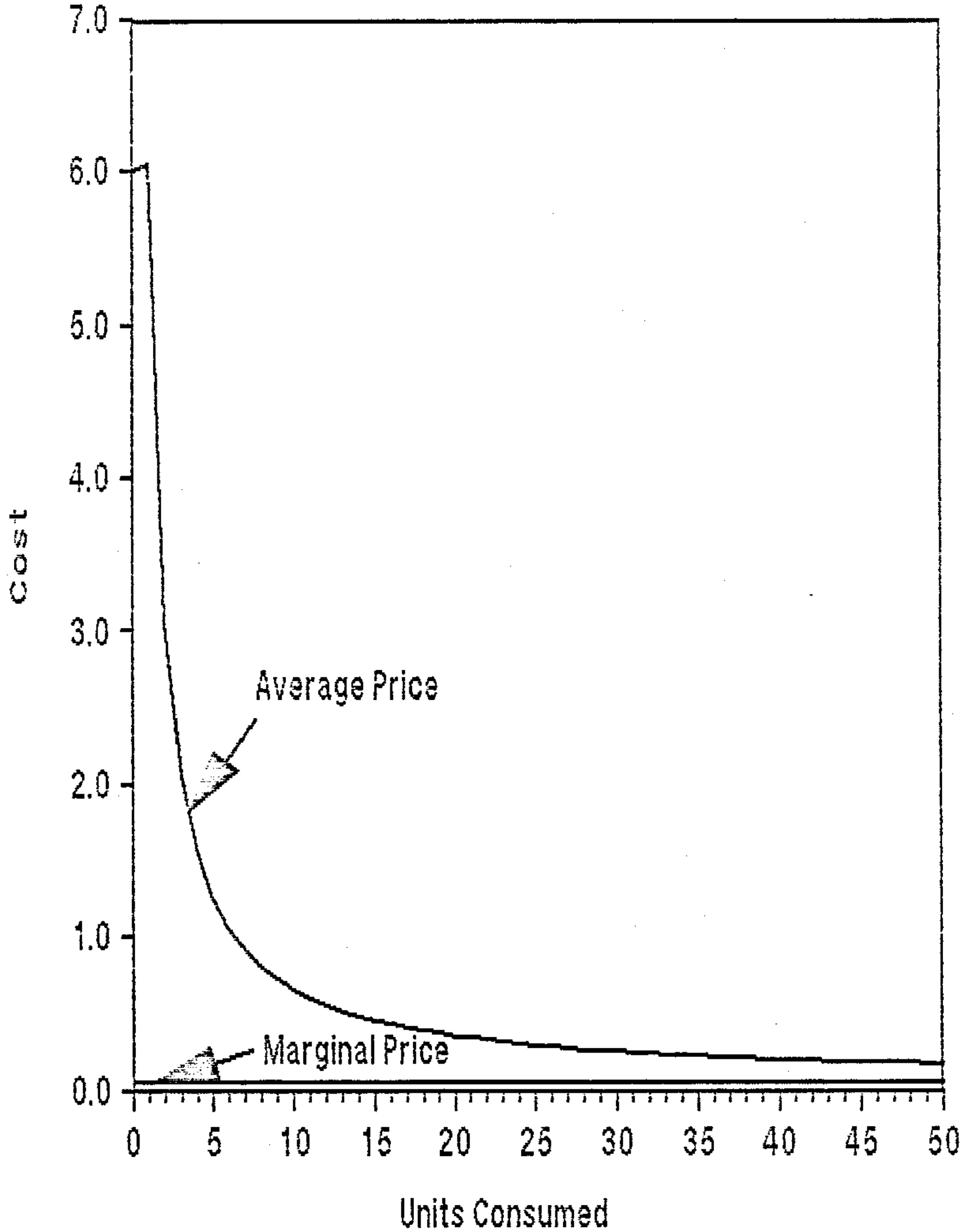
✗ Denotes poor classification or missing data problem facing the forecaster is a reliable source of data for their models. Forecasting electricity sales is not an exact science, and some approximations are allowed. Some of the minor classification errors encountered when translating 1980 SICs to 1968 SICs are probably less severe than those in EMEB's own MLH classification of consumers. It would therefore be foolish to dispense with these classes. Proxies can be used in some instances where data is missing, such as using SIC 43 as a proxy for the combined effect of SICs 43 and 26 (because SIC 26 is missing from Census of Production Summary Tables for the East Midlands). I have therefore made the best of the data available and expanded the number of forecasting classes to the maximum number I judge the data to be able to stand. In most instances I am aware of the size of any minor classification error in the output data through examining the electricity sales accounted for by the offending firms. This is possible because I can discover from EMEB computer records how much electricity is accounted for by each MLH code in the *current* year.

The final forecasting classes used are shown in table 4.7.

4.4 THE PRICE VARIABLE

The most common price variable used in previous studies is the price of electricity relative to a composite index of the price of all other fuels. The "other fuels" price index usually weights the price of gas, oil, and coal by the amount of the respective fuel used. This leads to estimation problems since the weights are a function of the price of each fuel. The prices used are normally average prices. This causes estimation problems and is theoretically incorrect. For tariffs with a standing charge, average price becomes inversely related to electricity consumed. Marginal price represents the true price paid by customers for a small increment in load, and this is probably a better variable to use. Alternatively, it can be argued that customers *perceive* average price and not marginal price.

FIGURE 4.3 - Average and Marginal Price



The above argument about standing charges is less appropriate for larger customers. Average price for them is likely to be closer to marginal price. For smaller customers, on quarterly tariffs, the fixed cost is a larger proportion of total cost. The difference between average and marginal cost will therefore be greater. This is illustrated in figure 4.3. Monthly tariffs have a maximum demand (MD) charge. This reflects the cost to the Board of the customer increasing his capacity. An increase in units generally follows from an increase in capacity. Average price therefore stays close to marginal price.

Theoretically, the electricity price variable should be the (consumption) weighted average of the marginal price paid by monthly and quarterly billed customers. A separate price index should also be constructed for each Trade Code.

There is a hiatus between the theoretical index and what is practically achievable. Data is unavailable for consumption of other fuels by EMEB Trade Code. Even producing a single index of marginal price for electricity is not possible, although EMEB set the tariff. There are as many marginal prices as there are rates in the tariff. But the marginal prices cannot be aggregated because a firm does not have a fixed load shape. Each firm will also have a different load shape.

The price index I use is not ideal, and this is true of the price indices used in all similar studies, such as Baxter and Rees. The index I used is:

$$\frac{(P^e_t/WPI)}{\left(\left(\sum_{i=1}^{n} P_{it}\cdot W_{it}\right)/\sum_{i=1}^{n} W_i\right)}$$

where P^e = price of electricity

P_i = price of other fuels

W_i = consumption of other fuels

4.5 MEASURING ECONOMIC OUTPUT.

Output of the service industries is defined as GDP minus IIP. This gives a few definitional problems. For example, output of the services includes farms, yet the index of the output of the services is used to predict commercial sales - which does not include farms. Sales to farms is evaluated independently.

It is notoriously difficult to measure the output of the service industries. Understanding and interpreting econometric estimation problems requires a thorough understanding of the data used. Streissler (1970) cites an example to show how important it is to understand the statistics used in models - a researcher in Austria showed that profits rose over time at the same rate as wages and salaries. To those familiar with the statistics this was no surprise. There was no information on profits so official statistics assumed they moved in proportion to wages and salaries!

Similar problems await the naive in the data used for load forecasting. Employment is used in the services sector as a proxy for output. Extreme care is therefore necessary when using employment as an explanatory variable in a commercial model. One could end up using two employment measures in a model! Construction of UK output measures is therefore discussed.

The OUTPUT measure of GDP is considered, but not the income or expenditure measures. GDP is the *total value of goods and services produced by residents of the United Kingdom before allowing for capital consumption, and is equivalent to GNP less net property income from abroad.*

The output measure of GDP is constructed by summing total national output of *finished* goods. Goods are summed by the price charged to the final consumer. The simplest measure of final output is to calculate the value added by each firm in the production process. Net Value Added in Manufacturing is the regional measure given in the Annual Census of Production. Value added is required to calculate VAT. This is why the statistic is available. The output of service industries is difficult to calculate since there are no physical units of production and many services such as health and education may be provided free or at a nominal charge. In such cases employment is used as a proxy for output. The dangers of this are highlighted by the present conservative administration. Improving productivity has been an important feature of their policy. The use of employment as a proxy for output implicitly assumes that productivity remains unchanged ! Changes in productivity in the services sector of the economy will inevitably cause problems in econometric models of commercial sales.

Changes in GDP between periods is measured with a *Laspeyres* (base weighted) index. Each sector of the economy is weighted according its contribution to GDP in the base year. These weights are then combined with the change of output to estimate an index of output. The index of production is estimated in a similar way.

$$\frac{\Sigma W_i \cdot \frac{Oc_i}{Ob_i}}{\Sigma W_i}$$

where Oc_i=current estimate of the net output of industry i
Ob_i=net output of industry i in the base year
W_i =weight of industry i

A problem with this method is that the weights become outdated. A typical example is the recent massive increase in production from the continental shelf. The weights assigned to continental shelf activities clearly understates output of this sector at a time when output is rising fast.

All the measurement problems above will make econometric models less precise. The problems are real but certainly do not prevent adequate models being built. They might explain why models of electricity sales in some smaller sectors perform badly. This will be particularly evident in the commercial sector. Independent models for each sector will reduce some of the inaccuracy.

4.6 CAPACITY UTILISATION.

Most businesses consume a fixed amount of electricity irrespective of output. Electricity consumption per unit of output declines as output rises, unless the plant being used to expand output is less electricity-efficient. Capacity utilisation will rise as output rises, at least in the short-run, until investment takes place to expand capacity. The capacity utilisation variable can therefore be included to allow for these effects above (although they are of opposite magnitude). The variable is derived from the Confederation of British Industry (CBI) Quarterly Trends Survey. It is the percentage of firms reporting their present level of output to be satisfactory minus the percentage reporting their present level of working to be below capacity. An example of this source of data is given in question 4 of appendix IV. The capacity utilisation variable takes valued between +100, when all firms are working below capacity, and -100, when all firms are working at a satisfactory level of capacity. In logarithmic models this is unacceptable. The value of the capacity variable must take a value between 0 and 100, so that the logarithm of the number can be determined. In logarithmic models, therefore, the capacity variable was transformed in the following way so that it took a value between 0 and 100 prior to taking logarithms.

$$C^* = (100 - C)/2$$

where C = capacity utilisation

C^* = transformed capacity variable

4.7 DEGREE DAYS

Degree days is a widely published variable which measures the heat required to keep a building at a certain internal temperature - in this case 65·F.

NOTES TO CHAPTER 4

1 These terms are explained in chapter 6.1.

CHAPTER 5

MODEL FORMULATION

The industrial electricity sales model is based on economic theory but it is *constrained by the availability of data*. The data limitations cause econometric problems when the models are estimated using Classical Linear Regression and these are covered in chapter 6.

This chapter describes a general model dictated by economic theory which would have been estimated if data were available. If sufficient degrees of freedom had been available the model would have been estimated using Hendry's *Error Correction Mechanisms*[1]. This chapter shows this was not possible and that compromises had to be made.

Electricity sales to industry depends on: industrial output; utilisation of the stock of electricity consuming capital (capacity utilisation); the price of electricity; the price of other fuels; the price of labour; the stock of electricity utilising capital; the weather; and fixed components such as electricity used for lighting, computing, staff canteens and so on.

5.1 OUTPUT

The output elasticity of electricity sales to industry is not unity. That is, electricity sales do not necessarily increase by one percent when output increases by one percent. The *average* consumption of electricity per unit of output decreases. The fixed consumption for lighting and so on is spread over more output. A constant consumption, different for each season, is followed by consumption varying with output. The form of the relationship depends whether the elasticity of output with respect to price is constant, increasing, or decreasing. Constant elasticity would imply a double log model. This is a convenient model to work with since the coefficient of output is the elasticity. If a linear relationship between sales and output exists, each successive increase in output produces a certain *number* of extra kWh's sold. This gives a declining elasticity, hence increasing returns to electricity because of the fixed consumption. The output elasticity may be a function of other factors. It may depend on the degree of capacity utilisation, for example. This sophisticated modification is used in later models.

When new firms arrive to meet an increase in demand there may be two distinct effects:

1 If the new firms arrive in an industry dominated by increasing returns there may be an increase in average consumption per incremental unit of output. This is likely because the new firms are probably too small to take advantage of the economies of scale in electricity realised by existing firms.

2 If the industry is dominated by smaller firms then the new firms are likely to attain all available economies of scale. Furthermore, the new firms will probably be more efficient since they will have new plant and machinery. This is not always true, of course. Firms may buy second hand, or the new plant may use more electricity at the expense of some other factor. Computer Numerically Controlled (CNC) machinery uses electricity in many instances to replace labour. But generally, lower consumption per unit of output is expected.

It is difficult to pre-judge the output effect which may be different for each industry.

5.2 CAPACITY UTILISATION

Utilisation of electricity consuming capital stock affects the output elasticity. When the number of firms in the industry and the capital stock is fixed there are two possible and opposite effects:

1 In times of low output, firms operate below designed optimum plant capacity. As output rises firms move towards a more efficient level of working and consumption per unit of output falls.

2 As output rises, the incremental units will be produced on the older, least efficient plant and machinery. Consumption per unit of output will therefore rise.

There are no prior expectations for the sign of the capacity coefficient. The above explanation shows intuitively that capacity utilisation is highly correlated with output.

5.3 WEATHER

Some electricity is used for space and water heating. Temperature, rainfall, illumination, and the cooling power of the wind affect space and water heating requirements. Temperature is the most significant weather variable and is the only one used. The variables are too highly correlated to use more than one. This keeps the models simpler, and does not consume unnecessary degrees of freedom. Also, the other effects are relatively small and cannot be adequately used together in quarterly data. As an example, the cooling power of the wind, often called the "chill factor", depends on temperature. The chill factor rises as temperature falls. In quarterly data, this effect cannot be built into the model. There is no way of determining whether the wind and low temperatures occurred simultaneously, or independently.

Temperature is multiplicative with output. As output rises, new plant is installed. The new plant also needs heating and hot water.

The elasticity of electricity consumption with respect to temperature varies with temperature. Temperature should probably be in quadratic form besides being multiplicative with output. Changes in the stock of electric heating equipment, such as a change in the momentum of storage heater sales, distorts relationships.

Electricity consumption may become more or less sensitive to temperature.

Temperature elasticity is also a function of price. Electricity may become more expensive and account for a larger proportion of a customer's budget. In this case the demand for electricity will become more elastic. The increase in price will make customers quicker to turn down their heating when temperature falls. Energy conservation becomes more viable and has a shorter payback period. Therefore, as price rises less electricity will be required.

5.4 SEASONALITY

This is no problem if unadjusted output data is used. Unfortunately, most published data is seasonally adjusted. The models test adjusted and unadjusted data. Surprisingly, some of the output data required for the models was not available as unadjusted data. Models were therefore estimated with seasonally adjusted data in those cases. This produces estimation problems because:

1 "De-seasonalising" data induces autocorrelation.
2 If several variables are "de-seasonalised" using different methods then the relationship between the variables could become distorted.
3 The degrees of freedom used by the "de-seasonalising" technique are unknown. This cannot subsequently be allowed for in statistical tests of significance.
4 Smoothing of the data may obscure some of the finer details in the data which is being modelled.

A constant and three seasonal dummies estimate fixed consumption such as lighting. If temperature is absent from the equation the dummies also include the seasonal heating component. When seasonally adjusted output data are used, the dummies also include the variation in sales due to seasonal output effects.

If adjusted output data are used, electricity sales should be adjusted by the same method to obtain accurate regression co-efficients. This is clearly an impractical second best solution. Obtaining non-adjusted data uses resources more efficiently. The precise nature of the CSO's seasonal adjustment is not known although they use a variation on the CENSUS X-11 technique.

5.5 PRICE

Electricity has substitutes in the production function of most firms. Therefore, the price of electricity and the price of competing fuels are important. Labour can also be a substitute for capital (hence electricity) in the production function, so the price and availability of labour may be a relevant explanatory variable. The effect of price on the amount of each factor of production used will not be instantaneous. Firms will take time to move from their current factor mix to their desired factor mix. This can be modelled in several ways.

1 The simplest and most convenient technique to use for estimation is the Koyck Transformation. This imposes a geometrically declining lag on *all* the exogenous variables. This may be inappropriate for some variables, such as temperature, where the effect is instantaneous. It may overcome some autocorrelation due to the quarterly billing problem, but will introduce autocorrelation if none was present previously. The Koyck Transformation imposes the *same* lag structure on each explanatory variable. This will not be the best method of modelling adjustment lags since the adjustment in consumption due to price effects will normally be longer than for other variables.

2 An alternative to the Koyck transformation is the use of polynomial distributed lags (PDL) on the relevant variables. This indicates the time profile of the adjustment process.

5.6 TECHNOLOGICAL CHANGE

New plant is likely to consume less energy per unit of output unless the new plant used electricity to replace other factors of production. Investment in new plant could be expected to reduce the average consumption per unit of output. Technology may advance but only investment in the new technology has an impact on electricity consumption. No measure of technological change can be easily used in an econometric study of electricity demand. This has been a problem to electricity demand forecasters for some time. There are perhaps three ways to capture the effect of technological change:

1 The amount of coal used in an industry has been used by Baxter and Rees to measure the state of technology in that industry. This is not so relevant today since very little coal is now used by most industries. Technology has changed the type of goods that is now produced. Coal may be used in the manufacture of iron and steel, but would be implausible in the manufacture of computer machinery. More goods are now *assembled* rather than produced from raw materials in the UK. Use of coal is used mainly in primary industries and is therefore in decline. Coal is therefore a better measure of the mix between assembly and primary manufacture than it is as a measure of technology. Technology has advanced so far from the time of Baxter and Rees's study that most industries no longer use substantial amounts of coal. Even the iron and steel industries are now turning to electric melting. In this industry coal is perhaps a good measure of technological change, but so is the tons of metal produced in a blast furnace compared to the amount produced in electric furnaces. This statistic is available. In other industries there is no regular data for the consumption of coal by quarter and by region. Baxter and Rees's solution was thus discounted. It should not be overlooked, however, that coal could be used by a firm to generate electricity.

2 A time trend is a token gesture for measuring changes in electricity consumption due to technological change. This implies that technological change takes place at a constant rate over time. This is a strong assumption. Even if invention occurs at a constant rate, innovation normally requires large capital sums.

3 *Innovation* leads to what I loosely term "technological change". Innovation requires capital and is therefore related to the state of the economy. It is determined by: the rate of interest; profitability; the general health of the industry; and the industry's forecast of its future. A comprehensive model of an industrial sector should ideally model these complex investment decisions, which are essential for innovation.

Technology is introduced in later models. It is a complex issue, and, like all other studies, my treatment of technology leaves room for improvement. I have attempted to use method (3), and my models are similar to those of Kouvaritakis (1983). Chapter 6.3.1 give the consequences of omitting a relevant explanatory variable.

5.7 GENERAL MODEL

The ideas discussed above imply the following general model. Seasonal dummies and dynamics are excluded. The model is in logarithm to allow for multiplicative relationships. It does not include any labour, technology, or price of capital variables. It is not sufficient to throw all relevant variables and lags into an equation and expect it to perform satisfactorily.

In a model of electricity sales, some coefficients are actually functions of others. For example, price elasticity, β_4, may itself be a function of temperature. As it gets colder, peoples preferences may shift from saving money to keeping warm. Betancourt (1981) uses a similar technique of varying elasticities. This feature has been included in the following model.

5 MODEL FORMULATION

$S = A.Q^{\beta 1}.C^{\beta 2}.C2^{\beta 3}.P^{\beta 4}.D^{\beta 5}.D2^{\beta 6}.T^{\beta 7}$ (1)

where S = electricity sales
Q = industrial output
C = capacity utilisation
P = composite price variable
D = degree days
T = a time trend

and $\beta_1 = \beta_{11} + \beta_{12}Q + \beta_{13}C + \beta_{14}C^2$
$\beta_4 = \beta_{15} + \beta_{16}T$
$\beta_5 = \beta_{17} + \beta_{18}P + \beta_{19}T$
$\beta_6 = \beta_{20} + \beta_{21}P + \beta_{22}T$
$\beta_7 = \beta_{23} + \beta_{24}P$

Substituting the above into equation (1) gives :
(Small letters denote natural logarithms)

$$s = \beta_0 + \beta_{11}q + \beta_{12}Qq + \beta_{13}Cq + \beta_{14}C^2q + \beta_2 c + \beta_3 c^2 + \beta_{15}p + \beta_{16}Tp + \beta_{17}d + \beta_{18}Pd + \beta_{19}Td + \beta_{20}d^2 + \beta_{21}Pd^2 + \beta_{22}Td^2 + \beta_{23}t + \beta_{24}Pt + \beta_8 S1 + \beta_9 S2 + \beta_{10}S4$$

The above General Static Model is too complex. A well defined dynamic model based on the above is impossible to estimate. In the static version there are 20 parameters to be estimated from only 40 observations. Multicollinearity is certainly a problem. This equation gives high R^2 but poor t-values. A simpler dynamic linear model is estimated later and its problems discussed in depth.

The general model, above, overstates the degrees of freedom available. Remember that some degrees of freedom are used by seasonal adjustment!

Some of the features of the general model are gradually introduced into a Simple Linear Static Model in the following chapters.

NOTES TO CHAPTER 5

1 A useful introduction to Hendry's *Error Correction Mechanisms* is provided in Thomas (1985).

CHAPTER 6

ESTIMATION TECHNIQUE

This chapter outlines the technique of OLS, and discusses some of the qualities required of econometric models. Econometric problems are illustrated on the static linear model:

$$S = \beta_0 + \beta_1 D1 + \beta_2 D2 + \beta_3 D3 + \beta_4 Q + \beta_5 P + \beta_6 D + \beta_7 C + u \quad (1)$$

where S = electricity sales
D1..D3 = seasonal dummies
Q = industrial output
P = price
D = temperature
C = capacity utilisation
u = error term

Many models were estimated during the thesis but only the most important models and results are presented. Different models require different techniques. The data determines the estimation technique in some cases. One of the main aims of this study has been to keep the equations as simple as possible within the constraints of economic theory. I also tried to use estimation techniques which are simple and easy to interpret.

Ordinary Least Squares (OLS) and related techniques are used to estimate all the models presented in this thesis. I do not suggest that these techniques are superior to others. Some would argue that Box-Jenkins is a better way to estimate the models, as it sidesteps some of the problems OLS encounters. I have chosen to examine industrial electricity sales using standard econometric techniques because: they are most widely used and understood; and as such are more likely to be of help to others following in my footsteps. Time-series models, such as Box-Jenkins, have many virtues. One of them is the ability to deal with the lack of adequate information which plagues electricity sales forecasting models. I use time-series models when the classical OLS assumptions are violated beyond adaptation to OLS, when data are unavailable on independent variables, or when time series techniques provide better estimates. Time-series models are most helpful for short-term forecasting. The models considered in this thesis are aimed more at the medium to long term.

Before examining the models in later chapters it is worth reviewing the classical assumptions.

6.1 THE CLASSICAL ASSUMPTIONS

No assumptions are needed to produce estimates of the parameter coefficients. Without examining the properties of the error term, however, the reliability of the coefficients is unknown.

Econometric models take the form:

$$y = \beta X + u$$

where y = vector of observations on the dependent variable
X = matrix of observations on independent variables
u = vector of error terms.

The most desirable properties of econometric models in the above form are known as the classical assumptions[1]. These are:

1 The dependent variable is a linear function of the independent variables plus a disturbance term.

2 $E(u_t)=0$ for all t.
The mean value of the error term is zero.

3a $Var(u_t)=E(u_t^2)=\sigma_u^2$ constant, for all t.

3b $Cov(u_t,u^s)=E(u_t u_s)=0$, for all t,s.

FIGURE 6.1 - Properties of Estimators

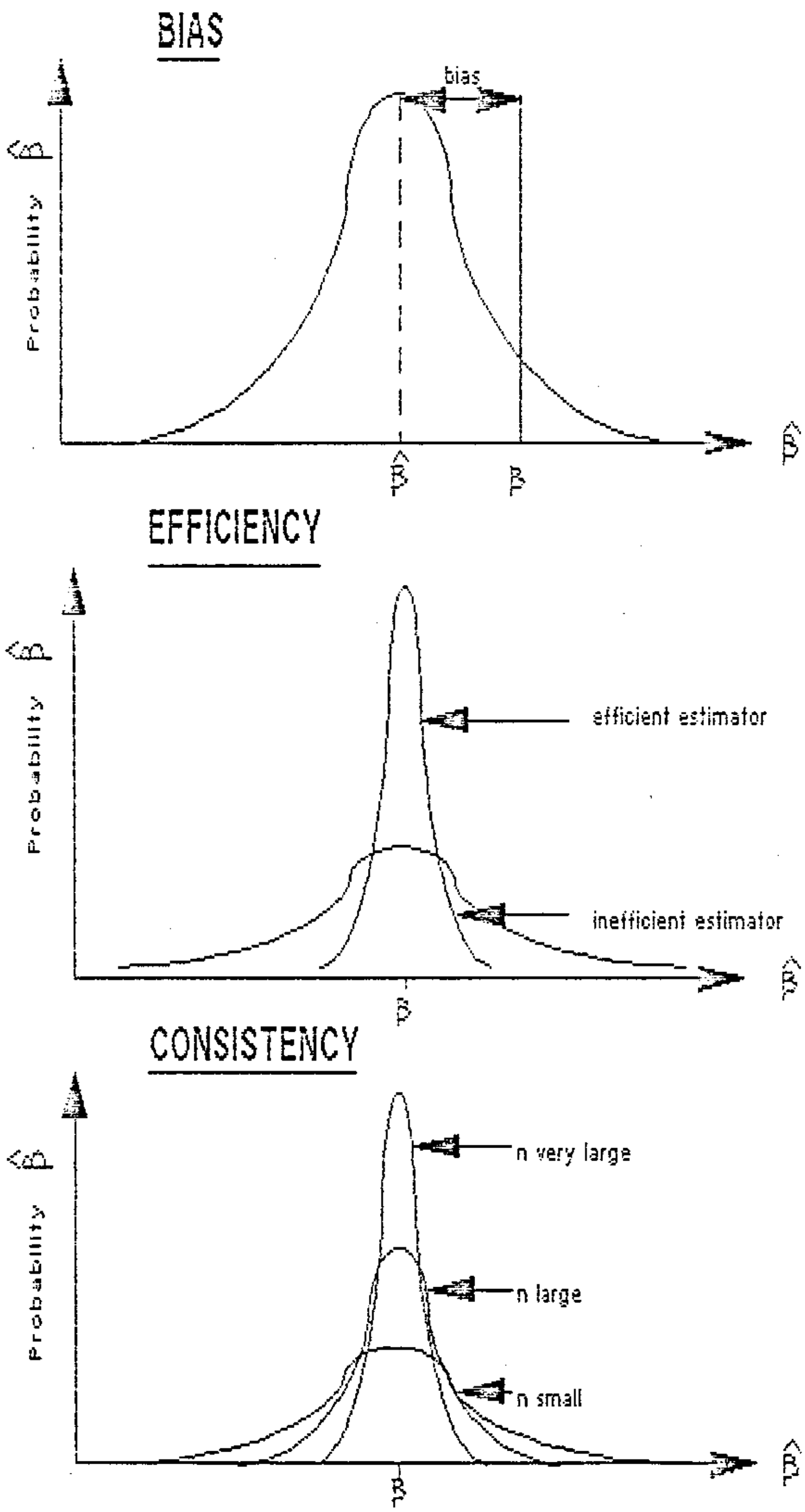


FIGURE 6.2 - The Classical Assumptions

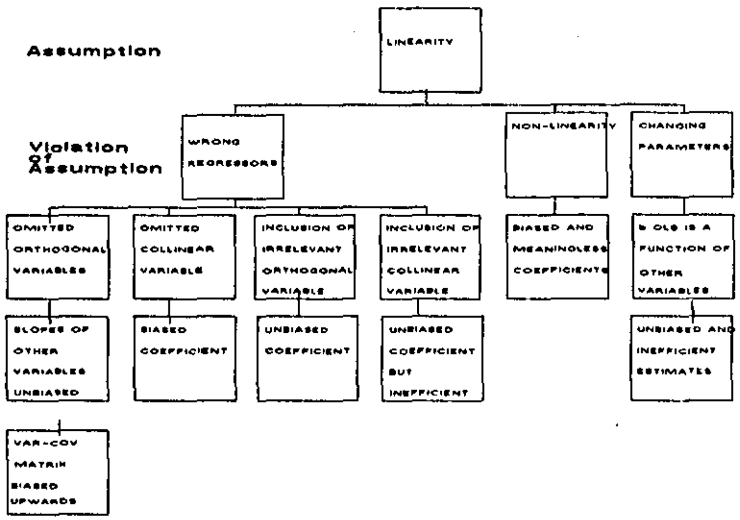


FIGURE 6.2 cont

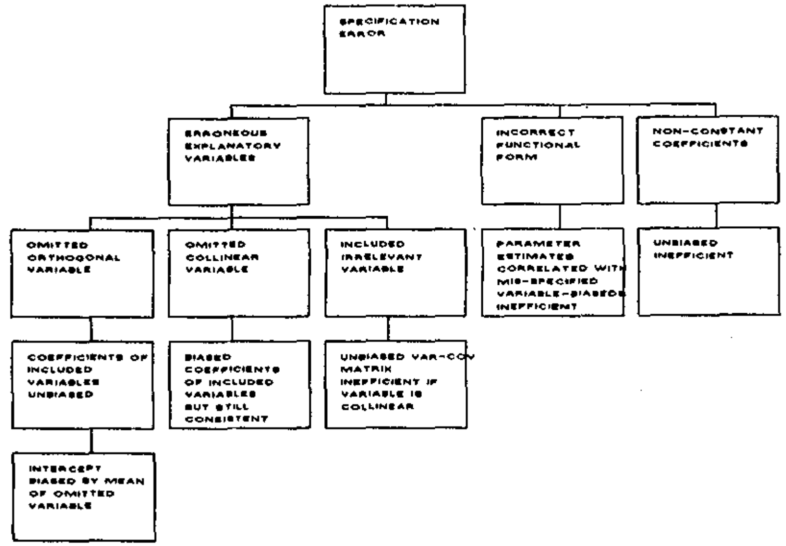


FIGURE 6.2 cont

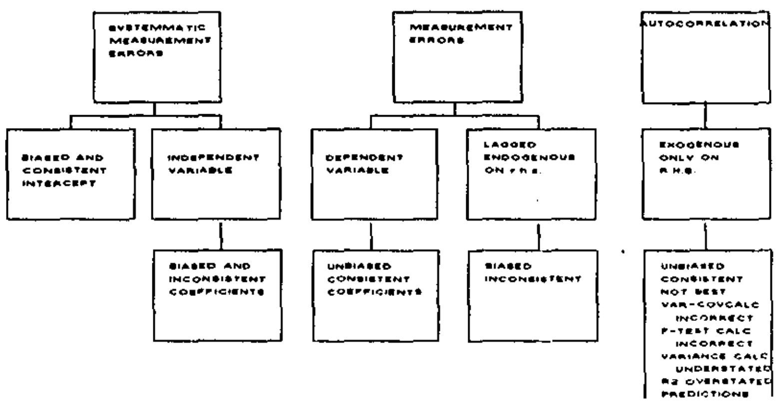
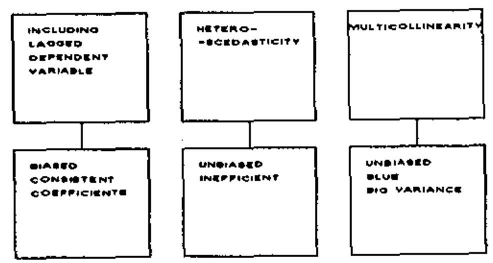


FIGURE 6.2 cont



4 $E(u_t X_s) = X_s E(u_t) = 0$ for all t,s.

The independent variable is fixed in repeated samples. Using a lagged value of the dependent variable as an independent variable will cause this assumption to break down since the dependent variable is determined in part by previous errors (see assumption 1).

5 There must be more observations than independent variables and the independent variables should be uncorrelated with each other.

Three other terms are used to describe the properties of estimators. The true value of the estimator in the following is denoted by β, and the OLS estimator by $\hat{\beta}$.

1 Bias

Figure 6.1 shows the sampling distribution of $\hat{\beta}$, which is a biased estimator of β. The size of the bias is $\beta - \hat{\beta}$. If $E(\hat{\beta}) = \beta$ then $\hat{\beta}$ is an unbiased estimator of β.

2 Efficiency

Under the classical assumptions:

$$\operatorname{var}(\hat{\beta}) = E(\hat{\beta}-\beta)^2 = \frac{\sigma_{\hat{u}}^2}{\sum_{t=1}^{n} (X_t - \bar{X})^2}$$

The OLS variance has the smallest variance of all linear unbiased estimators. If assumption 3 or 3a break down then:

$$\operatorname{var}(\hat{\beta}) \neq \frac{\sigma_{\hat{u}}^2}{\sum_{t=1}^{n} (X_t - \bar{X})^2}$$

and the variance becomes larger (i.e. $\hat{\beta}$ is no longer the *best* estimator). Efficiency though, is a relative concept, and the best estimator to use is the one with the smallest variance. The difference between a relatively efficient estimator and an inefficient one is shown in figure 6.1. The OLS estimator is often referred to as being BLUE, that is, the best linear unbiased estimator of β.

3 Consistency

This is an asymptotic property of $\hat{\beta}$, that is, a large sample property. $\hat{\beta}$ is consistent if the sampling distribution of $\hat{\beta}$ converges around $\hat{\beta}$ as the sample size increases, as shown in figure 6.1. That is plim $\hat{\beta}=\beta$.

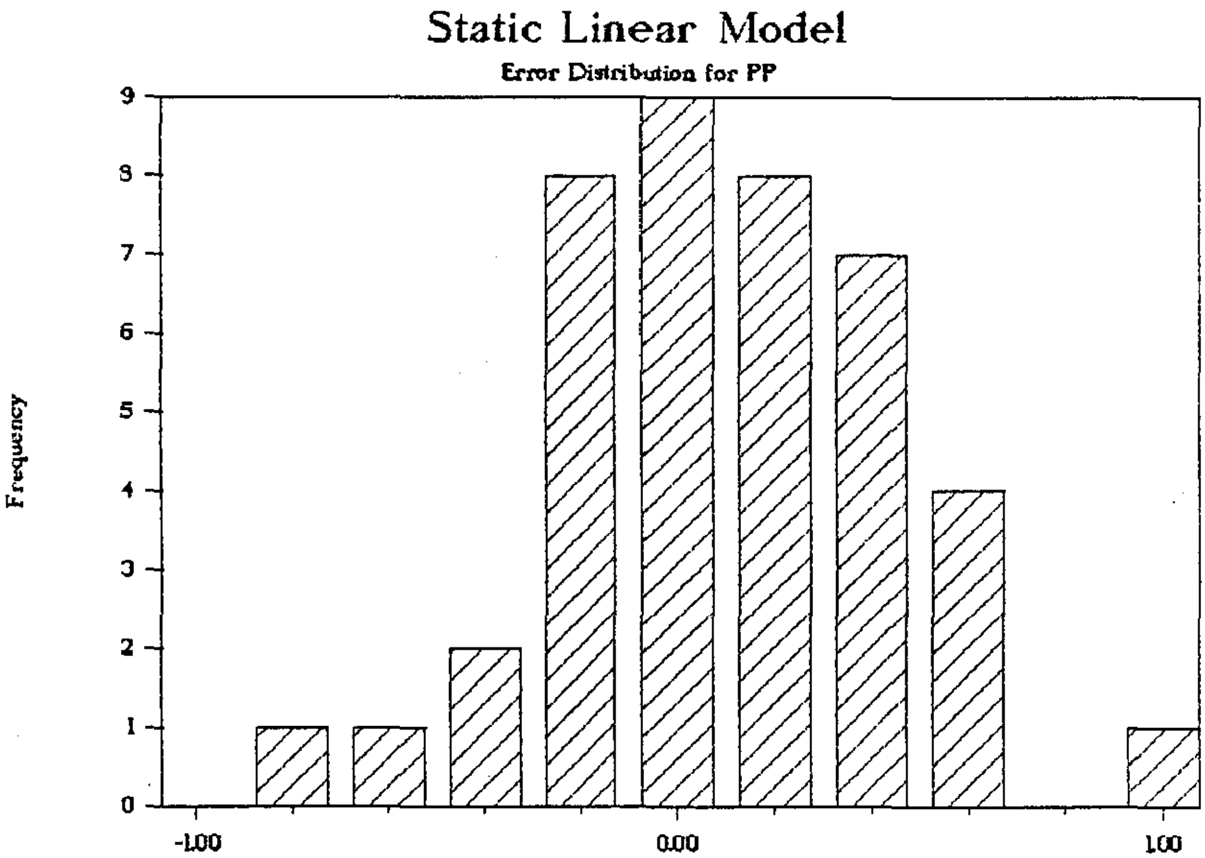
A sufficient condition for consistency is that both bias and variance tend toward zero as the sample size tends to infinity. That is lim $E(\hat{\beta}) = \beta$ and lim $var(\hat{\beta}) = 0$

When the model fulfils the classical assumptions OLS is the best technique to use. It will have the highest R^2; parameter estimates will be unbiased; and it will have the minimum variance of all linear unbiased estimators. As the sample size is increased, the variance-covariance matrix of b tends toward zero. The OLS estimate of b is therefore also consistent. Furthermore, if the errors are normally distributed the OLS parameter estimate is the best amongst all unbiased estimators, and it is asymptotically efficient.

The models are tested to see if they conform to the classical assumptions. Where possible they are transformed to give the desired properties of models suitable for estimation by OLS. Alternative estimators are not calculated when regression fails to give the best estimators. That is beyond the scope of the current exercise.

Figure 6.2 shows the classical assumptions and the consequences of their violation. These classical assumptions are often violated by simple models. These violations and their effect on parameter

FIGURE 6.3


Static Linear Model
Error Distribution for PP
Frequency
9
8
7
6
5
4
3
2
1
0
-1.00
0.00
1.00

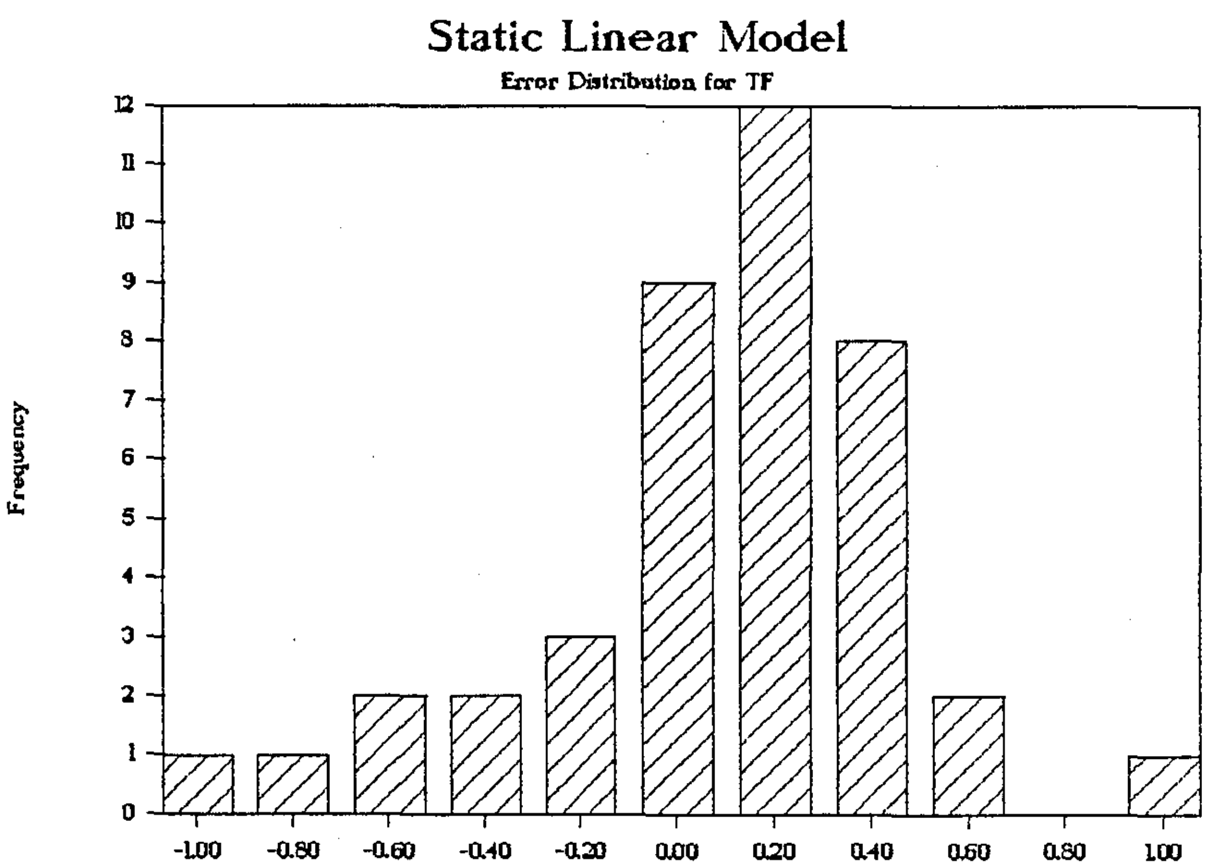
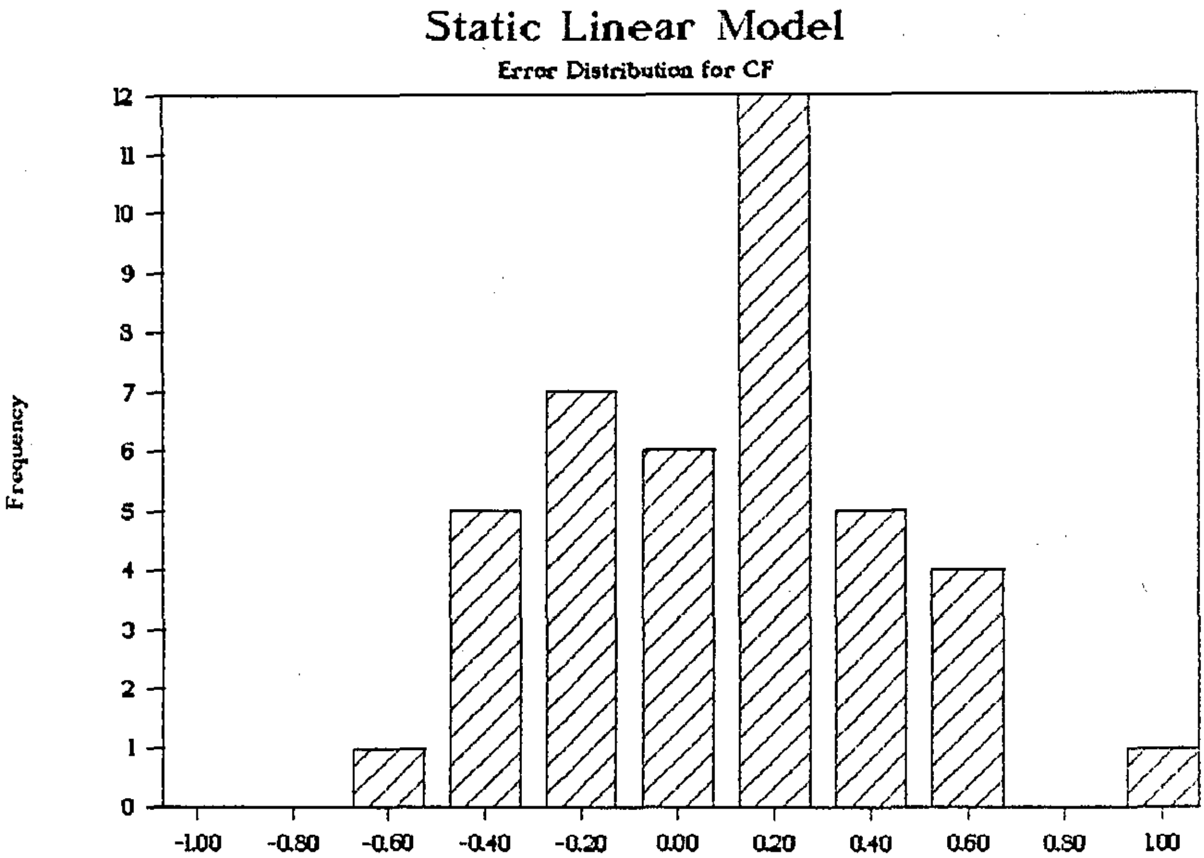

Static Linear Model
Error Distribution for TF
Frequency
12
11
10
9
8
7
6
5
4
3
2
1
0
-1.00
-0.80
-0.60
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
1.00

FIGURE 6.3 cont.



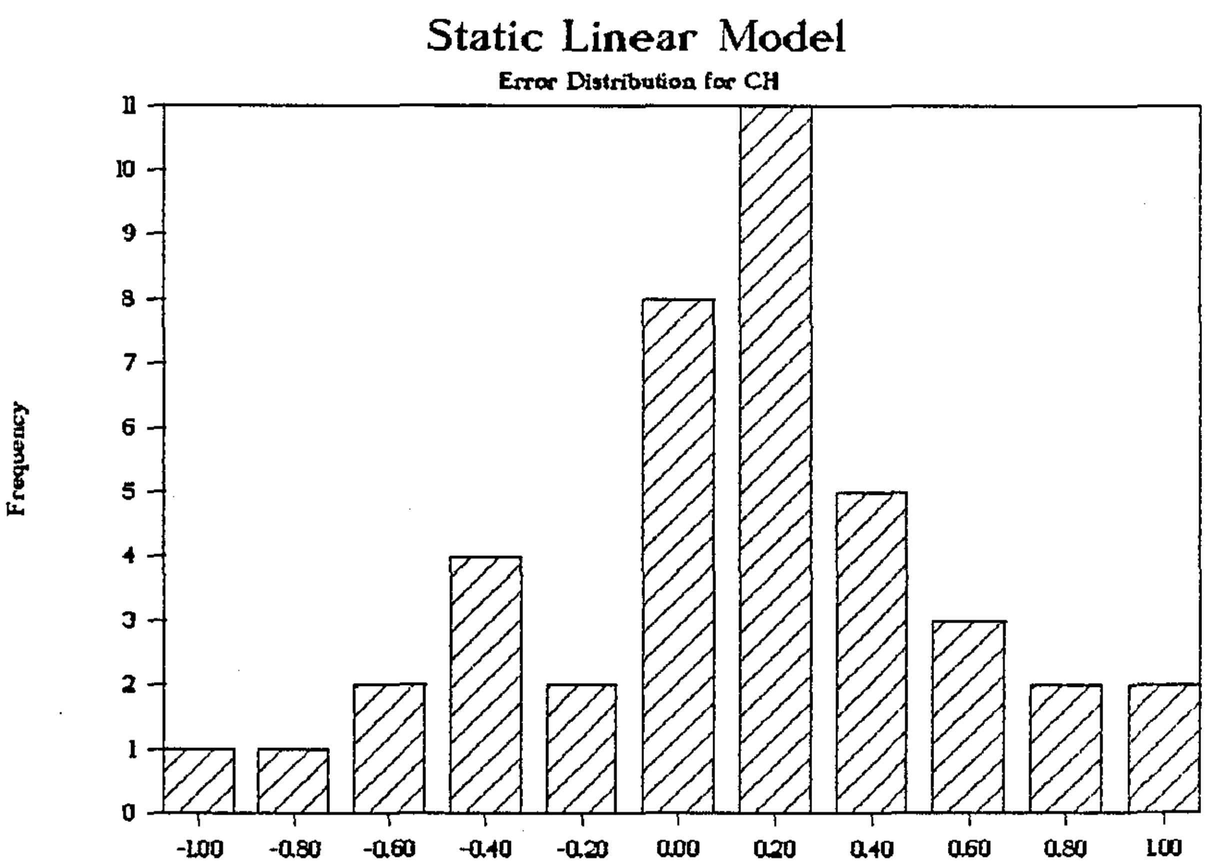
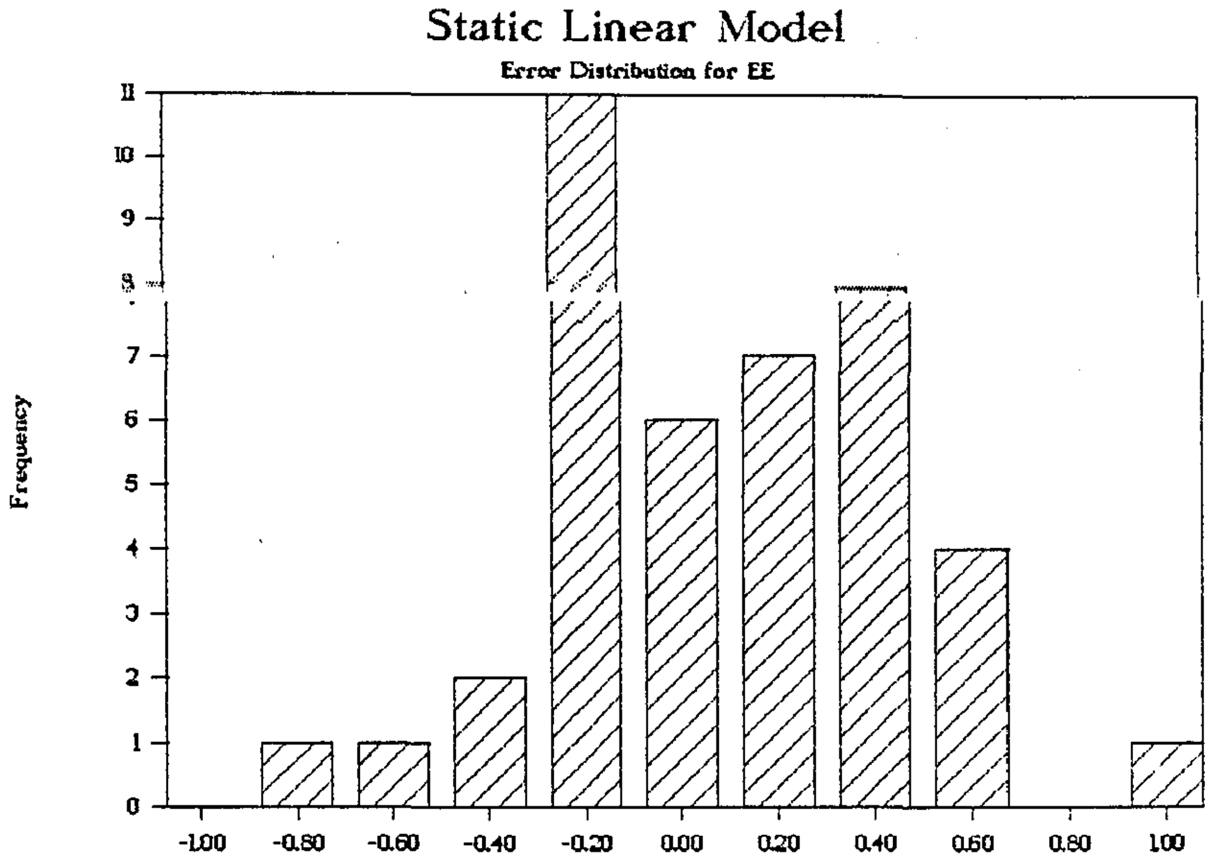
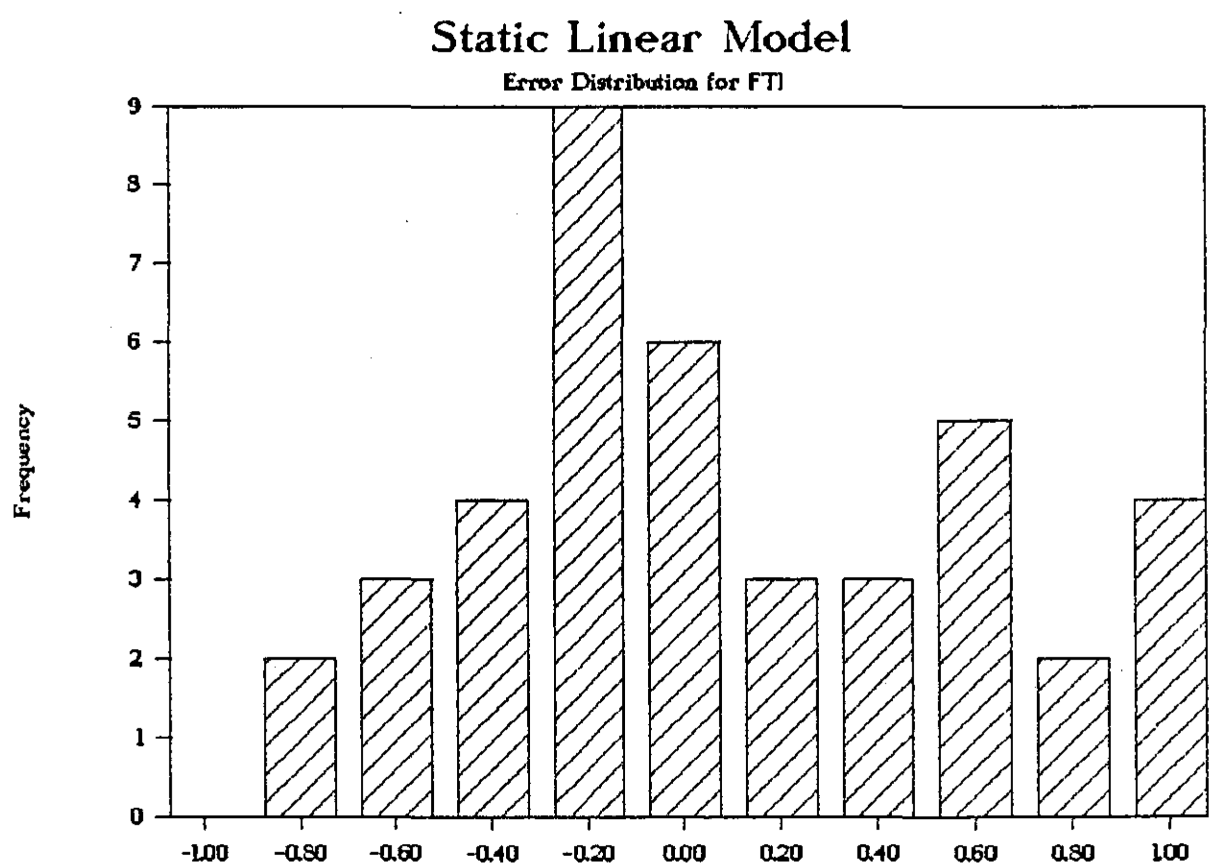


FIGURE 6.3 cont.





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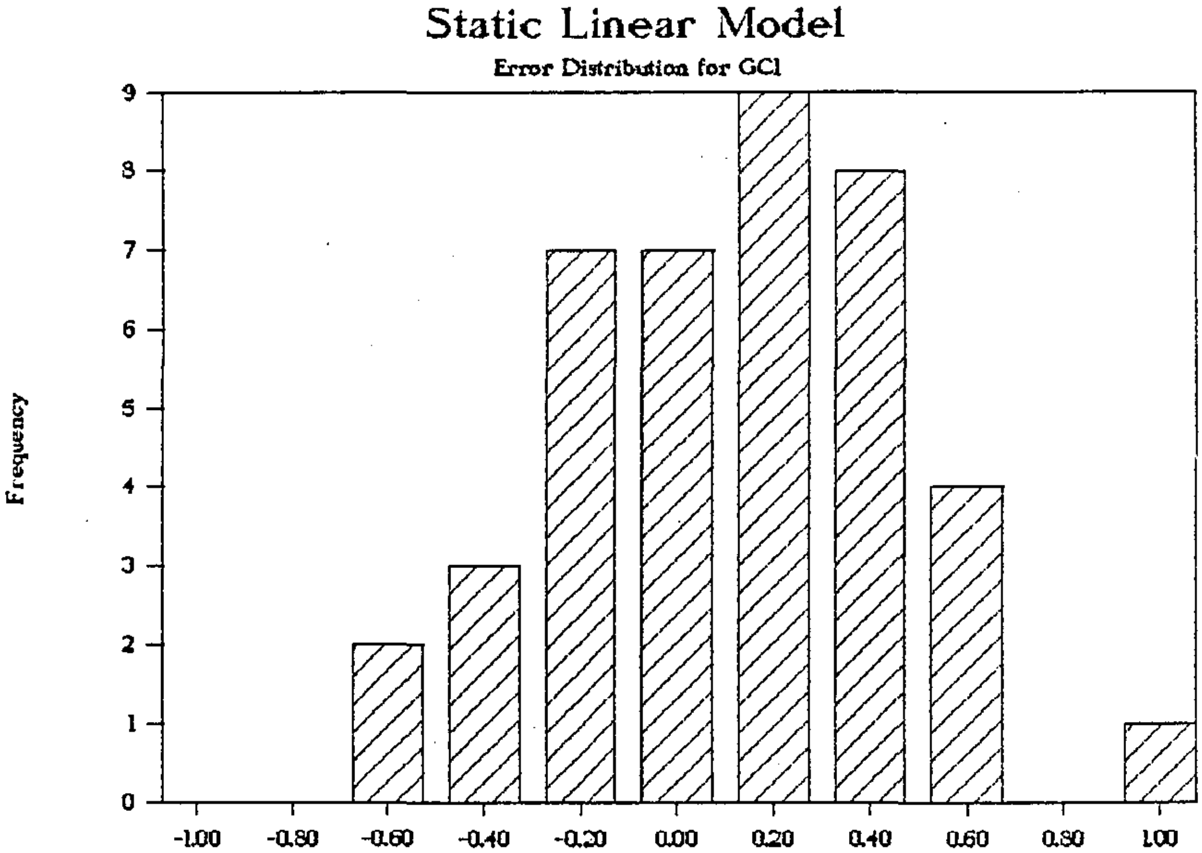


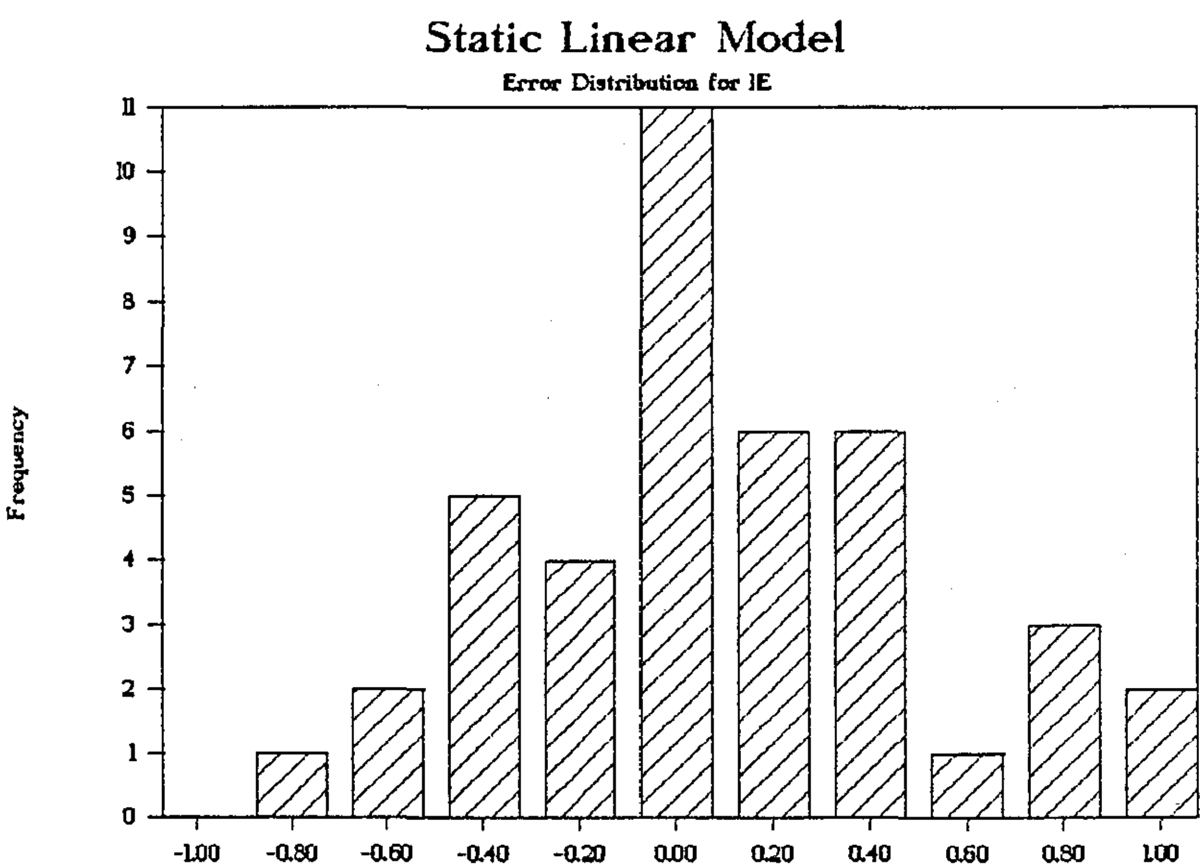
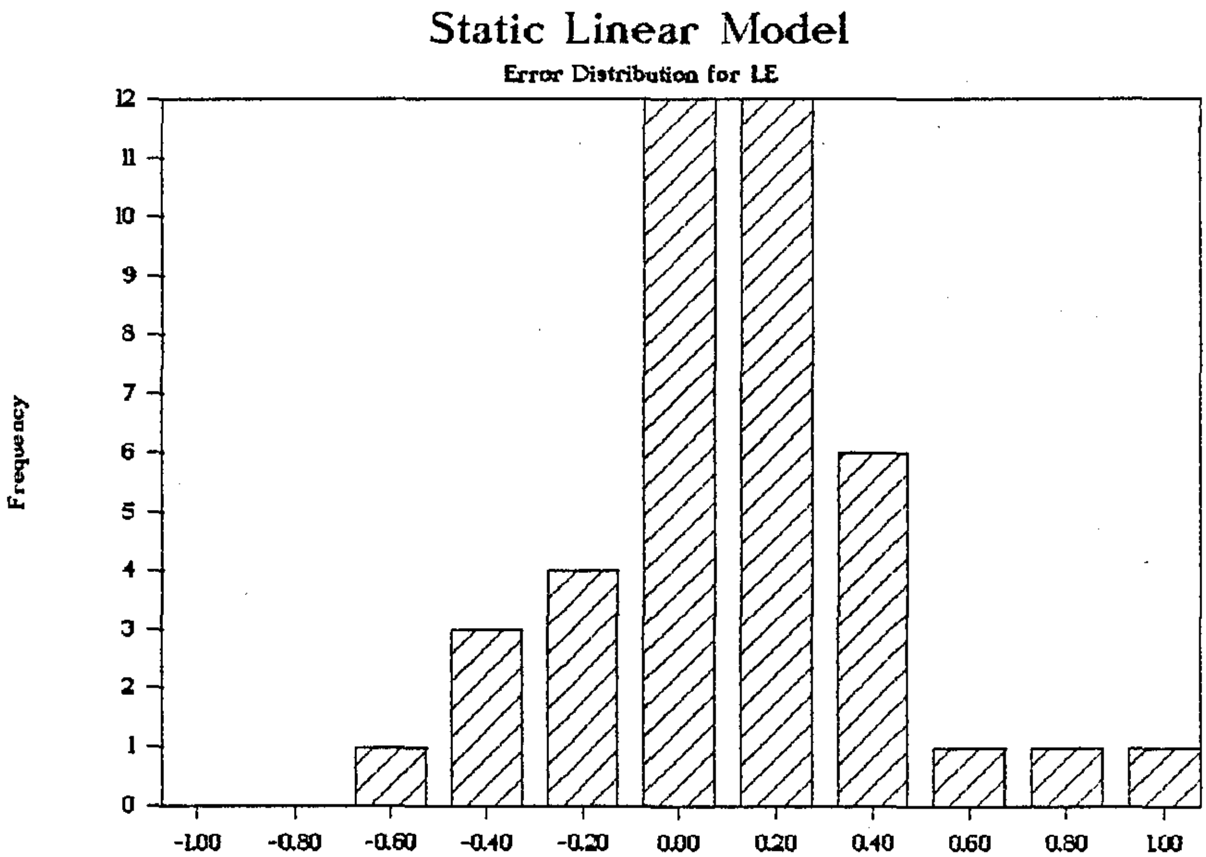


FIGURE 6.3 cont.



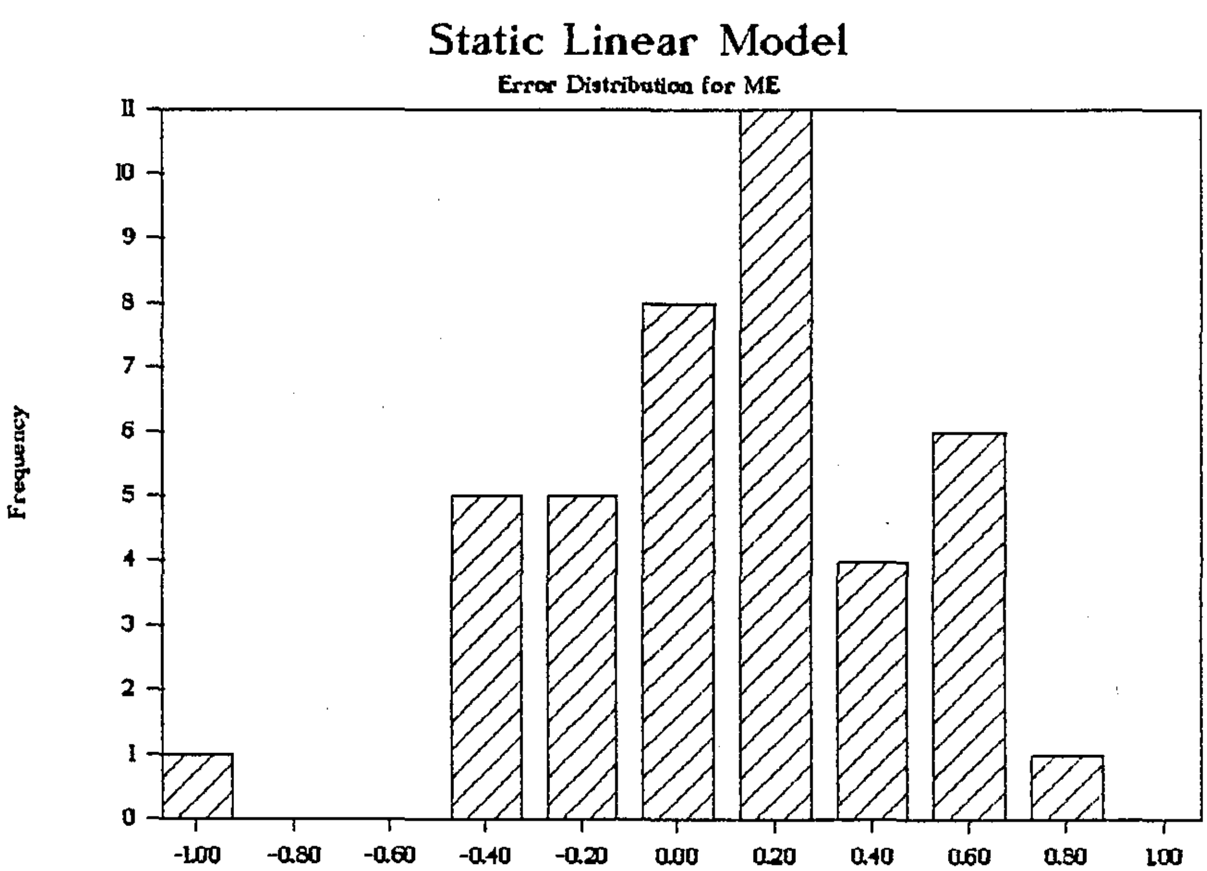
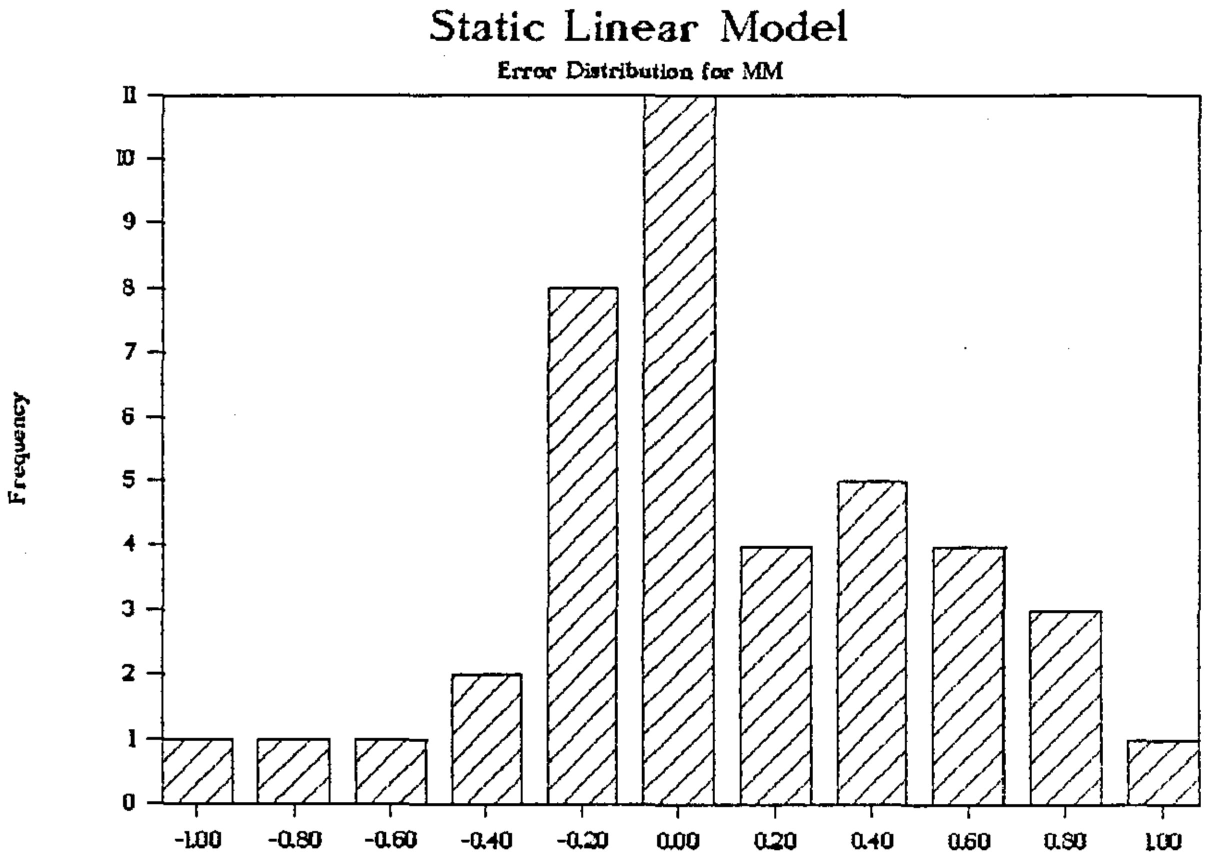


FIGURE 6.3 cont



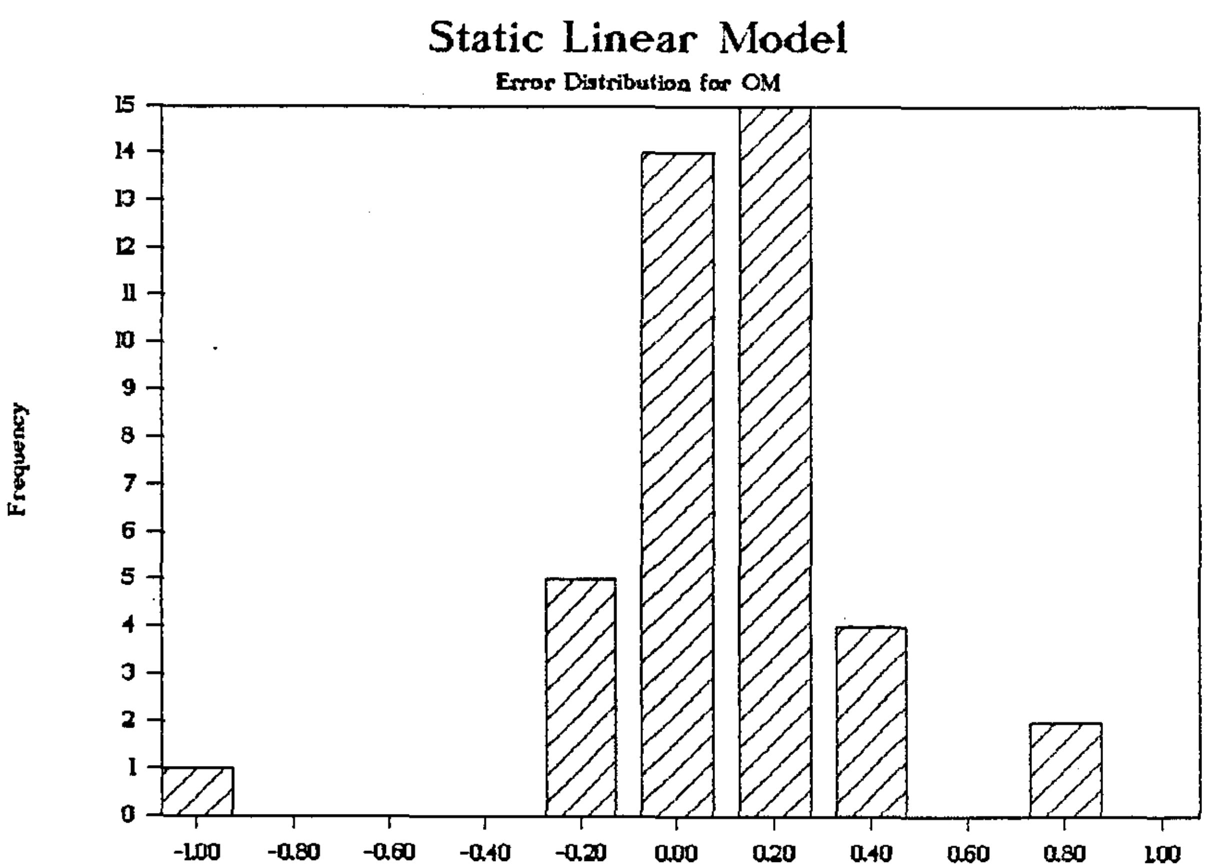
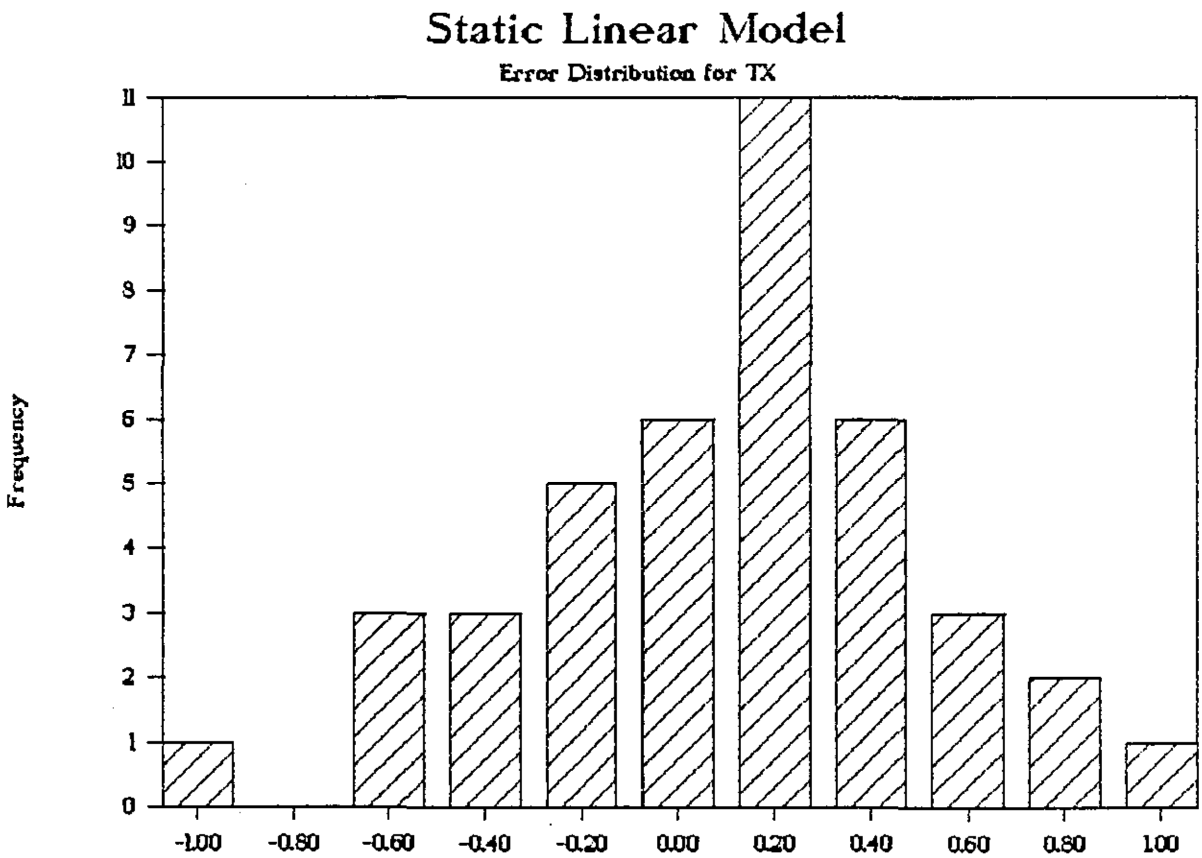


FIGURE 6.3 cont



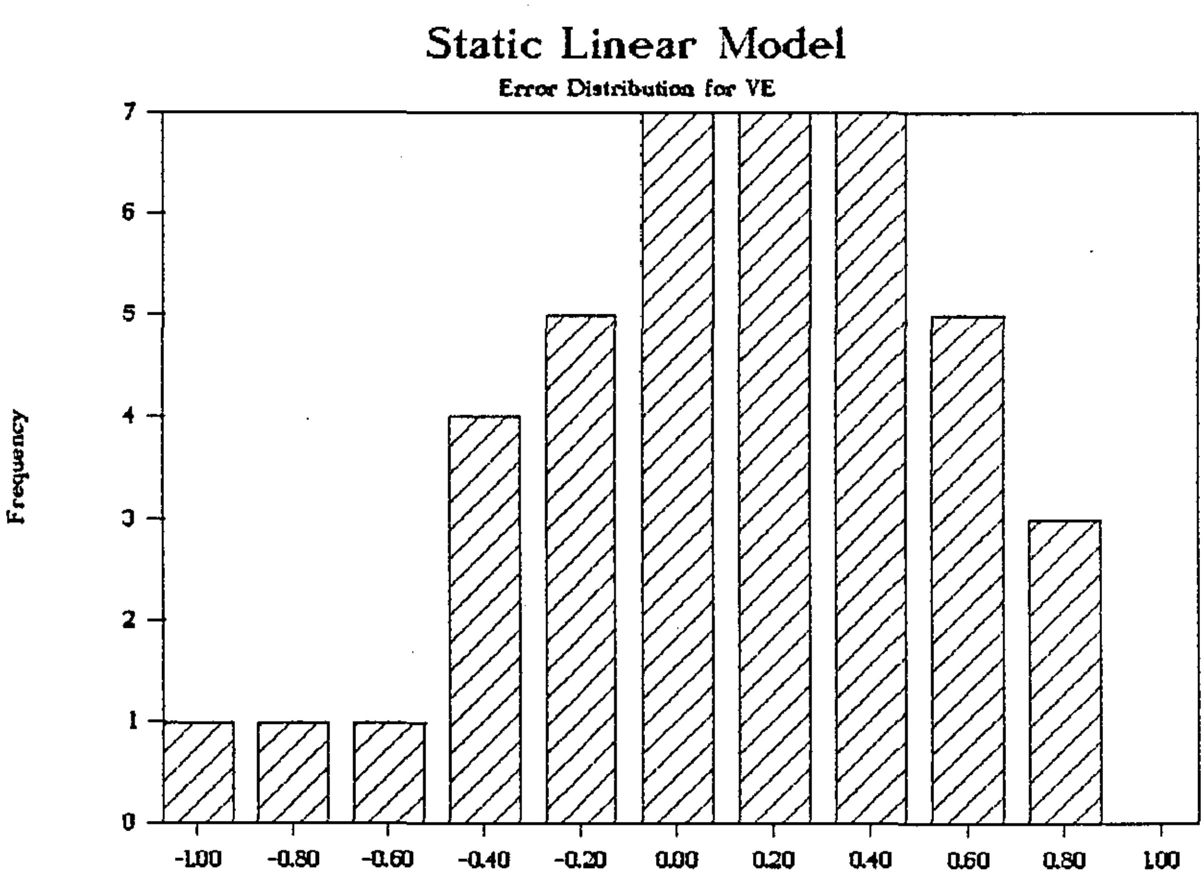


TABLE 6.1 - Static Linear Model Estimated by OLS

	C	S1	S2	S4	Output	Price	Temp	Capacity	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	63124	-2298	-1182	-2632	-25	-6571	12	-58	0.927	2077	1.73	1.092	2.720	16.290
	7.98	-0.53	-0.65	-0.83	-0.28	-11.47	2.54	-3.21						
GC	112360	-8660	-774	-7279	732	-17574	26	-25	0.841	4895	1.60	1.487	7.975	22.822
	6.73	-0.85	-0.18	-0.97	3.34	-7.01	2.29	-0.48						
CH	-7759	-32871	-14821	-31939	445	22763	53	-98	0.777	10116	0.96	11.031	15.790	17.504
	-0.20	-1.57	-1.70	-2.09	1.41	9.67	2.29	-1.12						
ME	25818	5422	1405	774	1226	-14056	44	8	0.916	6492	1.29	5.109	10.285	23.800
	1.55	0.40	0.25	0.08	4.35	-3.11	2.93	0.09						
EE	57669	2019	440	-272	325	-9347	20	26	0.958	2797	1.55	2.076	5.565	22.428
	5.74	0.35	0.18	-0.06	4.26	-12.77	3.08	0.96						
VE	-81269	15786	9081	8380	2112	3540	46	-78	0.836	13125	1.71	1.649	5.414	16.770
	-1.90	0.59	0.80	0.43	3.56	0.69	1.53	-1.12						
FT	1159	-26835	-15754	-25313	2203	-15073	32	-39	0.874	7633	1.36	3.793	20.988	27.815
	0.01	-1.68	-2.34	-2.17	2.79	-4.34	1.78	-0.61						
LE	786	1066	577	628	21	499	1	0	0.880	388	1.49	2.308	11.233	17.855
	0.70	1.31	1.68	1.05	1.37	3.37	1.42	-0.14						
CF	-1231	2232	1716	652	107	1347	7	2	0.944	994	1.90	0.079	2.425	2.506
	-0.51	1.07	1.99	0.43	3.25	3.75	3.21	0.31						
TF	13420	2446	1202	1228	103	-2700	4	-11	0.940	865	2.00	0.322	14.705	15.732
	8.47	1.36	1.60	0.93	5.15	-10.76	2.13	-2.52						
OM	183336	-21187	-10927	-21457	1037	-33187	77	-77	0.843	14204	1.20	10.374	14.738	22.503
	7.05	-0.72	-0.88	-0.99	3.15	-8.05	2.31	-1.07						
MM	-169574	-51718	-6240	-32069	2709	15585	113	233	0.934	15802	1.35	6.167	15.935	23.769
	-6.19	-1.52	-0.44	-1.29	7.64	2.36	3.02	1.70						
IE	49965	-11368	-4073	-10968	263	-6086	33	118	0.817	5211	0.68	20.404	23.685	32.273
	1.93	-1.06	-0.90	-1.40	1.66	-3.01	2.74	1.45						
GC	102163	-11288	-2066	-9406	858	-18849	29	11	0.840	4903	1.64	1.413	7.155	23.903
	6.86	-1.00	-0.44	-1.12	4.28	-8.05	2.28	0.35						
MM	-86845	-38246	323	-26886	1726	29514	102	-287	0.934	15852	1.25	7.063	15.586	24.090
	-2.35	-1.17	0.02	-1.11	3.08	3.18	2.80	-1.63						

TABLE 6.2 - Correlation Matrices for Static Linear Model

C O R R E L A T I O N M A T R I C E S

	IES	S1	S2	S4	IE	PR	QDD	IEC
IES	1.000	0.509	-0.110	0.053	0.111	-0.655	0.629	0.213
S1	0.509	1.000	-0.344	-0.344	0.035	-0.061	0.736	-0.053
S2	-0.110	-0.344	1.000	-0.323	-0.053	0.021	-0.245	0.148
S4	0.053	-0.344	-0.323	1.000	0.044	0.021	0.269	-0.028
IE	0.111	0.035	-0.053	0.044	1.000	0.262	0.103	-0.553
PR	-0.655	-0.061	0.021	0.021	0.262	1.000	-0.051	-0.344
QDD	0.629	0.736	-0.245	0.269	0.103	-0.051	1.000	-0.037
IEC	0.213	-0.053	0.148	-0.028	-0.553	-0.344	-0.037	1.000

	MMS	S1	S2	S4	MM	PR	QDD	MMC
MMS	1.000	0.206	0.037	0.077	-0.681	0.799	0.345	-0.194
S1	0.206	1.000	-0.344	-0.344	-0.001	-0.061	0.736	0.107
S2	0.037	-0.344	1.000	-0.323	0.034	0.021	-0.246	-0.002
S4	0.077	-0.344	-0.323	1.000	-0.027	0.021	0.269	0.025
MM	-0.681	-0.001	0.034	-0.027	1.000	-0.589	-0.019	0.030
PR	0.799	-0.061	0.021	0.021	-0.589	1.000	-0.051	-0.166
QDD	0.345	0.736	-0.246	0.269	-0.019	-0.051	1.000	0.086
MMC	-0.194	0.107	-0.002	0.025	0.030	-0.166	0.086	1.000

	CMS	S1	S2	S4	CM	PR	QDD	TFC
CMS	1.000	0.527	-0.178	0.071	0.500	-0.620	0.639	-0.368
S1	0.527	1.000	-0.344	-0.344	-0.032	-0.061	0.736	-0.163
S2	-0.178	-0.344	1.000	-0.322	0.013	0.021	-0.246	0.080
S4	0.071	-0.344	-0.322	1.000	0.036	0.021	0.269	-0.040
CM	0.500	-0.032	0.013	0.036	1.000	-0.568	0.018	-0.438
PR	-0.620	-0.061	0.021	0.021	-0.568	1.000	-0.051	0.117
QDD	0.639	0.736	-0.246	0.269	0.018	-0.051	1.000	-0.227
TFC	-0.368	-0.163	0.080	-0.040	-0.438	0.117	-0.227	1.000

	TFS	S1	S2	S4	TF	PR	QDD	TFC
TFS	1.000	0.640	-0.148	0.117	0.202	-0.491	0.804	-0.407
S1	0.640	1.000	-0.344	-0.344	0.062	-0.061	0.736	-0.163
S2	-0.148	-0.344	1.000	-0.322	-0.021	0.021	-0.246	0.080
S4	0.117	-0.344	-0.322	1.000	0.021	0.021	0.269	-0.040
TF	0.202	0.062	-0.021	0.021	1.000	0.041	0.089	-0.480
PR	-0.491	-0.061	0.021	0.021	0.041	1.000	-0.051	0.117
QDD	0.804	0.736	-0.246	0.269	0.089	-0.051	1.000	-0.227
TFC	-0.407	-0.163	0.080	-0.040	-0.480	0.117	-0.227	1.000

	CFS	S1	S2	S4	CF	PR	QDD	CFC
CFS	1.000	0.656	-0.069	0.100	-0.107	0.389	0.837	-0.033
S1	0.656	1.000	-0.344	-0.344	-0.017	-0.061	0.736	-0.119
S2	-0.069	-0.344	1.000	-0.322	0.059	0.021	-0.246	0.150
S4	0.100	-0.344	-0.322	1.000	-0.024	0.021	0.269	-0.031
CF	-0.107	-0.017	0.059	-0.024	1.000	-0.435	0.014	-0.632
PR	0.389	-0.061	0.021	0.021	-0.435	1.000	-0.051	0.277
QDD	0.837	0.736	-0.246	0.269	0.014	-0.051	1.000	-0.105
CFC	-0.033	-0.119	0.150	-0.031	-0.632	0.277	-0.105	1.000

TABLE 6.2 - Correlation Matrices for Static Linear Model

CORRELATION MATRICES

	LES	S1	S2	S4	LE	PR	QDD	LEC
LES	1.000	0.596	-0.098	0.147	0.527	0.446	0.782	-0.058
S1	0.596	1.000	-0.344	-0.344	0.034	-0.061	0.736	-0.075
S2	-0.098	-0.344	1.000	-0.322	-0.003	0.021	-0.246	0.155
S4	0.147	-0.344	-0.322	1.000	-0.020	0.021	0.269	-0.001
LE	0.527	0.034	-0.003	-0.020	1.000	0.854	0.024	-0.006
PR	0.446	-0.061	0.021	0.021	0.854	1.000	-0.051	0.140
QDD	0.782	0.736	-0.246	0.269	0.024	-0.051	1.000	-0.066
LEC	-0.058	-0.075	0.155	-0.001	-0.006	0.140	-0.066	1.000

	FTS	S1	S2	S4	FT	PR	QDD	FTC
FTS	1.000	0.138	-0.139	-0.076	0.589	-0.875	0.077	0.039
S1	0.138	1.000	-0.344	-0.344	0.021	-0.061	0.736	-0.063
S2	-0.139	-0.344	1.000	-0.323	-0.056	0.021	-0.246	0.138
S4	-0.076	-0.344	-0.323	1.000	0.028	0.021	0.269	-0.054
FT	0.589	0.021	-0.056	0.028	1.000	-0.614	-0.002	0.379
PR	-0.875	-0.061	0.021	0.021	-0.614	1.000	-0.051	-0.288
QDD	0.077	0.736	-0.246	0.269	-0.002	-0.051	1.000	-0.099
FTC	0.039	-0.063	0.138	-0.054	0.379	-0.288	-0.099	1.000

	VES	S1	S2	S4	VE	PR	QDD	VEC
VES	1.000	0.576	-0.098	0.106	0.554	0.422	0.730	-0.138
S1	0.576	1.000	-0.344	-0.344	0.048	-0.061	0.736	-0.117
S2	-0.098	-0.344	1.000	-0.323	0.019	0.021	-0.246	0.255
S4	0.106	-0.344	-0.323	1.000	-0.041	0.021	0.268	-0.184
VE	0.554	0.048	0.019	-0.041	1.000	0.897	0.029	0.126
PR	0.422	-0.061	0.021	0.021	0.897	1.000	-0.051	0.201
QDD	0.730	0.736	-0.246	0.268	0.029	-0.051	1.000	-0.193
VEC	-0.138	-0.117	0.255	-0.184	0.126	0.201	-0.193	1.000

	EES	S1	S2	S4	EE	PR	QDD	EEC
EES	1.000	0.521	-0.172	0.113	0.645	-0.742	0.650	-0.251
S1	0.521	1.000	-0.344	-0.344	-0.012	-0.061	0.736	0.106
S2	-0.172	-0.344	1.000	-0.323	-0.037	0.021	-0.246	-0.021
S4	0.113	-0.344	-0.323	1.000	0.050	0.021	0.269	0.001
EE	0.645	-0.012	-0.037	0.050	1.000	-0.768	0.027	-0.469
PR	-0.742	-0.061	0.021	0.021	-0.768	1.000	-0.051	0.347
QDD	0.650	0.736	-0.246	0.269	0.027	-0.051	1.000	0.121
EEC	-0.251	0.106	-0.021	0.001	-0.469	0.347	0.121	1.000

TABLE 6.2 - Correlation Matrices for Static Linear Model

C O R R E L A T I O N   M A T R I C E S

	MES	S1	S2	S4	ME	PR	QDD	MEC
MES	1.000	0.712	-0.176	0.124	0.402	0.202	0.877	-0.386
S1	0.712	1.000	-0.344	-0.344	-0.009	-0.061	0.736	-0.156
S2	-0.176	-0.344	1.000	-0.322	0.124	0.021	-0.246	0.147
S4	0.124	-0.344	-0.322	1.000	-0.048	0.021	0.269	-0.015
ME	0.402	-0.009	0.124	-0.048	1.000	0.717	0.010	-0.606
PR	0.202	-0.061	0.021	0.021	0.717	1.000	-0.051	-0.485
QDD	0.877	0.736	-0.246	0.269	0.010	-0.051	1.000	-0.160
MEC	-0.386	-0.156	0.147	-0.015	-0.606	-0.485	-0.160	1.000

	TXS	S1	S2	S4	TX	PR	QDD	TXC
TXS	1.000	0.561	-0.035	0.129	0.449	0.216	0.780	-0.206
S1	0.561	1.000	-0.344	-0.344	-0.013	-0.061	0.736	-0.053
S2	-0.035	-0.344	1.000	-0.323	0.048	0.021	-0.246	0.002
S4	0.129	-0.344	-0.323	1.000	-0.025	0.021	0.269	-0.076
TX	0.449	-0.013	0.048	-0.025	1.000	0.760	0.020	-0.178
PR	0.216	-0.061	0.021	0.021	0.760	1.000	-0.051	0.335
QDD	0.780	0.736	-0.246	0.269	0.020	-0.051	1.000	-0.162
TXC	-0.206	-0.053	0.002	-0.076	-0.178	0.335	-0.162	1.000

	CHS	S1	S2	S4	CH	PR	QDD	CHC
CHS	1.000	0.233	-0.048	-0.078	0.391	0.762	0.227	-0.047
S1	0.233	1.000	-0.344	-0.344	0.110	-0.061	0.736	0.083
S2	-0.048	-0.344	1.000	-0.323	-0.063	0.021	-0.246	-0.079
S4	-0.078	-0.344	-0.323	1.000	-0.025	0.021	0.269	0.011
CH	0.391	0.110	-0.063	-0.025	1.000	0.116	0.098	-0.534
PR	0.762	-0.061	0.021	0.021	0.116	1.000	-0.051	0.228
QDD	0.227	0.736	-0.246	0.269	0.098	-0.051	1.000	0.045
CHC	-0.047	0.083	-0.079	0.011	-0.534	0.228	0.045	1.000

	GCS	S1	S2	S4	GC	PR	QDD	GCC1
GCS	1.000	0.388	-0.038	0.058	0.425	-0.680	0.506	-0.254
S1	0.388	1.000	-0.344	-0.344	-0.093	-0.061	0.736	-0.103
S2	-0.038	-0.344	1.000	-0.323	0.030	0.021	-0.246	0.188
S4	0.058	-0.344	-0.323	1.000	0.041	0.021	0.269	0.002
GC	0.425	-0.093	0.030	0.041	1.000	-0.605	-0.113	0.116
PR	-0.680	-0.061	0.021	0.021	-0.605	1.000	-0.051	-0.077
QDD	0.506	0.736	-0.246	0.269	-0.113	-0.051	1.000	-0.048
GCC1	-0.254	-0.103	0.188	0.002	0.116	-0.077	-0.048	1.000

	PPS	S1	S2	S4	PP	PR	QDD	PPC
PPS	1.000	0.420	-0.151	0.077	0.677	-0.805	0.522	-0.410
S1	0.420	1.000	-0.344	-0.344	-0.063	-0.061	0.736	0.017
S2	-0.151	-0.344	1.000	-0.323	0.026	0.021	-0.246	0.078
S4	0.077	-0.344	-0.323	1.000	0.041	0.021	0.269	-0.084
PP	0.677	-0.063	0.026	0.041	1.000	-0.709	-0.003	-0.539
PR	-0.805	-0.061	0.021	0.021	-0.709	1.000	-0.051	0.228
QDD	0.522	0.736	-0.246	0.269	-0.003	-0.051	1.000	-0.064
PPC	-0.410	0.017	0.078	-0.084	-0.539	0.228	-0.064	1.000

estimates and confidence limits are discussed below. A normally distributed error term is assumed in each model. This may not be strictly true because of the data used. For example, late billing may occur infrequently but will amount to large errors when it does. For simplicity this is ignored. The distribution of the errors in the static linear model is shown in figure 6.3. Although the number of observations is small (only 41) the shape of the normal distribution can be seen taking shape, although the distribution of OM and CF appear to be troublesome. The usual t-tests and F-distribution appear to be appropriate.

All the models have problems of varying degree. The preferred model will be the one in which the problems are *least important for forecasting*. It is often impossible to correct all the problems arising in a model. For example, one could face a choice between including two intercorrelated explanatory variables and having a model which suffers from multicollinearity or, alternatively, dropping one of the offending variables and having a model with specification error.

The result of applying OLS to the simple static linear model of equation (1) with UK output data is shown in table 6.1. It is a typical naïve model. It might be chosen by the forecaster who is unaware of the data problems, inter-dependence between variables, and the associated problems with the classical least squares assumptions. It is a poor model to be estimated by OLS, but a good way of illustrating the econometric problems which need to be overcome.

6.2 MULTICOLLINEARITY - VIOLATION OF ASSUMPTION 5.

The static linear models have a good R^2 but the t-values of the output and capacity utilisation coefficients are low. The matrix of partial correlation coefficients in table 6.2 show the problem - a high negative correlation between output and capacity utilisation. We know intuitively that capacity utilisation will rise as output rises. (The scale of the capacity utilisation variable is inverted in this model. Full utilisation of capacity gives a value of -100, and zero utilisation gives a value of 100.) The relationship is not exact so OLS estimation can proceed. In this case the multicollinearity is caused by the particular data sample. Increasing the number of observations will reduce the problem. As more plant is installed to deliver more output, capacity utilisation may fall again. There will then be more observations on capacity utilisation at each level of output.

Multicollinearity may arise because several variables shift together over time. This can occur irrespective of any true relation between the variables. In the static model the relative price of electricity falls over time whilst in some industries output rises over the same period. These variables become negatively correlated. If seasonal dummies are included with the temperature variable then there will be multicollinearity between these variables. Again the partial correlation matrix shows the strong relationship between temperature and seasonal dummies.

6.2.1 Consequences of Multicollinearity

The OLS estimator is still the BLUE and the calculation of R^2 is still correct. None of the classical assumptions have been violated unless there is an *exact* relationship between two or more of the independent variables. Multicollinearity is nearly always present in time series models. There are no strict rules when multicollinearity is "serious". The major concern is that the standard errors of the parameters of the collinear variables become large. An intuitive explanation is that there is insufficient independent movement in each collinear variable to determine its independent effect on the dependent variable.

Multicollinearity, therefore, leads to low confidence in the coefficients of a model, and subsequently to poor estimates of the elasticities to be calculated. Dropping one of the suspected collinear variables, however, may cause specification error.

6.2.2 Testing for Multicollinearity

There are no formal tests for multicollinearity. It is, however, possible to subjectively assess the severity of the problem using the following "rule of thumb":

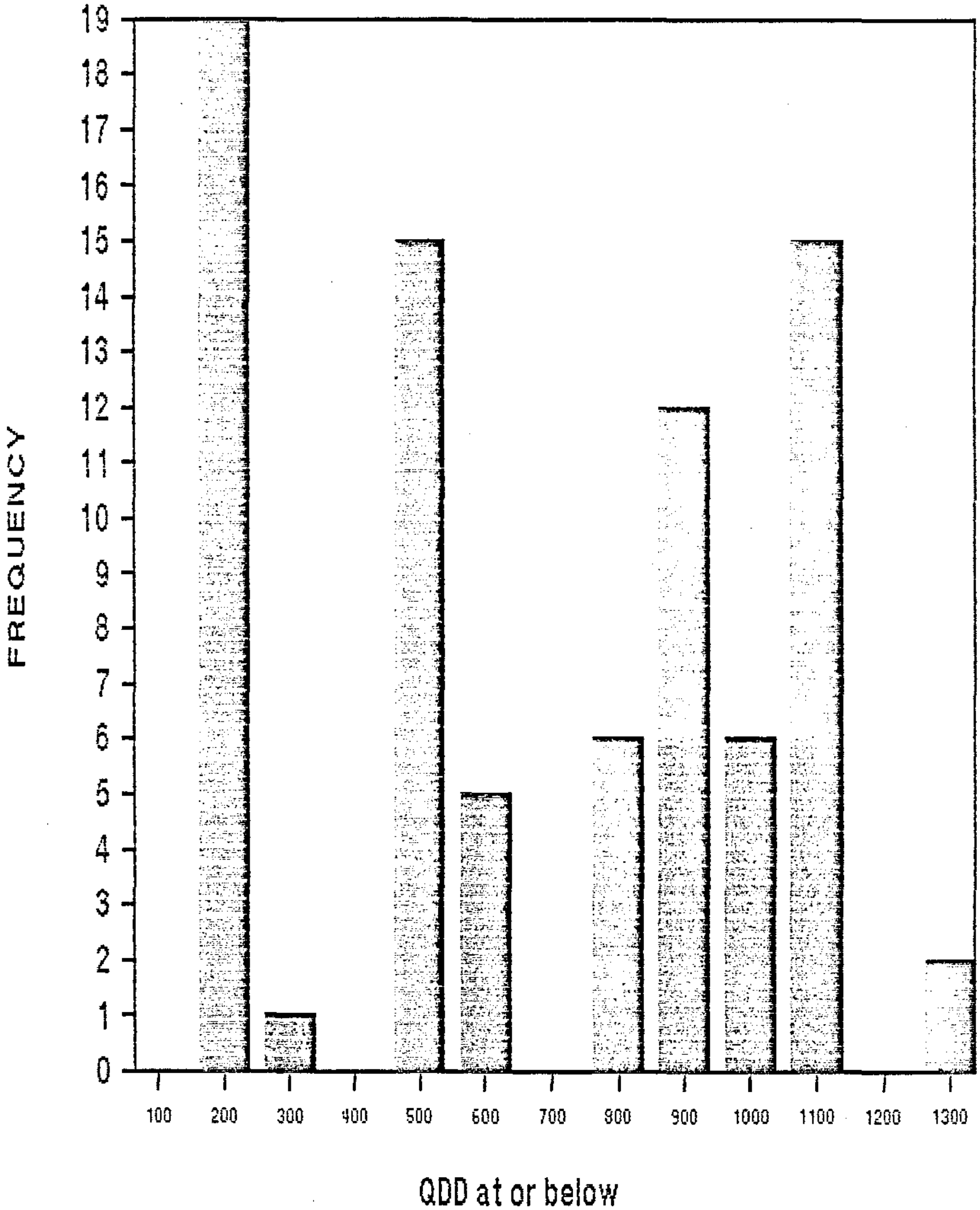
1 Examine the t-values of the coefficients. If these indicate the parameter is not significantly different from zero and it is known to be a relevant explanatory variable then multicollinearity may be present. If two relevant variables have insignificant parameter estimates, and dropping one of the variables improves the t-value of the other variable noticeably, then multicollinearity is a problem.

2 The correlation matrix may indicate the severity of the multicollinearity problem. Kennedy (1985) suggests that correlation of 0.8 or more should be avoided between independent variables. Others argue that the correlation between the independent variable and the dependent variable should be greater than between the independent variable and any other independent variable. In Table 6.2 this means that the correlation in the first row should be greater than on any subsequent row.

6.2.3 Multicollinearity in the Static Linear Model

A combination of the two methods above identifies collinear variables. Table 6.2 shows that in Leather and Leather Goods (LE) the correlation between price and output is 0.854; but the correlation between price and electricity sales is only 0.446, and output and electricity sales only 0.527. This shows in the t-values of the variables in Table 6.1. - the output coefficient is insignificant; the price coefficient is significant but it is the wrong sign. Electricity sales, output, and relative price have all fallen over the estimation period. The

FIGURE 6.4 - Frequency Distribution of Degree Days



correlation between time and each of the variables has hidden the true relationships. Because LE has been declining, some of the relationships have changed. No variable is included to model the changes the rationalisation of output has had on the industry. There may, therefore, be a specification error. The somewhat stepped nature of the price and regional output variable might also contribute a little to collinearity between output and price.

In the same equation, capacity utilisation is more highly correlated with price than with sales. Again this is due to the downward trend in both variables. The coefficient of capacity is consequently not significantly different from zero.

Similar arguments apply to other industries. In Instrument Engineering (IE), output and capacity are more highly correlated with each other than either is with sales. The correlation between temperature and seasonal dummies is depicted in figure 6.4. The observations on the temperature variable are divided into four groups, coinciding with the seasonal dummies. Seasonal dummies 2 and 4 are more highly correlated with 1 and each other than they are with sales. Temperature has a higher correlation with dummy 1 than either has with output. Price and capacity are correlated more with each other than capacity is with sales.

Only in the case of price and output of Leather and Leather Goods does the correlation between independent variables exceed 0.8. However, multicollinearity is still a general problem.

The extent of the problem is indicated by table 6.3. If a variable is totally independent of all other included variables, i.e. the correlation between the variables is zero, then the variable is said to be orthogonal. When all variables are orthogonal the correlation matrix has a diagonal of ones and all other correlations are zero. The determinant of this matrix is one. If all the variables in the correlation matrix are

TABLE 6.3 - Determinant of Correlation Matrices

C O R R E L A T I O N   M A T R I C E S

Orthogonal Variables	Collinear Variables
$$\begin{vmatrix} 1&0&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0\\ 0&0&1&0&0&0&0&0\\ 0&0&0&1&0&0&0&0\\ 0&0&0&0&1&0&0&0\\ 0&0&0&0&0&1&0&0\\ 0&0&0&0&0&0&1&0\\ 0&0&0&0&0&0&0&1 \end{vmatrix}$$	$$\begin{vmatrix} 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1\\ 1&1&1&1&1&1&1&1 \end{vmatrix}$$
Determinant = 1	Determinant = 0

(Seasonally Adjusted East Midland Output)

Instrument Engineering

EIGENVALUES: 0.0109 2.51 0.0727 1.9 1.01 1.32 0.754 0.422

Value of Standardised DETERMINANT = 0.0016

Metal Manufacturing

EIGENVALUES: 0.0106 2.48 0.0768 1.33 1.95 0.402 0.767 0.976

Value of Standardised Determinant for MM = 0.0016

Timber & Furniture

EIGENVALUES: 0.0121 2.84 0.487 1.35 1.36 1.12 0.0626 0.778

Value of Standardised DETERMINANT = 0.0017

Leather & Leather Goods

EIGENVALUES: 0.012 2.71 0.0617 1.34 1.94 0.798 0.129 1.01

Value of Standardised DETERMINANT = 0.0005

Food Drink & Tobacco

EIGENVALUES: 0.0805 2.53 0.0101 1.34 1.96 0.4 0.709 0.968

Value of Standardised DETERMINANT = 0.00154

Electrical Engineering

EIGENVALUES: 0.0117 2.92 0.223 1.34 2.01 0.0338 0.803 0.657

Value of Standardised DETERMINANT = 0.00048

Mechanical Engineering

EIGENVALUES: 0.0122 2.93 0.476 2.1 1.34 0.256 0.0361 0.849

Value of Standardised DETERMINANT = 0.00032

Glass & Cement

EIGENVALUES: 0.0106 2.46 0.111 1.34 1.88 0.389 0.789 1.03

Value of Standardised DETERMINANT = 0.00239

Paper & Publishing

EIGENVALUES: 0.011 2.92 0.216 1.92 1.36 0.0431 0.732 0.8

Value of Standardised DETERMINANT = 0.00054

Metal Manufacture

EIGENVALUES: 0.0106 2.48 0.0768 1.33 1.95 0.402 0.767 0.976

Value of Standardised DETERMINANT = 0.00162

Textiles

EIGENVALUES: 9.15E-3 2.59 0.0599 1.34 1.87 0.787 0.167 1.18

Value of Standardised DETERMINANT = 0.00067

Chemicals

EIGENVALUES: 0.0107 2.17 0.131 1.75 0.361 1.33 0.729 1.52

Value of Standardised DETERMINANT = 0.00273

Vehicles

EIGENVALUES: 0.0129 2.69 0.0719 1.39 2.08 0.828 0.132 0.788

Value of Standardised DETERMINANT = 0.00068

Clothing & Footwear

EIGENVALUES: 0.0119 2.62 0.761 1.35 0.31 1.97 0.0412 0.946

Value of Standardised DETERMINANT = 0.0008 perfectly collinear, each element of the matrix will be one, and the determinant of the correlation matrix will be zero (see table 6.3). No further statistical tests are necessary to see that the determinants of table 6.3 show an extremely high level of multicollinearity between the independent variables. The determinants range from 0.00032 in Mechanical Engineering to 0.00273 in Chemicals and Allied Trades.

Table 6.2 shows the specific incidence of multicollinearity. One of the most serious offenders is seasonal dummy one and quarterly degree days. This shows in the lack of significant seasonal dummy ones in the model. Another problem lies in the correlation between capacity utilisation and output. Again, this shows in the poor significance of the output and capacity coefficients.

6.2.4 Solutions for Multicollinearity

Multicollinearity is only a problem when it affects those parameter variances which are important. Precise parameters are not needed for the effects of temperature and seasonal dummies unless their effect is particularly being studied. The combined effect will generally suffice. Here, multicollinearity can be ignored, unless the pattern of multicollinearity is changing.

Precision is required for the parameters of output, price and capacity, since these are of particular interest.

When *forecasting* is the only aim and the pattern of multicollinearity is constant, then no problem exists. It is unlikely, however, that the pattern of multicollinearity will remain the same between variables in the future. If that were true, then some of the variables could be omitted.

More data will help to overcome multicollinearity in these models. In time, therefore, the problem will become less severe.

Re-specifying the model as a simultaneous equation model is not feasible in this case. Output is related to capacity utilisation in this sample, but there is really no *real* relationship between the two variables, as explained above. The relationship is distorted by the stock of capital. This is difficult to measure. Modelling the stock of capital is beyond the current scope of these models. A suitable simultaneous equation model might avoid some of the problems, but is not attempted due to the limitations in data, and the time constraint on the study.

The estimation technique of Principal Components can sometimes be used to overcome multicollinearity. In this case though, it is inappropriate. No orthogonal variables with economic meaning can be created from the existing set of variables. Even if this was possible, Principal Components uses less information from the sample than OLS. Similarly, none of the parameter estimates are known in advance. The model cannot therefore be transformed to rationalise the variables - as might be the case when including cross-section parameter estimates in time series models.

One possible solution for multicollinearity is the Ridge Regression. This makes arbitrary adjustments to the sums of squares along the diagonal of $(X'X)^{-1}$ to make the matrix less nearly singular. Ridge Regression gives biased estimates but with smaller Mean Squared Error (MSE) than OLS estimates. Ridge Regression is a statistical trick, and has not been used since it adds complexity to the models and detracts from the main theme of the study - to make the study usable for forecasting.

If a collinear variable is dropped the model will be mis-specified. This is discussed below.

6.3 SPECIFICATION ERROR - VIOLATION OF ASSUMPTION 1

Three types of specification error might occur. The models may include an erroneous set of explanatory variables; they may have the wrong functional form; or the parameter estimates may not be constant.

6.3.1 Erroneous Explanatory Variables

An equation will sometimes not contain the appropriate explanatory variables. Three instances occur: omission of a relevant collinear variable; omission of a relevant orthogonal variable; inclusion of an irrelevant variable.

A solution for multicollinearity is to drop one of the collinear variables. There are two possible effects when a relevant explanatory variable is omitted. These depend whether the omitted variable is orthogonal or collinear with the independent variables.

If the omitted variable is collinear, the coefficient of the included variable(s) will be biased.

If the omitted variable is orthogonal, the coefficient of the included variable(s) will be unbiased. The intercept *will* be biased unless the mean of the omitted variable is zero.

In the static linear model this implies that dropping one of the collinear variables to avoid multicollinearity will give biased and inconsistent estimators. The direction of the bias is determined by the sign of the correlation between the omitted variable and the dependent variable, and the sign of the correlation between the omitted variable and the included explanatory variable. If both have the same sign the bias will be upwards. If they have opposite signs the bias will be downwards.

The models are designed for forecasting. Multicollinearity gives unbiased and consistent estimators and is therefore preferable to mis-specifying the model, which gives biased and inconsistent estimators.

Technological change should be included in the model but is notoriously difficult to measure. No variable has been found which represents technology satisfactorily; it is therefore frequently omitted from models. The models presented here are no exception. The consequences of its omission are noted above, and depend whether technological change is orthogonal to the other independent variables. This depends upon the time period studied. Technological change will always rise. Firms do not move backwards in technology. It does not, therefore, have zero mean - so the intercept *will* be biased. During the sample period technology has advanced in various steps. Output has not always increased. The level of manufacturing output in the UK economy over the period has not, by 1985, reached its previous peak! A high degree of correlation between the two is therefore unlikely. Relative price has fallen continuously whilst technology has advanced. A high negative correlation might therefore be expected - giving biased estimates of the price coefficient. The direction of the bias will depend whether the advance of technology has resulted in more or less electricity sales. There will be a downward bias in the price coefficient if it has resulted in less sales. If it has resulted in more electricity use then the bias will be upwards.

Negative correlation between the absent technology variable (which should be included - see 5.6) and the price variable may be responsible for the "wrong" sign of the price coefficient in some industries.

If an *IRRELEVANT VARIABLE* is included in the model the coefficients and the variance-covariance matrix will remain unbiased. The variance-covariance matrix becomes larger unless the variable is orthogonal, however, so the estimates become inefficient. It may therefore be advisable to include seasonal dummies and temperature in the model. At worst this will only give less efficient estimators. If they are relevant and excluded then the temperature coefficient will be biased.

6.3.2 Non-Linear Models

There may be specification error even when all the explanatory variables are present. Assumption 1 requires the dependent variable to be a *linear* function of the independent variables plus an error term. If a linear model is estimated when the true relationship is non-linear specification error is present. This can normally be corrected by transforming the independent variables or by transforming the entire equation to give a model that is linear in the variables. In the static model, the relationship between temperature and sales is not linear. As temperature falls the effect on sales becomes progressively stronger. The relationship would be better described by:

$$S_t = \beta_0 + \beta^1(1/T_t) + \beta^2(1/T_t^2) + u_t$$

The quadratic term for temperature makes the effect of temperature on sales greater with each successive increment in temperature.

Using a linear model instead of a quadratic, non-linear, model is equivalent to the omission of a relevant explanatory variable. The parameter estimates of any variables correlated with the quadratic term will be biased and have a higher variance than necessary.

The static linear model could also be postulated in multiplicative form (with multiplicative error terms!). The whole equation may then be transformed by taking logarithms. The linear and logarithmic models could not be compared by R^2. The R^2 of the linear model gives the proportion of the variation in the dependent variable explained. The logarithmic model gives the proportion of the variation in the logarithm of the dependent variable explained. A Box-Cox transformation would have to be applied to the data prior to estimation if the R^2 are to be compared.

6.3.3 Non-Constant Coefficients

The classical assumptions require parameters to be constant. This is sometimes not true of the real world. More specifically it is not true of output elasticity. The long-run and short-run output elasticity will differ. In the short-run, as output rises, firms will utilise their plant more intensively. In the long-run they will equip themselves with new plant to cope with further anticipated increases in output. New plant will often be more energy efficient than existing plant. Output elasticity will therefore change.

The parameters of some variables may be functions of other variables, as discussed in chapter 5 on model specification. Output elasticity is a function of price and capacity utilisation. This could be made explicit. Instead of the model:

$$S = \beta_0 + \beta_1 O + \beta_2 P + \beta_3 C + \beta_4 T$$

The model might be better specified as :

$$S = \beta_0 + \pi_1 O + \beta_4 T$$

where $\pi_1 = \beta_5 + \beta_6 P + \beta_7 C$

giving the model:

$$S = \beta_0 + (\beta_5 + \beta_6 P + \beta_7 C)O + \beta_4 T$$

$$= \beta_0 + \beta_5 O + \beta_6 PO + \beta_7 CO + \beta_4 T$$

Unfortunately, when a parameter is determined by other variables *and an error term* the error of the model to be estimated becomes more complex. The OLS estimator is still unbiased but a maximum likelihood estimator is needed for efficiency.

6.4 SYSTEMATIC MEASUREMENT ERRORS - VIOLATION OF ASSUMPTION 2

If there is systematic measurement error in sales causing constant overstatement, or understatement, the intercept will be biased but consistent. This is only a problem when measuring seasonal effects.

The technique of OLS automatically produces errors with a mean value of zero. This puts the mean of measurement errors into the intercept. Systematic measurement error can only be detected with prior knowledge.

6.5 MEASUREMENT ERRORS - VIOLATION OF ASSUMPTION 4

All the variables used are measured with error. The effect of measurement error differs for the classical model depending whether the error is in the dependent or independent variable.

6.5.1 Errors in Measurement of the Dependent Variable

If electricity sales are measured with error the coefficients of the parameters of the independent variables retain their classical properties. The estimators will be unbiased, consistent and the usual statistical tests remain valid. At low levels of output firms may have a choice of which plant they wish to use. There may, therefore, be more variation in sales at lower levels of output. This has been tested by visual inspection of the residuals and does not appear to be a problem.

6.5.2 Error in Measurement of Independent Variables

The interpolated structure of the output variable makes it particularly prone to measurement error. This is more serious than measurement errors in sales. Biased and inconsistent estimators result.

The true relationship between sales (S) and output (P) is :

$$S_t = \alpha + \beta P_t + u_t$$

The measured value of P is P^*. Assuming random additive errors in this example:

$$P_t^* = P_t + v_t$$

If it is further assumed that v_t satisfies the classical assumptions and is independent of P_t and u_t, then :

$$S_t = a + \beta(P_t^* + v_t) + u_t$$

The equation estimated will be :

$$S_t = \alpha + \beta P_t^* + u^*_t$$

where $u_t^* = u_t + -\beta v_t$

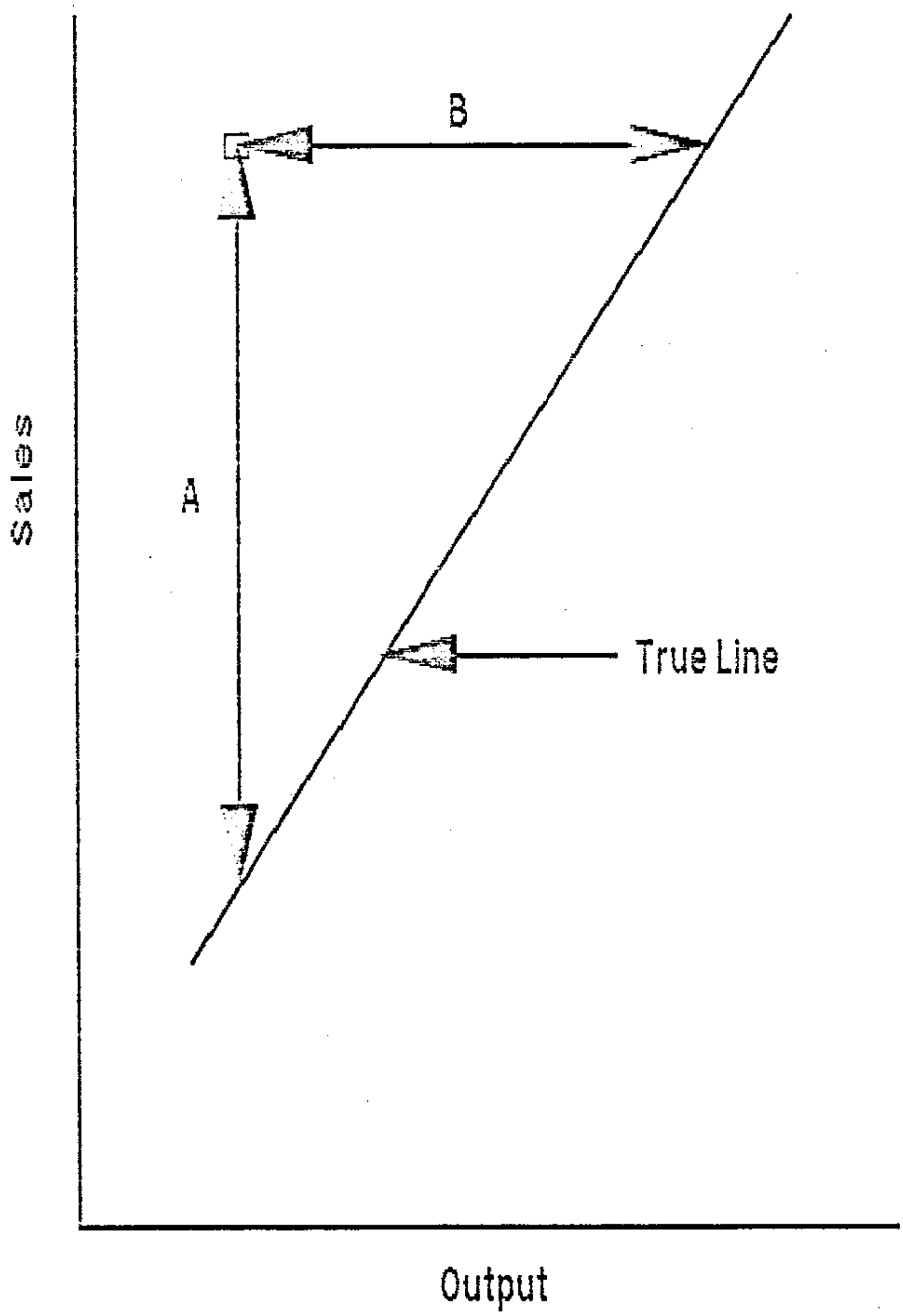
The new composite error term is no longer independent of the explanatory variable. Now :

$$\begin{aligned} E(P_t^* u_t^*) &= E(P_t + v_t)(u_t - \beta v_t) \\ &= E(P_t u_t) + E(v_t u_t) - \beta E(P_t v_t) - \beta E(v_t^2) \end{aligned}$$

Under the above assumptions all but the last term is zero. Hence the estimators are biased and inconsistent. Therefore :

$$E(P_t^* u_t^*) = -\beta \sigma_v^2$$

FIGURE 6.5 - Measurement Errors



See Stewart and Wallis (1984) pp138 for probable limits of β.

The degree of the problem depends on the degree of independence between the measurement errors and the disturbance. This cannot be tested explicitly but the extent of the problem can be deduced from knowledge of the data.

Measurement errors in the independent variable are explained graphically in Figure 6.5.

OLS minimises the vertical distance, A. If Output is measured with error there will also be a horizontal error, B. Inverse Least Squares can be used to minimise B. The value x will deviate from the true line for a combination of the standard OLS reasons and measurement errors in the independent variable. Neither OLS or ILS is therefore strictly appropriate, but they can be used to provide limits for β. If the ratio of the two variances is known, then appropriate weights could be used. The measurement errors in output are not known. It is not, therefore, possible to say which is the best estimate of the true β.

Instrumental Variables is the most popular remedy for measurement errors. It is, unfortunately, unviable for these models. It is often the case that there are no suitable instruments, and this case is no exception.

It has already been noted that the way in which the output variable is constructed causes measurement errors. It could therefore be suggested that UK output statistics should be used. This creates its own problems.

Output is growing faster in the East Midlands than the UK. As output rises, the divergence between UK IIP and an East Midlands IIP increases. UK IIP will measure the East Midlands IIP with increasing error. Larger measurement errors will be associated with larger output. OLS provides the line of best fit to the data. The estimated equation will therefore give positive residuals to high output and negative residuals to low output. The output coefficient will be *biased*.

Firms now keep more information in a more accessible form about their activities. The BSO have presumably improved their techniques for collection and analysis of data. These two effects may have produced more accurate output data over the period.

6.6 AUTOCORRELATION - VIOLATION OF ASSUMPTION 3b

In time series data it is not unusual for assumption 3 to break down; that is, $E(u_t u_s) \neq 0$ for $t \neq s$.

In the models in this study autocorrelation has various causes:

1 Seasonal adjustment of data by moving average methods will induce autocorrelation.
2 The effect of a random "shock" may take several time periods to work its way out of the system. The errors in those time periods will all be affected and related to each other.
3 Transforming equations for estimation may introduce autocorrelation. The Koyck Transformation is an example. Inclusion of lagged dependent variables as regressors violates assumption 4 since the lagged dependent variable is a function of errors in previous periods. This problem is discussed in section 6.7.
4 Most economic time series data are autocorrelated. If a relevant autocorrelated variable is omitted from the model this will give autocorrelation in the mis-specified model. The specification of the model should be addressed if this occurs.

If autocorrelation is present and lagged endogenous variables are present on the right hand side of the equation then OLS estimates will be *biased* and *inconsistent*. This would be the case when the Koyck Transformation is applied. In some cases, however, the Koyck

FIGURE 6.6 - Biased Slope Coefficient

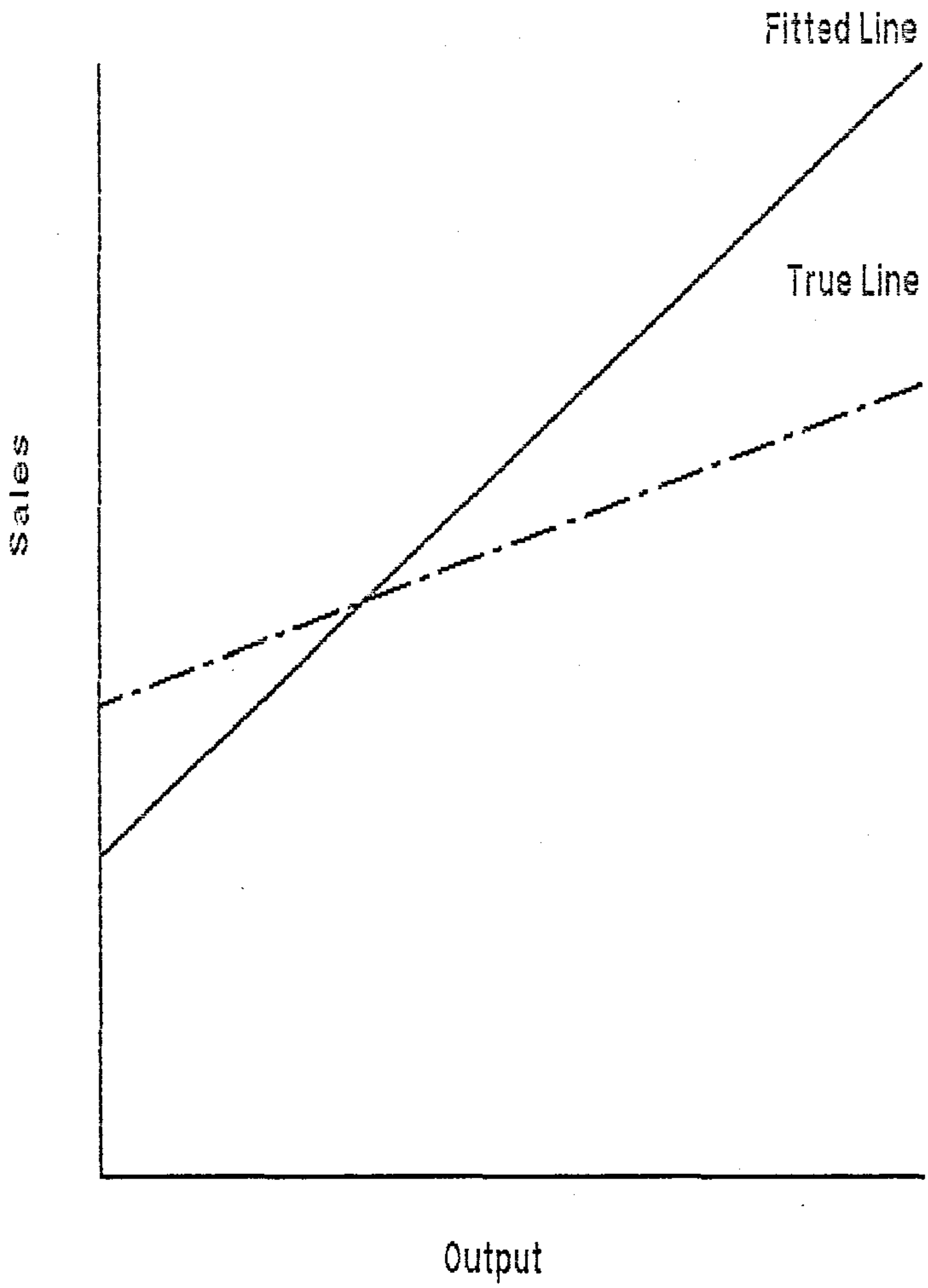
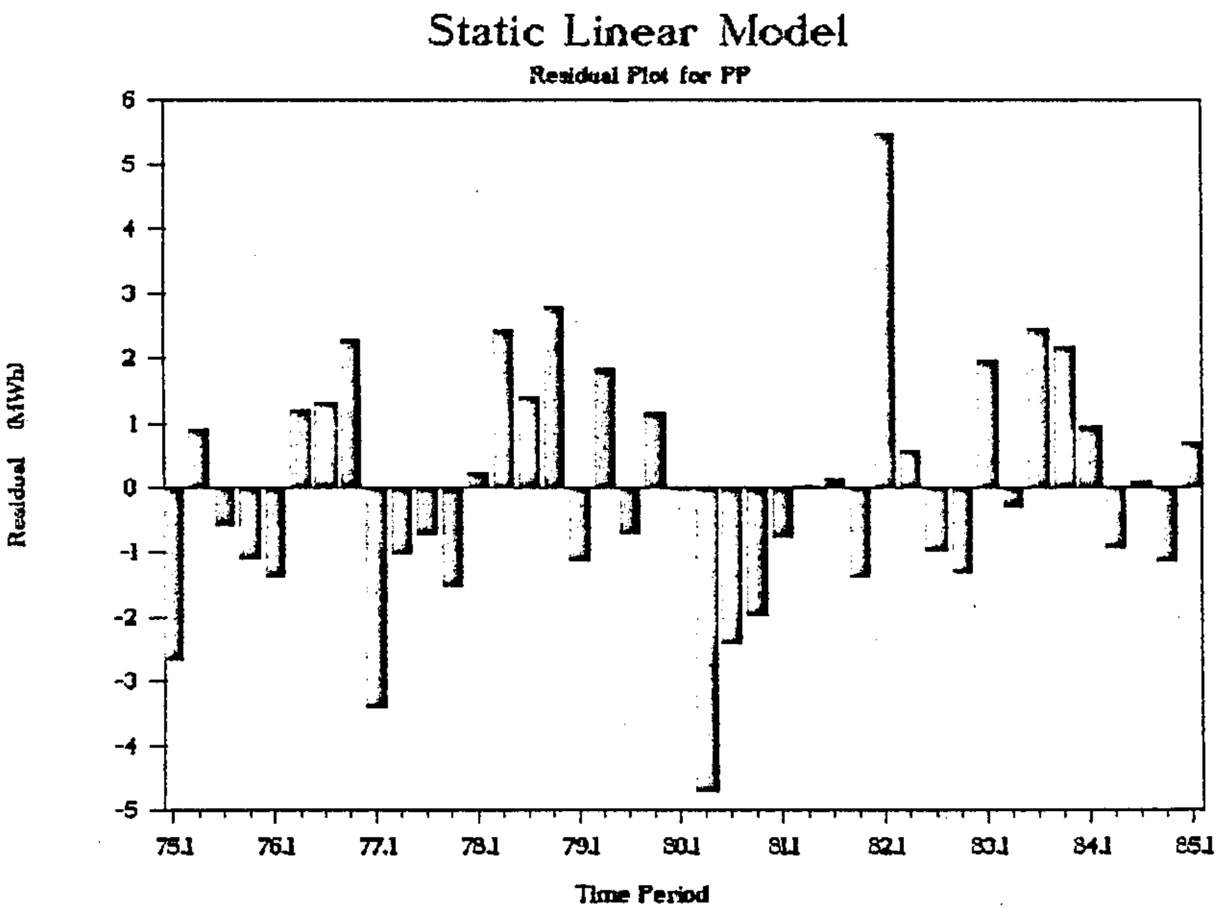
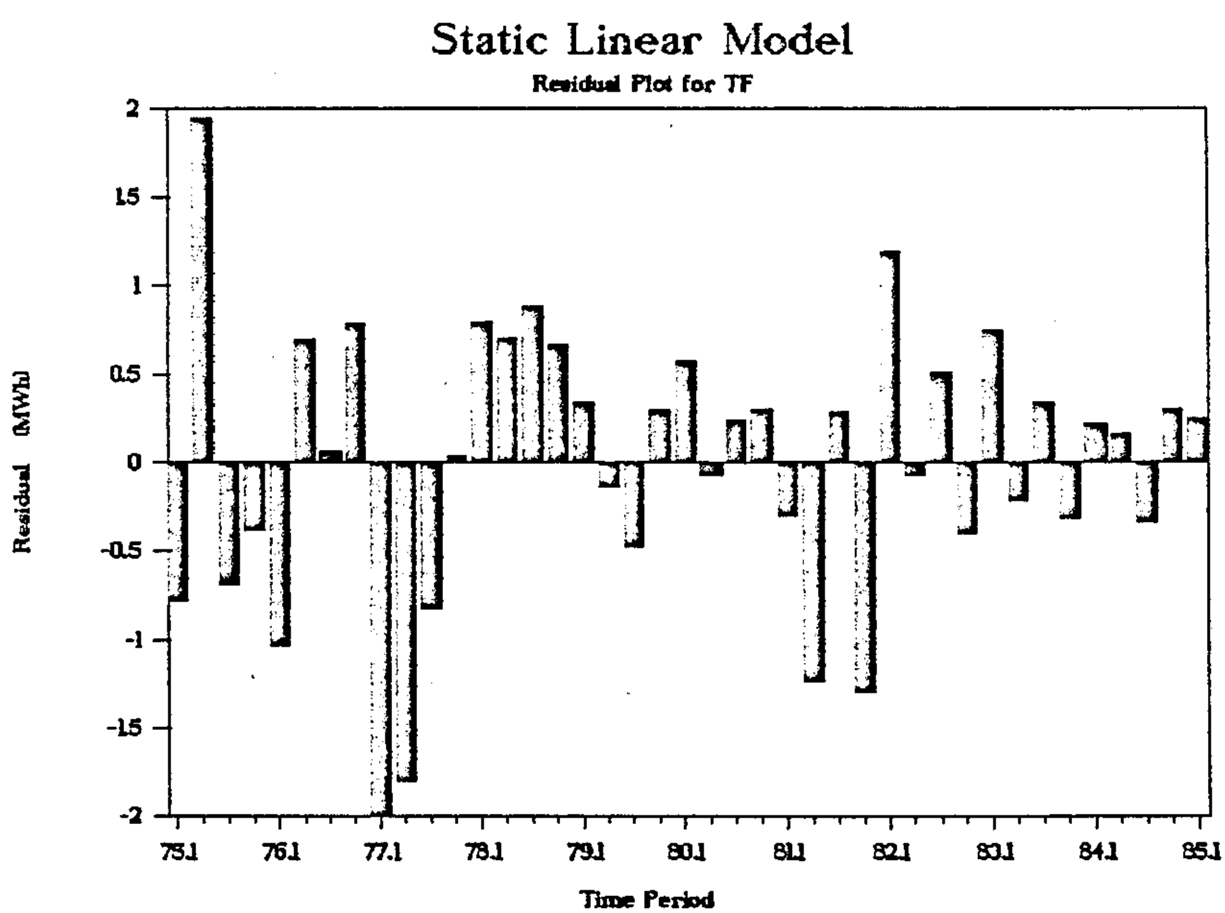


FIGURE 6.7

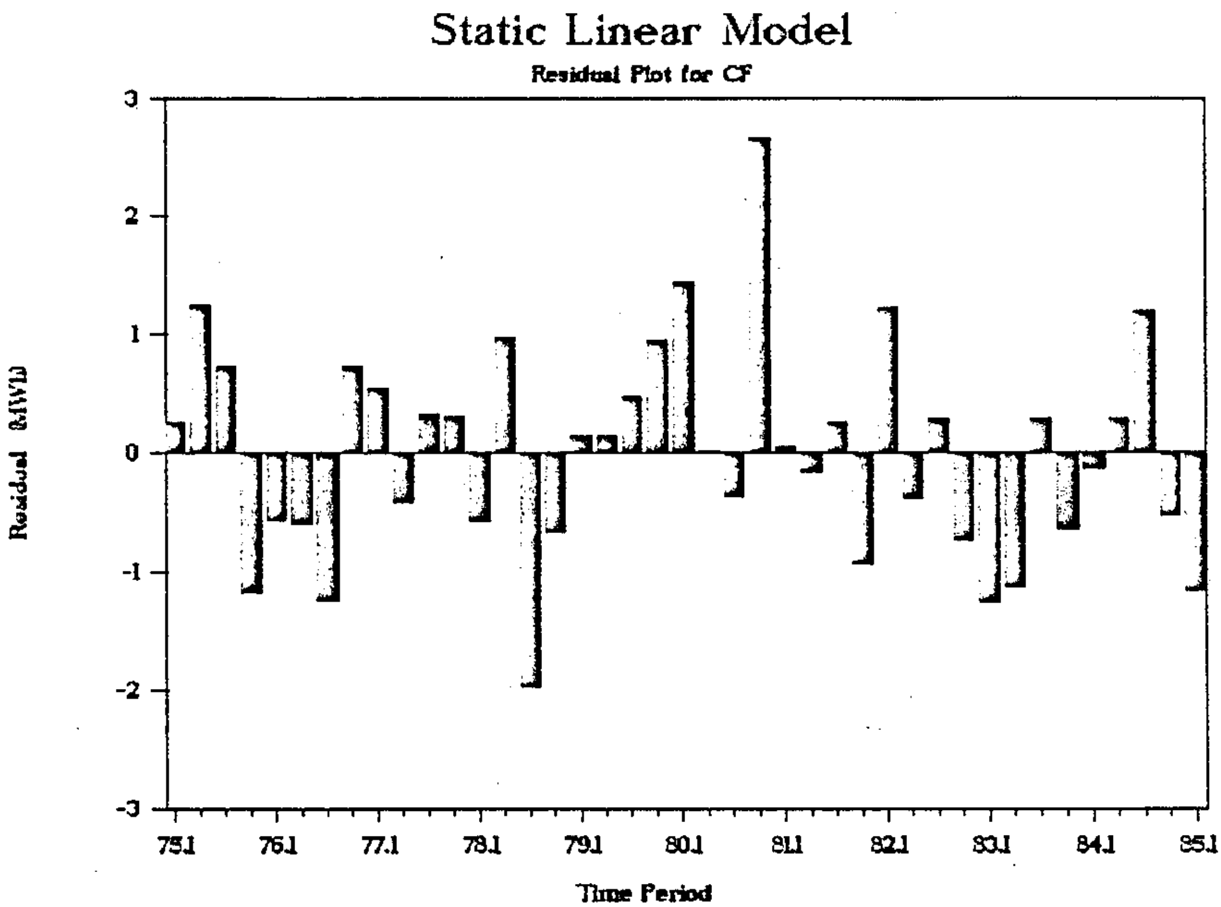


Static Linear Model
Residual Plot for PP
Residual (MWh)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
75.1
76.1
77.1
78.1
79.1
80.1
81.1
82.1
83.1
84.1
85.1
Time Period



Static Linear Model
Residual Plot for TF
Residual (MWh)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
75.1
76.1
77.1
78.1
79.1
80.1
81.1
82.1
83.1
84.1
85.1
Time Period

FIGURE 6.7 cont.



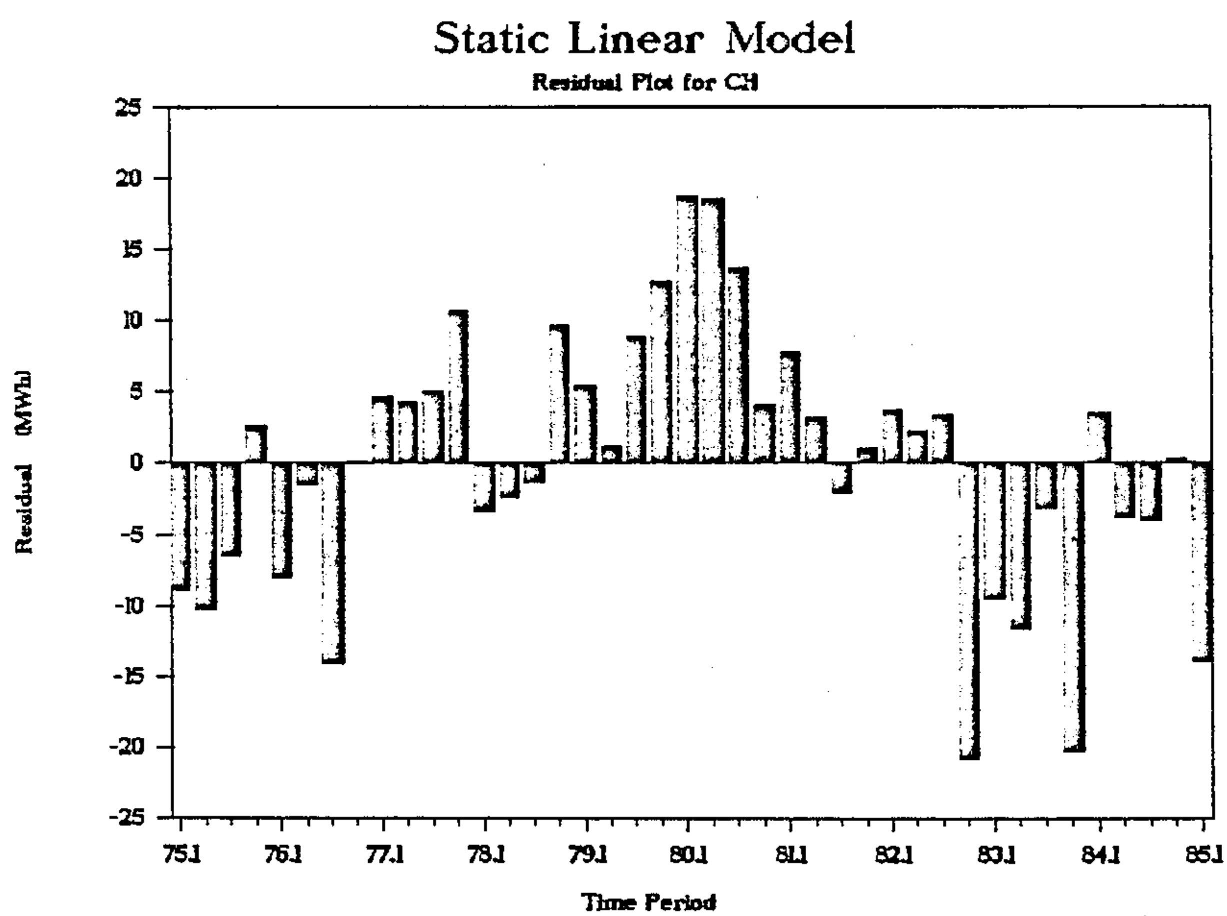
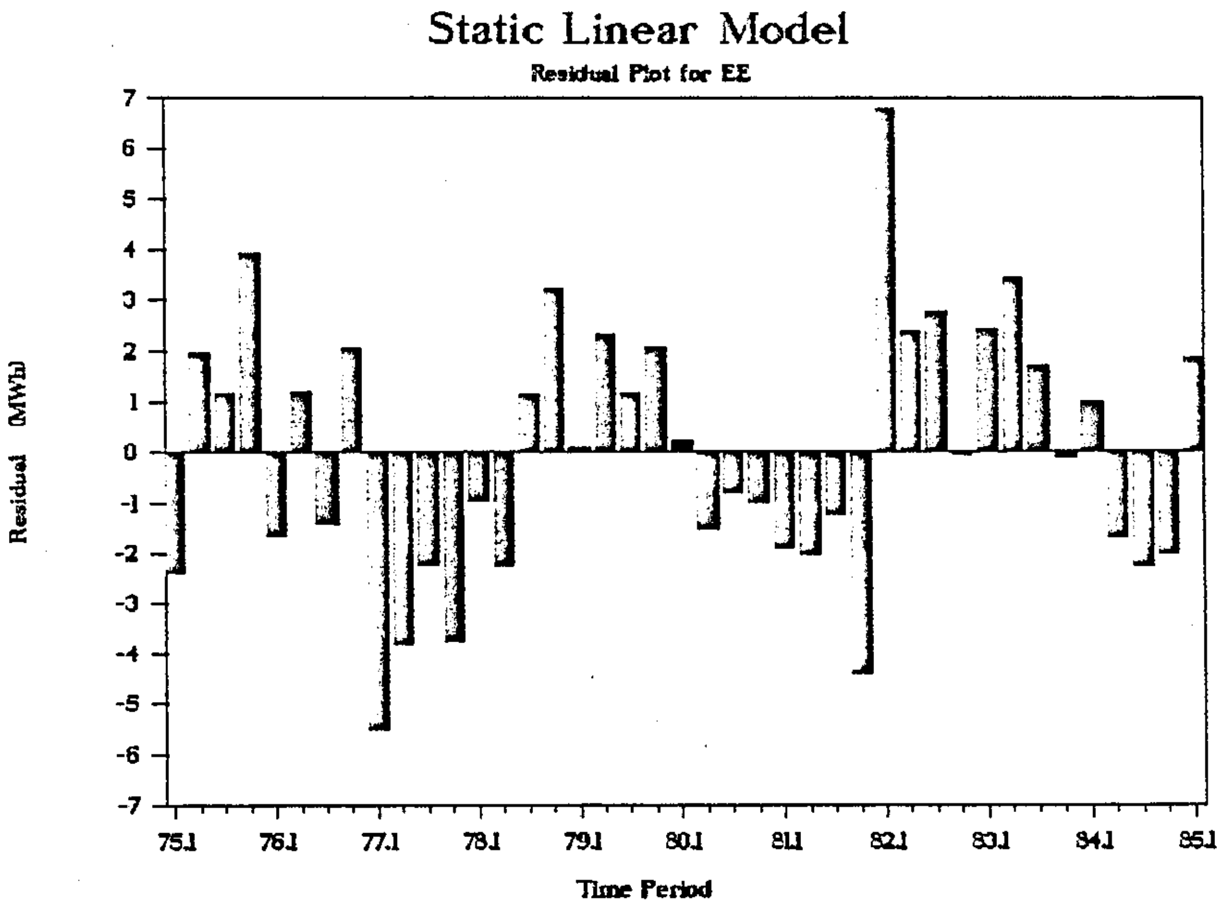


FIGURE 6.7 cont.



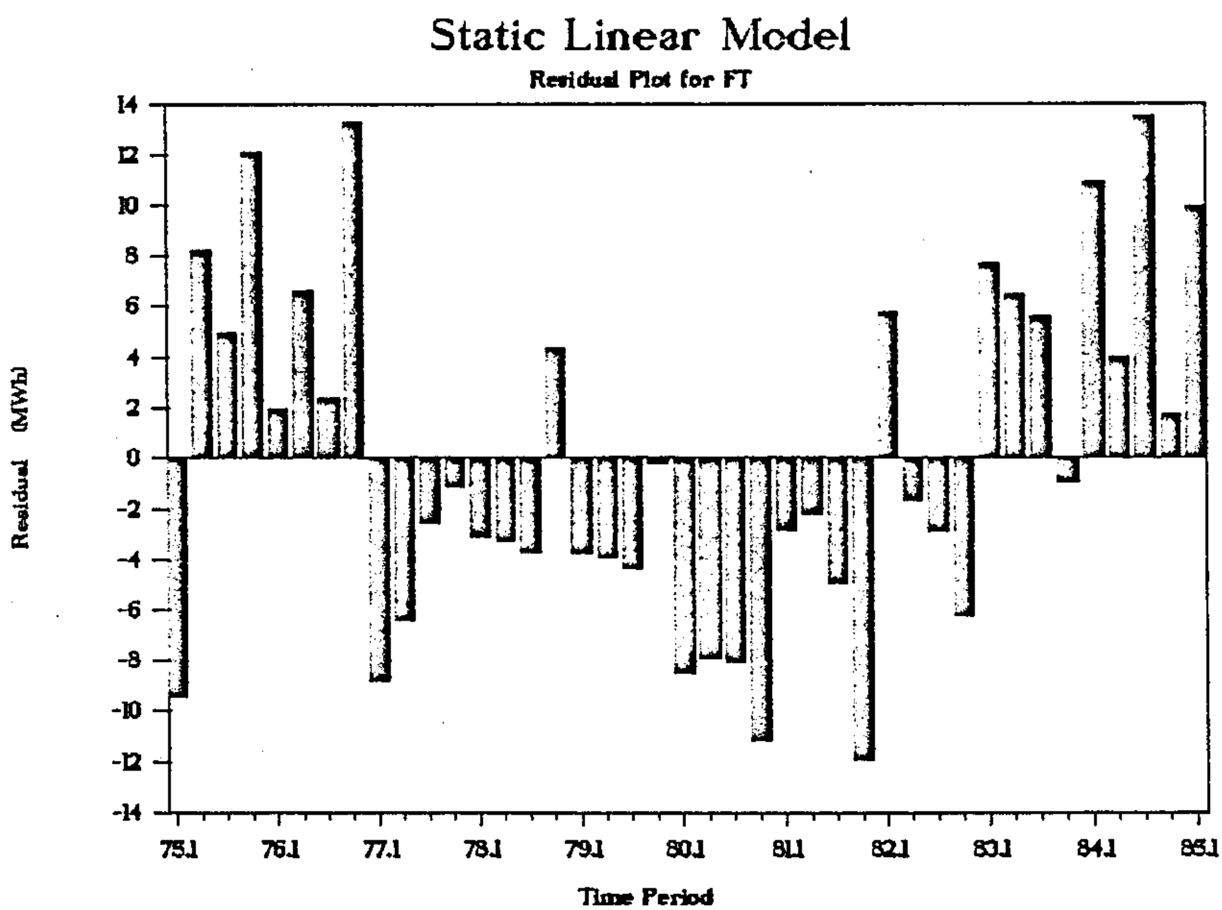
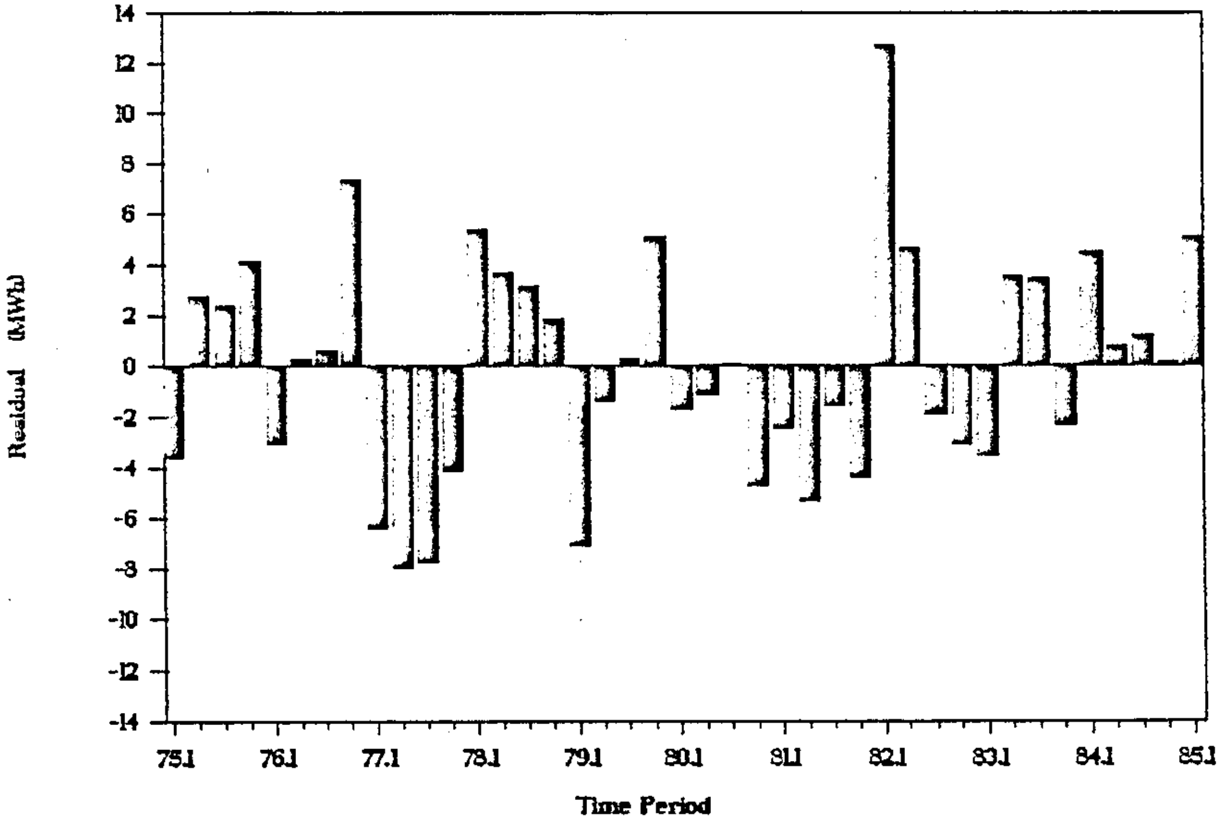


FIGURE 6.7 cont.

Static Linear Model

Residual Plot for GC



Static Linear Model

Residual Plot for IE

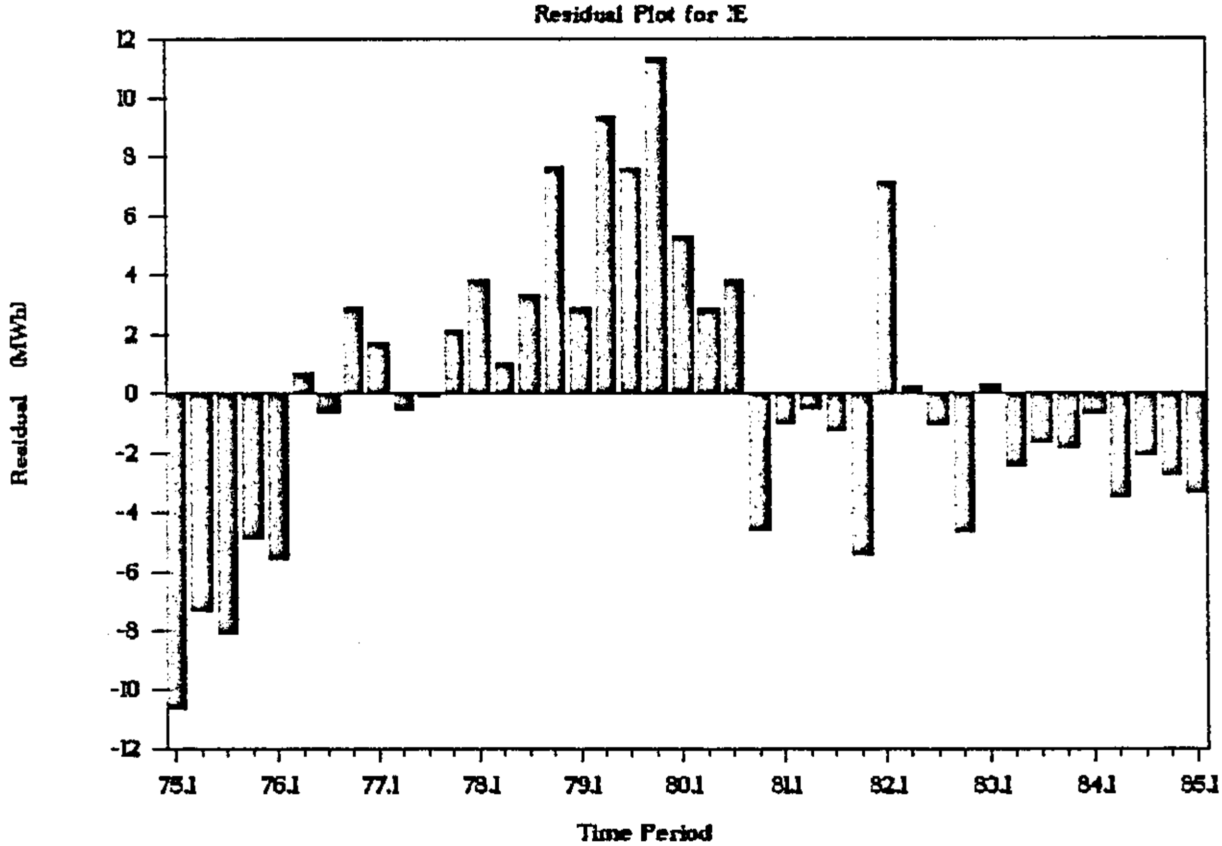
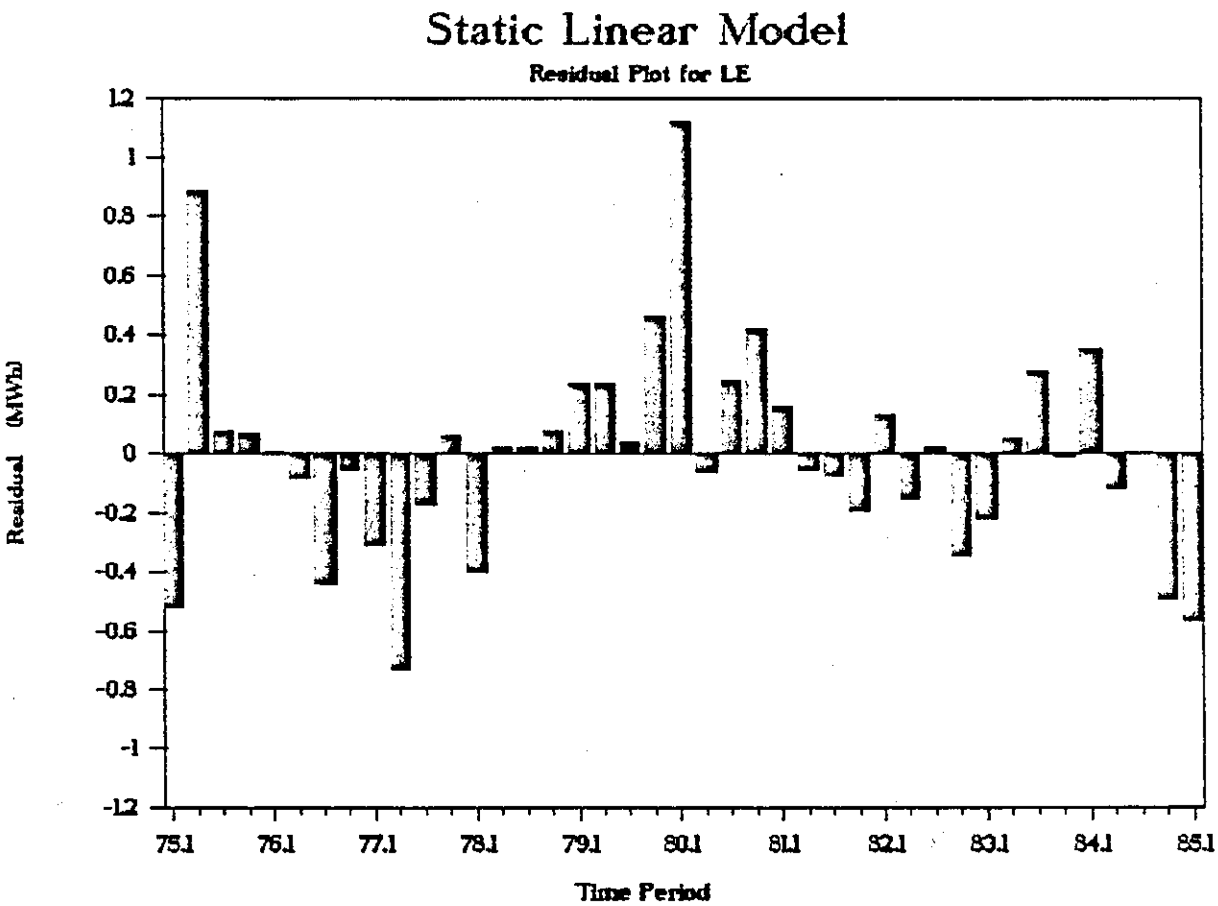


FIGURE 6.7 cont.



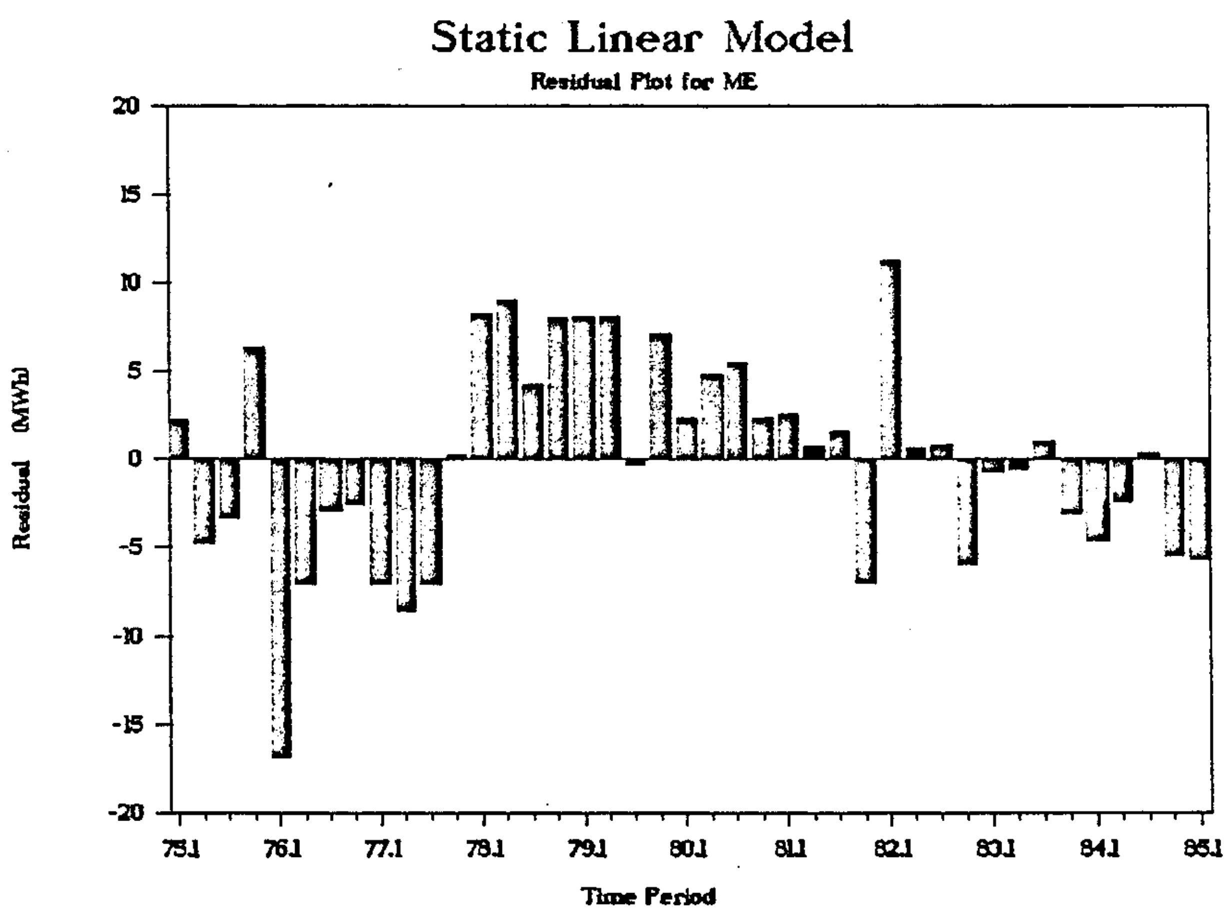
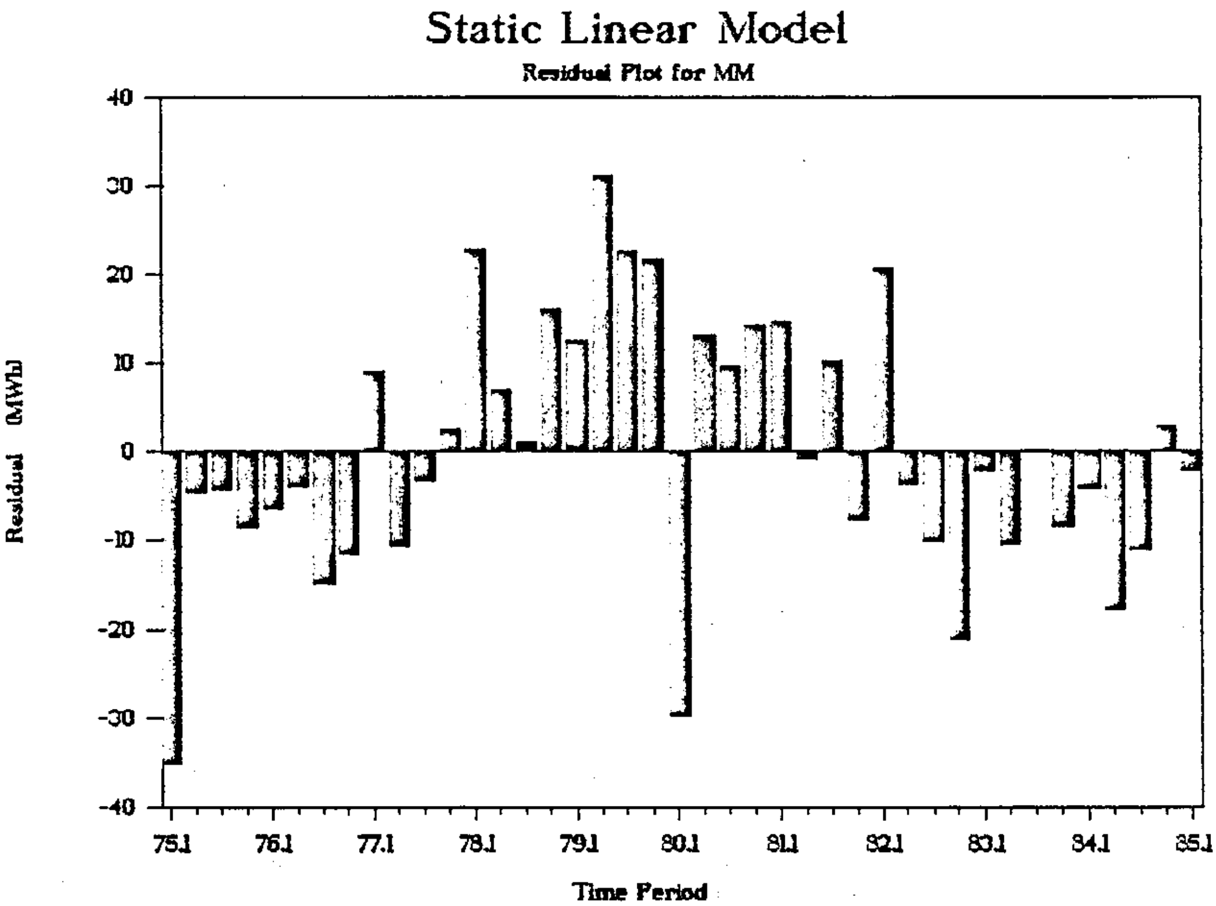


FIGURE 6.7 cont.



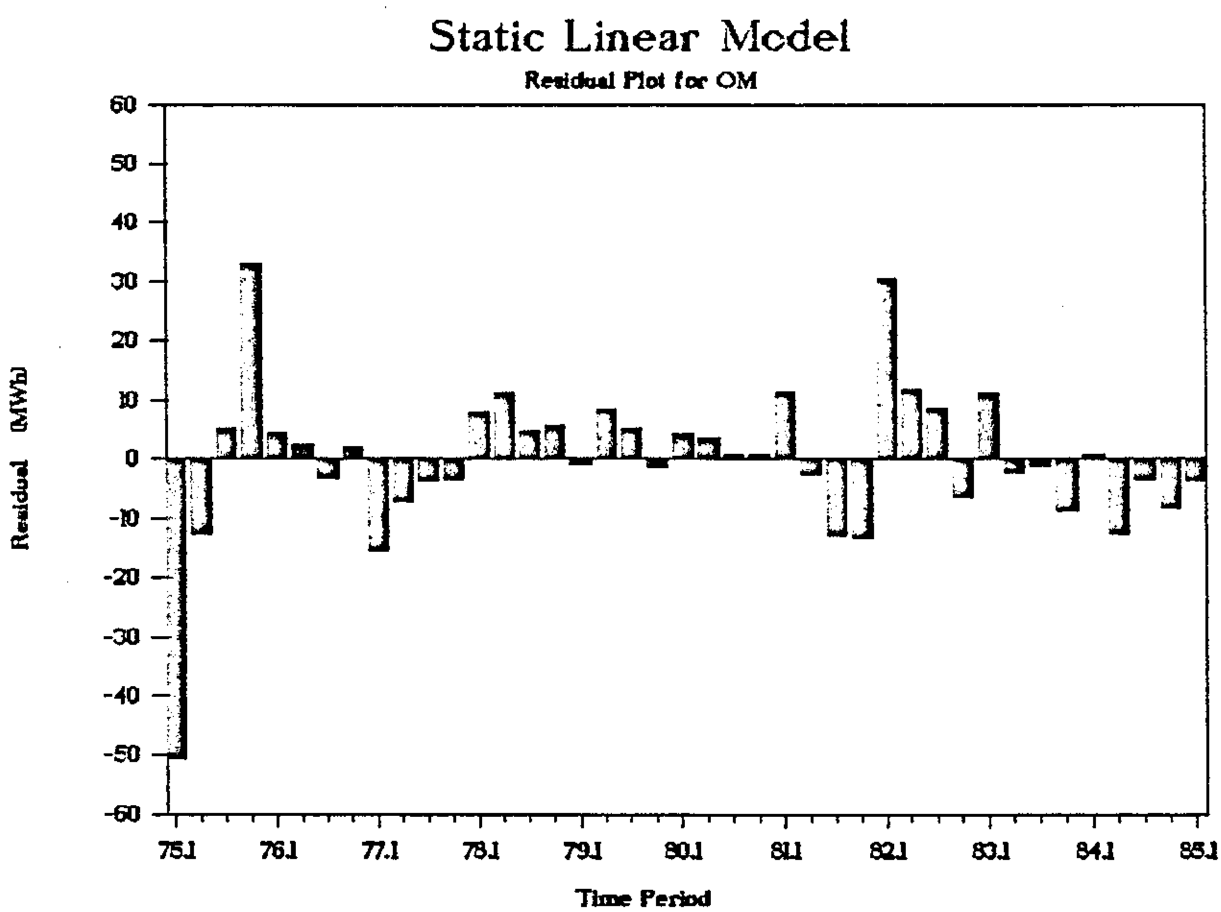
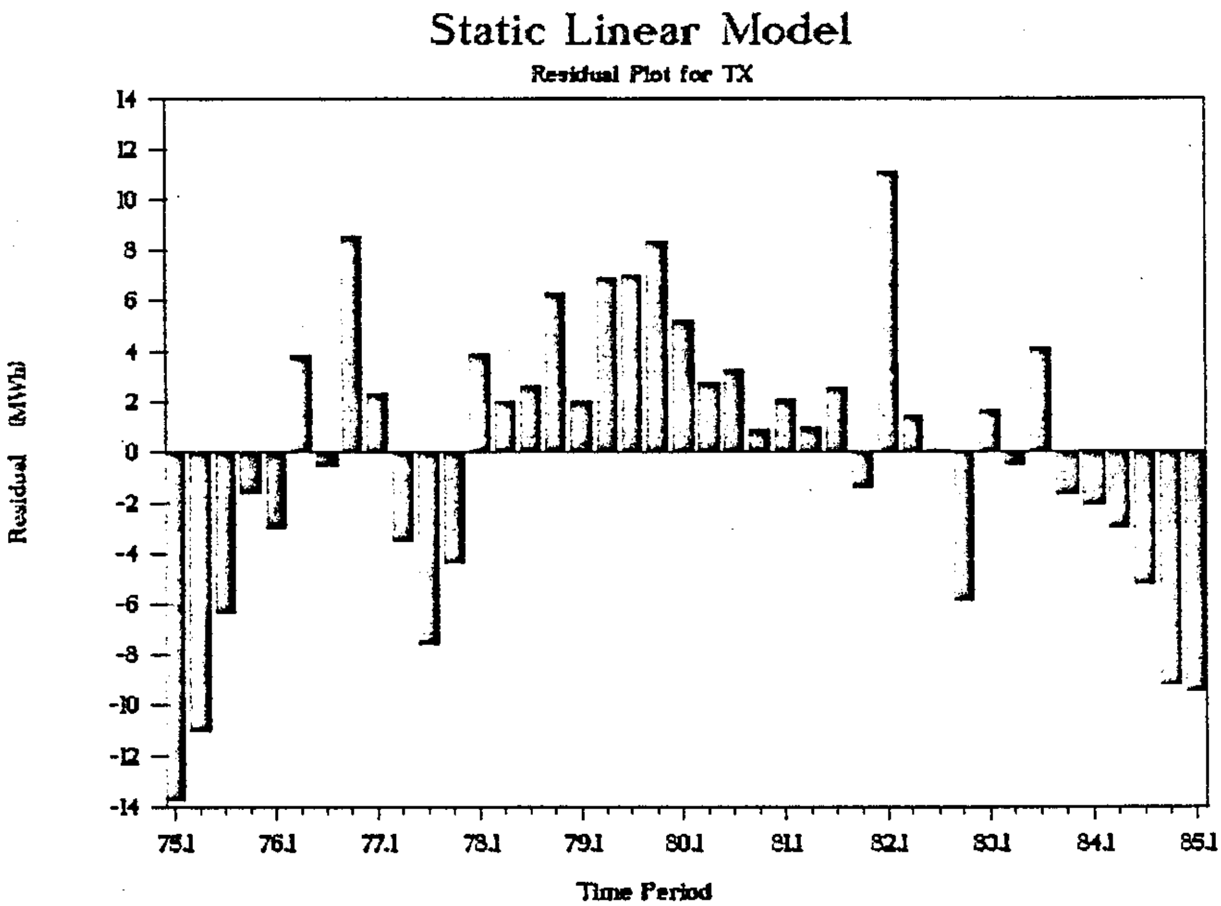
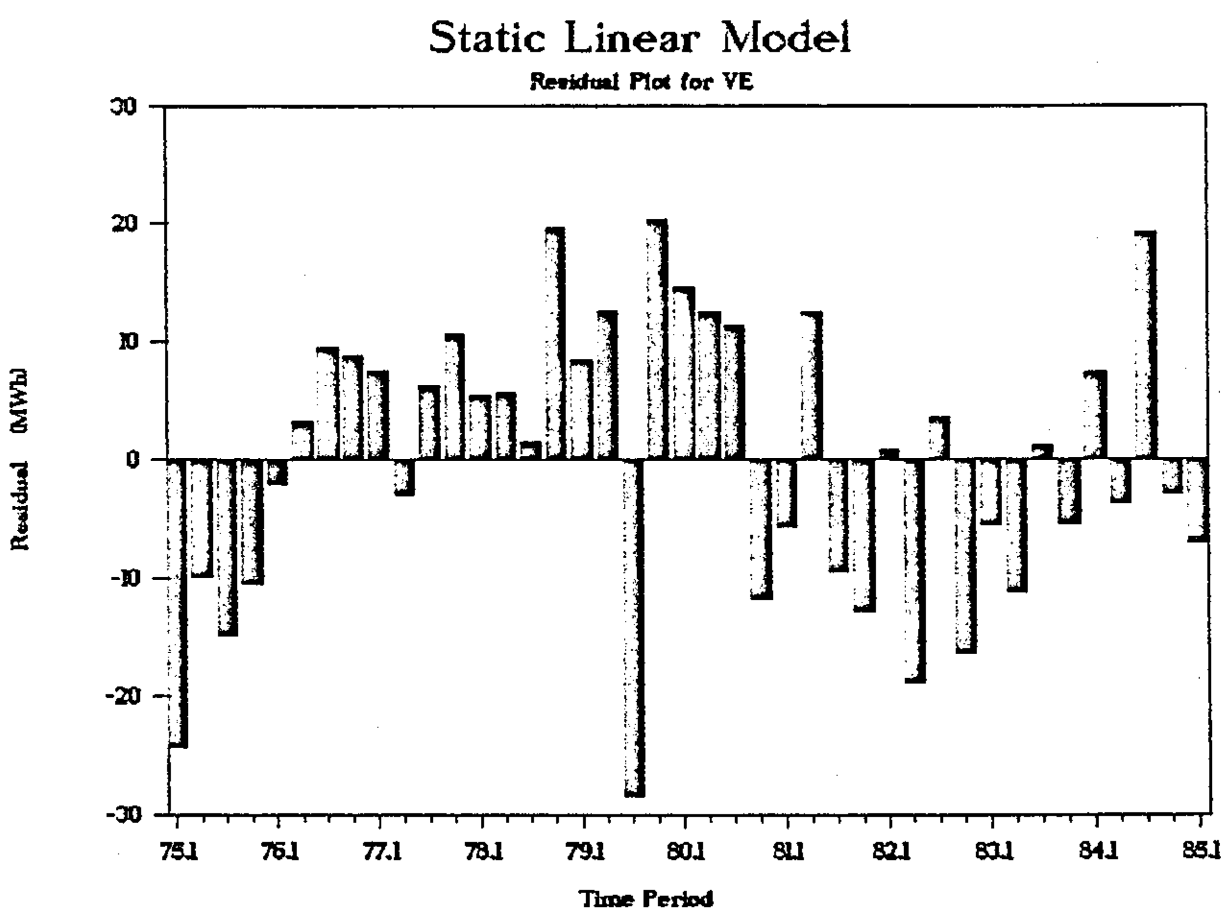


FIGURE 6.7 cont.





Transformation will remove autocorrelation.

If only exogenous variables are present on the right hand side of the equation then OLS estimators remain *unbiased* and *consistent* - but other problems arise.

1 The OLS estimator is not the "best" estimator since it does not have the property of minimum variance.
2 The OLS method of calculating variances and covariances becomes incorrect if errors are autocorrelated. The OLS variance-covariance matrix of $\hat{\beta}$ is $\sigma_u^2(X'X)^{-1}$ whilst the true variance-covariance matrix when autocorrelation is present is $(X'X)^{-1}X'VX(X'X)^{-1}$. V is the variance-covariance matrix of the errors. If the errors are positively correlated OLS will underestimate the true variances.
3 The OLS formula for F-tests is incorrect.
4 The OLS estimate of the error variance is an underestimate when positive autocorrelation is present. This gives an overoptimistic value of R^2.
5 Predictions will be inefficient - they will have larger variances than necessary.

When positive first order autocorrelation is present, in the relationship between output and sales for example, the situation depicted in Graph 6.6 will arise. Here $e_t = pe_{t-1} + u_t$. If the first error is large and positive the second error will be not quite so large but also positive, and so on. The plot of residuals from the model, shown in figure 6.7, also shows this autocorrelation. The problem is particularly obvious in these models. When the error becomes negative the next error will be negative. OLS will fit the best line to the data but *not necessarily the true line*. Intuitively OLS gives poor estimates of the true slope coefficient for output. The estimator is nevertheless unbiased in large samples since the errors average out. It is also easy to see that OLS with autocorrelation gives an overoptimistic estimate of R^2 for the true relationship.

FIGURE 6.8 - Durbin-Watson Tests on Static Linear Models

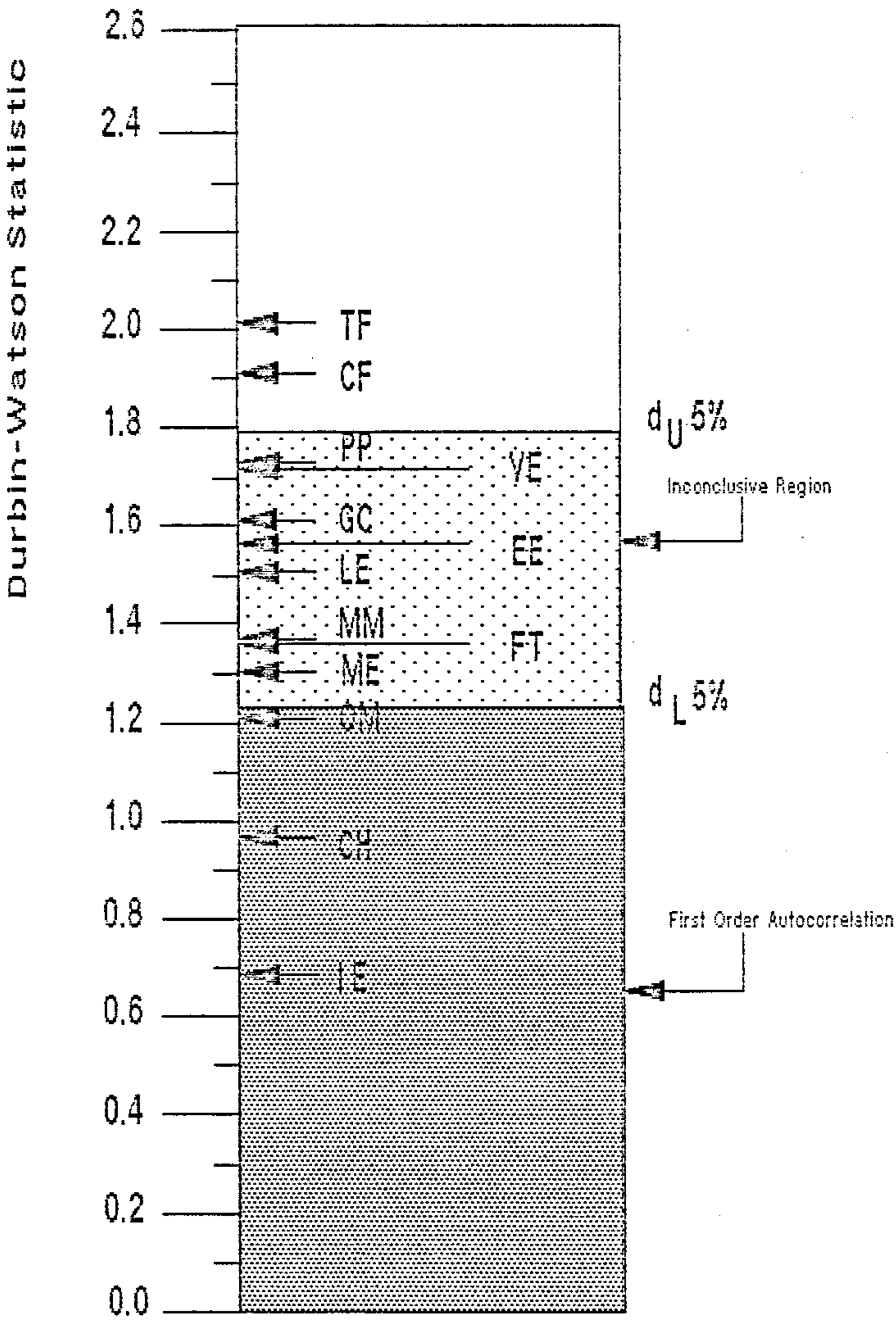
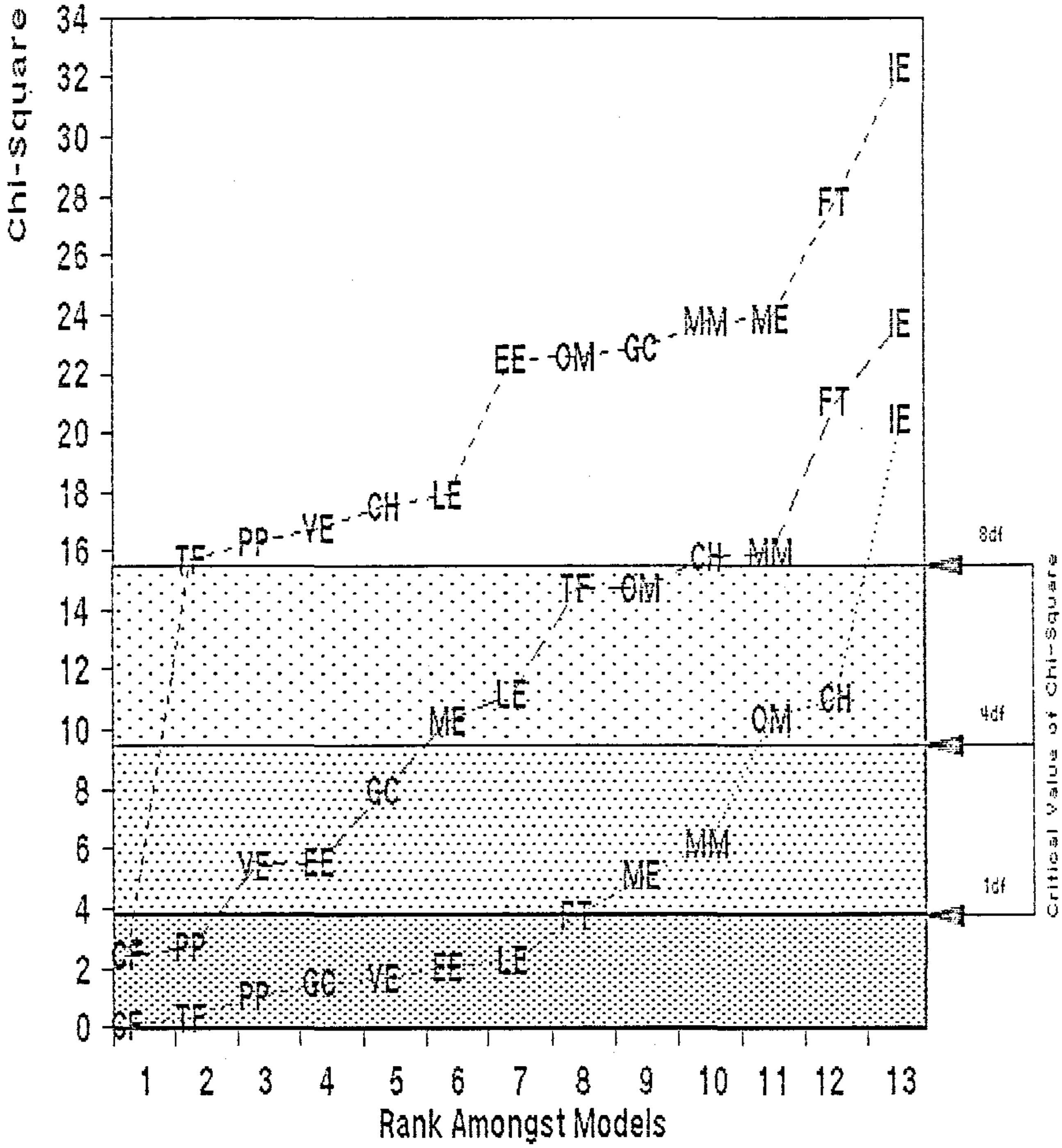


FIGURE 6.9 - Static Linear Model - Lagrange Multiplier Tests



Acceptable range for 8 th order Lagrange Multiplier test — 8 th order test

Acceptable range for 4 th order Lagrange Multiplier test — 4 th order test

Acceptable range for 1 st order Lagrange Multiplier test — 1 st order test

It is clearly important that the model is not autocorrelated. When it is, the statistical properties of the model are less reliable.

6.6.1 Tests for Autocorrelation

In a static model the Durbin-Watson statistic can be used to test for the presence of first order autocorrelation. Higher order autocorrelation can be tested by a similar method. The test is invalid when a lagged dependent variable is present. In these circumstances the D-W statistic is biased towards two. If the statistic is still beyond or inside the inconclusive region then autocorrelation is present, and is a problem. If the D-W statistic is within the acceptable region autocorrelation may still be a problem. The D-Ws of the static linear model are shown in Figure 6.8. This indicates that only TF and CF have acceptable D-W statistics. Most models show the D-W to be in the inconclusive region, and in the case of OM, IE, and CH, autocorrelation is a problem. A D-W test could be calculated for fourth order autocorrelation but this is not a popular test. There are easier alternatives.

Visual inspection of the residuals, as in figure 6.7, is a good starting point when checking for autocorrelation. It can instantly reveal the order of autocorrelation, the extent of the problem, and may give some clues to its cure. For instance, the years of expanding output between 1976 and 1980, between the oil price shocks, reveal mostly positive residuals.

Durbin's h statistic could be used in the presence of a lagged dependent variable. This is not always defined, however, and the *Lagrange Multiplier Test* was chosen in preference for its simplicity of calculation and its application to all orders of autocorrelation.

The lagrange multiplier test can be used with or without lagged dependent variables. The result of the lagrange multiplier test is shown in figure 6.9 for first, fourth, and eighth order autocorrelation. This shows the extent of the autocorrelation problem. If the lagrange multiplier is less than the critical value of Chi-squared, then autocorrelation is probably not present.

6.6.1.1 Calculating the Lagrange Multiplier

The residuals from the original equation are regressed against all the explanatory variables in the original equation plus the first p lags on the original residuals. If $nR^2 > \chi^2(p)$ then autocorrelation is present. Where n is the number of observations in the original equation and p is the order of the autocorrelation test. At the 95% confidence level the value of $X^2_{(1)}$ is 3.84 and $X^2_{(4)}$ is 9.49 (first and fourth order tests respectively).

The D-W statistic, *d*, can give a first approximation for p since $d \approx 2(1-p)$.

6.6.2 Solution for Autocorrelation

When autocorrelation is present the model must be transformed to one with serially independent errors. This can be achieved by lagging the original model and multiplying by p. In the case of only one independent variable this gives:

$$Y_t = a + bX_t + u_t \qquad (2)$$

Lagging (2) by one period for first order autoregressive correction and multiplying by p gives:

$$pY_{t-1} = pa + bpX_{t-1} + pu_{t-1} \quad (3)$$

Subtracting (3) from (2) gives the transformed equation with serially independent errors:

$$Y_t - Y_{t-1} = a(1-p) + b(X_t - pX_{t-1}) + e_t \qquad (4)$$

(Y_{t-1}) could be regressed on ($X_t - X_{t-1}$) using OLS if p is known. Correction for the specific pattern of autocorrelation is known as Generalised Least Squares (GLS). These estimates are the *best* estimates for autocorrelated models.

The Cochrane-Orcutt technique is the most commonly used method for obtaining estimates of p, and it is the method I have used. It is the method used by most econometrics package including those used in this study. In quarterly time series, first and fourth order autocorrelation are most common, although I have also tested for eighth order.

An estimates of p is obtained thus:

1 Apply OLS to the original equation.
2 Regress the errors of the original equation on their value lagged l periods, where l is the order of autocorrelation being corrected.
  $u_t = b.u_{t-l} + v_t$
3 The coefficient of u_{t-1} is the estimate of p.
4 Substitute this estimate of p into the transformed equation (3) and estimate using OLS.
5 Repeat the process until the estimates of p converge.

Most econometric packages perform these steps automatically.

6.7 LAGGED DEPENDENT VARIABLE - VIOLATION OF ASSUMPTION 4

Changes in the independent variable in previous periods is sometimes a relevant explanatory variable. If this is the case, and is not included in the model, then sales in period t are determined partly by the disturbance in t-1. If sales in t-1 is included as an explanatory variable, as in the Koyck Transformation, sales in t will be not be independent of the disturbance in t-1. If the lagged dependent variable was also determined by the error in t-2 sales will not be independent of the error in t-2 and so on. Sales is correlated with all previous disturbances but *not* with current or future disturbances. The coefficient of $sales_{t-1}$ is therefore biased but it is consistent.

The Koyck Transformation generates a moving-average error term. The coefficient of lagged sales is the same as the coefficient of the moving-average error term. A *weighted-regression* technique is required to estimate this model. Cochrane-Orcutt is an appropriate technique in these particular circumstances (this model could be re-interpreted as a case of errors-in-variables).

6.8 HETEROSCEDASTICITY - VIOLATION OF ASSUMPTION 3a

For the disturbances to be homoscedastic the diagonal elements of the variance-covariance matrix of the disturbance vector should be identical.

Examination of the residuals against each explanatory variable indicates no obvious sign of heteroscedasticity. If errors are correlated with output, or temperature the cause is measurement error or specification error and not heteroscedasticity. There are no obvious reasons to suggest that the variation in the true model should change with the size of any of the explanatory variables.

TABLE 7.1 - Guide to the Models

ESTIMATION TECHNIQUE

K Koyck Transformation

LS Ordinary Least Squares

C1 First Order Cochrane-Orcutt

C4 Fourth Order Cochrane-Orcutt

C14 First and Fourth Order Cochrane-Orcutt

MODELS

Attributes	M	S	F	L	C
Variable Output Elasticity				☐	☐
Quadratic Temperature				☐	☐
Linear	☐				
Logarithmic		☐	☐	☐	☐
RELative Fuel Prices		☐		☐	
Electricity/Cost of CAPital			☐		☐
Seasonal Dummies	☐				

TABLE 7.1 cont.

OUTPUT DATA

1 East Midland Seasonally Adjusted

2 East Midland Not-Seasonally Adjusted

3 UK Seasonally Adjusted

4 UK Not-Seasonally Adjusted

MODELS TESTED AND RESULTS PRESENTED IN APPENDIX V

Model

Estimation Technique	M	S	F	L	C
LS	M3LS				
KLS	M1KLS M2KLS M3KLS M4KLS	S2KLS S4KLS	F2KLS F4KLS	L2KLS L4KLS	C2KLS C4KLS
KC1	M1KC1 M2KC1 M3KC1 M4KC1	S2KC1 S4KC1	F2KC1 F4KC1	L2KC1 L4KC1	C2KC1 C4KC1
KC4	M1KC4 M2KC4 M3KC4 M4KC4	S2KC4 S4KC4	F2KC4 F4KC4	L2KC4 L4KC4	C2KC4 C4KC4
KC14	M1KC14 M2KC14 M3KC14 M4KC14				

CHAPTER 7

ESTIMATION RESULTS

Many models have been estimated in the course of this study, including polynomial distributed lag models, but I have concentrated on presenting the set of models utilising the Koyck Transformation. These show some important and striking results and reveal a lot about the data used.

Five different combinations of variables are used for the models, and these are estimated in five ways:

1 Static model by OLS;
2 Koyck Transformation by OLS;
3 Koyck Transformation with first order Cochrane-Orcutt;
4 Koyck Transformation with fourth order Cochrane-Orcutt;
5 Koyck Transformation with first and fourth order Cochrane-Orcutt.

Four different sets of data are used:

1 EM seasonally adjusted;
2 EM non-seasonally adjusted;
3 UK seasonally adjusted;
4 UK non-seasonally adjusted.

This gives 100 possible combinations to examine for 13 industries, giving 1,300 equations to evaluate. The total number of regressions estimated was close to 13,000 (including lagrange multiplier tests and models estimated but not presented). This amounts to a pile of regressions about seven feet tall! A guide to the models presented in the thesis is shown in table 7.1, and the results of the estimations are given in appendix V. The very large number of equations estimated have made it necessary to include many summary tables so that models can be compared. It is relatively easy to estimate a large number of equations but drawing meaningful conclusions is more difficult.

I have attempted to compare and choose between models with:

1	non-adjusted	and	seasonally adjusted output data;
2	EM	and	UK output data;
3	OLS	and	Cochrane-Orcutt;
4	logarithmic	and	linear models;
5	seasonal dummies	and	non-seasonal dummies;
6	constant	and	variable elasticity.
7	relative fuel prices	and	user cost of capital;

Items 1 to 3 can be examined within the context of the linear model, M, described in 7.1. A similar model in logarithmic form is examined in 7.2. This is essentially the same model as in 7.1 but gives the elasticities more easily. I have also dropped the seasonal dummies since they are of little use. Section 7.3 examines the idea of variable elasticities, and 7.4 introduces the *User Cost of Capital*, a variable to measure the rate of plant replacement, and hence technological change. The statistical validity of each model is also examined in detail.

Paper, Printing and Publishing appears in some tables but is not included unless it appears explicitly. As discussed previously, unadjusted data was unavailable to me when estimating the models. This is a pity because it is a well defined industry both before and after the 1980 reclassification. Leather and Leather Goods, LE, is not estimated for EM since data is not available in the Annual Census of Production Summary Tables.

7.1 DYNAMIC LINEAR MODEL

Non-seasonally adjusted output data is preferred to seasonally adjusted data. In all models there are more, or as many significant variables in the model with unadjusted data as there are in similar models with adjusted data. There is also a tendency towards less serial correlation in the models with unadjusted data.

TABLE 7.2 - Seasonally Adjusted v Unadjusted EM Output Data

(Linear Models)

EAST MIDLAND Output Co-efficients — Mean Difference between — Inter-Model

Model	KLS		KC1		KC4		KC14		Adjusted and Unadjusted Data Comparisons					
.	ADJ	NON-ADJ	ADJ	NON-ADJ	ADJ	NON-ADJ	ADJ	NON-ADJ	KLS	KC1	KC4	KC14	EM	UK
PP	94	94	74	74	156	156	115	115	0.00%	0.00%	0.00%	0.00%	74.72%	74.72%
	1.43	1.43	1.21	1.21	1.87	1.87	1.44	1.44						
GC	241	235	202	198	459	457	434	436	2.52%	2.00%	0.44%	0.46%	76.95%	78.13%
	1.52	1.51	1.28	1.27	2.29	2.36	2.17	2.27						
CH	313	343	251	256	274	295	241	246	9.15%	1.97%	7.38%	2.05%	26.69%	34.04%
	1.26	1.37	1.57	1.59	1.17	1.26	1.44	1.46						
ME	1434	1355	1242	1233	1304	1243	1537	1327	5.67%	0.73%	4.79%	14.66%	21.39%	9.46%
	4.62	5.06	3.96	4.49	5.5	6.01	6.42	6.31						
EE	104	115	72	76	93	97	71	71	10.05%	5.41%	4.21%	0.00%	38.82%	49.03%
	2.15	2.53	2.17	2.31	1.94	2.08	2.09	2.11						
VE	669	688	417	480	528	542	471	619	2.80%	14.05%	2.62%	27.16%	48.35%	35.72%
	2.09	2.47	1.51	1.83	1.62	1.77	1.17	1.67						
FT	645	668	275	350	320	334	328	339	3.50%	24.00%	4.28%	3.30%	94.39%	79.01%
	2.18	2.34	1.43	1.96	2.12	2.23	2.08	2.17						
LE	4	4	2	3	4	4	2	4	0.00%	40.00%	0.00%	66.67%	66.67%	26.67%
	1.5	1.61	1.08	1.17	1.35	1.53	0.55	0.93						
CF	-20	-15	-32	-30	-28	-30	-33	-35	-28.57%	-6.45%	-6.90%	-5.88%	-46.02%	-72.73%
	-0.42	-0.33	-0.86	-0.86	-0.54	-0.62	-0.89	-1.02						
TF	21	30	18	20	40	41	32	37	35.29%	10.53%	2.47%	14.49%	79.28%	65.63%
	0.81	1.16	0.95	1.04	1.81	1.91	1.56	1.69						
OM	85	103	24	27	120	131	136	146	19.15%	11.76%	8.76%	7.09%	122.74%	116.95%
	0.44	0.54	0.16	0.18	0.77	0.84	1.16	1.24						
MM	210	252	286	299	758	754	719	710	18.18%	4.44%	0.53%	1.26%	111.10%	99.65%
	0.52	0.64	0.95	1	1.81	1.85	2.35	2.34						
IE	97	106	68	70	73	78	55	58	8.87%	2.90%	6.62%	5.31%	57.34%	61.54%
	2.3	2.63	2.31	2.41	1.84	2.06	1.9	1.97						

East Midlands output data does not perform as well as UK output data on t-tests when account is taken of first order serial correlation. This is an indictment of the way regional data is collected. The BSO suggest there is only a small error in the collation of output statistics due to differences in the accounting year of firms. These models indicate otherwise. The error is a serious hindrance to precise estimation of the East Midlands output coefficient. It also makes statistical tests of the significance of the coefficients invalid. This confirms the pre-estimation view of the data discussed in chapter 4.

East Midlands output data also falls down where the definition of the industries changed in the 1980 reclassification of SIC codes. Sometimes the new definition cannot be reconciled to the old definition of the industry. This problem can be overcome by requesting the BSO to supply output for the EMEB region by EMEB trade code. The BSO charge for this service to cover their administrative and clerical costs. The information is expensive and was not obtained for this thesis.

7.1.1 Comparison of Seasonally Adjusted and Unadjusted Model

OUTPUT

Table 7.2 shows the size of the errors in measurement of the output coefficient if seasonally adjusted EM output data is used instead of non-adjusted data. The percentage error is the difference between the coefficients divided by the mean of the coefficients. In the Kls version (i.e. Koyck lag estimated by OLS) the error is between 0% for LE and 35.29% for TF. The small error in the case of LE is due to rounding the coefficient to the nearest integer. Large percentage errors are common, highlighting the importance of using unadjusted output data. Using non-adjusted data gives a wider range of observations on the output variable and should help to give more efficient estimates.

The choice of technique also determines the size of the output coefficient. Table 7.1 also gives the variation across the four methods of estimation, kls, kc1, kc4, and kc14. The difference in size of the output coefficient occurring because of different estimation techniques is even larger than the variation due to using adjusted data, ranging from under 10% to over 120%. The choice of technique is therefore also important to successful forecasting.

OLS estimation of the Koyck model shows that in 9 cases out of 11 (PP excluded) the t-value of the output coefficient is more significant using non-adjusted East Midland data than using seasonally adjusted East Midland data. A similar result holds for UK data with 10 out of 12 cases where the unadjusted t-value is better than the t-value for adjusted data. In many cases the improvement is very significant.

In 9 out of 12 cases the output coefficient is larger when non-adjusted East Midland data is used. This larger output effect is expected with non-adjusted data since more of the variation in sales is accounted for by the output effect. In the other three cases the difference is insignificant. Six out of 12 cases show non-adjusted data to give higher coefficients when UK data is used. This is because UK data is inappropriate.

One would expect higher and more significant coefficients by using unadjusted output data. This has been proved true in most cases.

OTHER VARIABLES

Unadjusted data gives slightly more optimistic t-values for the seasonal dummies, although the coefficients of the dummies are not much smaller. This would be expected since the output variable should be picking up the seasonal movements. The result seems to indicate that seasonal movements in electricity sales do not necessarily move in line with seasonal movements in

TABLE 7.3 Number of Significant variables in OLS Koyck Transformation Models

	E Midland Adjusted	E Midland Not-Adjusted	U K Adjusted	U K Not-Adjusted
Constant	5 (9)	6 (9)	5 (6)	4 (4)
S1	0 (1)	0 (2)	0 (0)	0 (2)
S2	4 (4)	4 (6)	3 (4)	4 (7)
S4	2 (2)	2 (2)	2 (2)	2 (2)
Output	4 (5)	5 (5)	6 (8)	8 (8)
Price	6 (6)	6 (6)	6 (6)	6 (6)
Temperature	6 (10)	6 (10)	7 (10)	8 (10)
Capacity	3 (4)	3 (3)	2 (2)	2 (2)
LDep	7 (10)	8 (10)	5 (8)	8 (9)
Σ	38 (51)	40 (53)	36 (46)	42 (50)
1 order LM Test	5	5	7	7
4 order LM Test	3	3	5	6

output. The temperature variable does not improve significantly when unadjusted data is used. This seems to indicate seasonal movements in electricity sales exist which are also independent of temperature - since the seasonal adjustment does not take out any temperature effect!.

In only 2 out of 10 cases the capacity utilisation variable is more significant when unadjusted data is used. When adjusted data is used the capacity variable picks out the seasonal variation in output since it is *not* adjusted. This tends to confirm the view that the capacity variable should be used to adjust the elasticity of output rather than be included as a first order effect, since both output and capacity variables are measuring the same effect.

The coefficient of price varies very little between adjusted and unadjusted data.

In 9 cases out of 10 the lagged dependent variable is more significant with unadjusted output data. Where the opposite is true the difference is tiny.

The lagrange multiplier test indicates less autocorrelation in the unadjusted data. So not only are the t-values of the unadjusted model generally much better, they are more valid. Clearly, *unadjusted data is preferable!*

7.1.2 Comparison of EM and UK Output Data

Seasonally adjusted UK output data gives superior results to seasonally adjusted East Midland data. T-values of output are superior in all but two cases, and there is also less 1st and 4th order autocorrelation. In the same two models price is more significant in the UK data model.

TABLE 7.4 - Number of Significant Variables in Koyck Lag Models when Estimating with First Order Cochrane-Orcutt

	E Midland Adjusted	E Midland Not-Adjusted	U K Adjusted	U K Not-Adjusted
Constant	2	2	3	3
S1	0	0	0	2
S2	6	7	5	6
S4	3	3	2	3
Output	3	3	7	8
Price	2	2	5	5
Temperature	7	9	7	9
Capacity	3	3	2	2
LDep	11	10	9	9
AR(1)	8	8	6	6
Σ	45	47	46	53
1 order LM Test	12	12	10	11
4 order LM Test	5	7	8	8

TABLE 7.5 - Number of Significant Variables in Koyck Lag Models when Estimating with Fourth Order Cochrane-Orcutt

	E Midland Adjusted	E Midland Not-Adjusted	U K Adjusted	U K Not-Adjusted
Constant	4	4	5	5
S1	2	1	1	0
S2	3	3	3	3
S4	1	3	1	0
Output	3	6	6	7
Price	2	2	4	5
Temperature	8	8	9	9
Capacity	1	1	1	1
LDep	10	10	8	8
AR(4)	3	3	3	3
Σ	37	41	41	41
1 order LM Test	6	7	10	10
4 order LM Test	6	6	8	9

Table 7.3 gives the number of variables in each equation significant at the 95% level. Numbers in brackets indicate the number of variables significant at the 90% level. The total number of equations examined is 12. The table also shows the number of equations where the lagrange multiplier test shows absence of autocorrelation.

This indicates that UK non-adjusted data gives the best overall results on the number of significant variables of the correct sign at the 95% level of significance. It also shows this model exhibits less serial correlation than the other models. There are several reasons why this is has occurred when one would expect East Midland non-adjusted data to give better results. These problems stem from the reclassification of Industrial codes in 1980, the period covered by the Annual Census of Production and mis-specification of the model.

The problems with the period covered by the Annual Census of Production become more apparent when 90% confidence limits are examined. These indicate that the East Midland Non-Adjusted model is superior on the number of significant variables criterion. It is no surprise that the number of times the lagged dependent variable is significant is greater in the East Midland data. The lagged dependent variable includes the effect of the inaccurate allocation of output to the appropriate time period. This also introduces additional serial correlation into the data. This is evident in the lagrange multiplier tests.

7.1.3 Autocorrelation

Tests of significance on the variables are invalid when autocorrelation is present. Table 7.3 indicates that autocorrelation is a widespread problem. It is present in just over half the cases. This renders the results of table 7.3 useless by themselves. Cochrane-Orcutt estimation can help to overcome the problems associated with autocorrelation. Tables 7.4 and 7.5 show the results of Cochrane-Orcutt estimation on the same model. First order autocorrelation is the most serious problem indicated by table 7.3. Estimation of the models using first order Cochrane-Orcutt and gives the greatest improvement in the results. Fourth order Cochrane-Orcutt also makes a substantial reduction in the degree of autocorrelation present in the model, especially with UK data. First order autocorrelation is more prevalent in East Midland data than fourth order - as one would expect from the construction of the output data.

First order Cochrane-Orcutt estimation improves the significance of the variables *and* reduces serial correlation. Lagged dependent variables are again more important in the East Midland models (perhaps because of the failure of the output variable) and the significance of the output coefficients falls. In the UK models the significance of output is unaffected. Lagged dependent variables in the East Midland model pick up the lags in the collation of the Census of Production data and any lags due to units sold but not yet billed.

7.1.4 Multicollinearity

Multicollinearity a very serious problem in this simple specification of the industrial model. The most serious sources of multicollinearity are between output and capacity utilisation, and between degree days and the seasonal dummies. This was discussed in chapter 6.2.

One of the most serious offenders is Seasonal Dummy One and Quarterly Degree Days. This manifests itself in the lack of significant first seasonal dummies in the models above. Another problem lies in the correlation between capacity utilisation and output. Again this shows in the poor significance of some of the coefficients of output and capacity.

Multicollinearity must take some of the blame for the poor significance of output, along with poor definition of the output and sales variables. Multicollinearity can be cured in this instance by increasing the sample size. This will give a wider selection of observations on each variable for each value of the other variables. For example, it would give more observations on temperature for each quarter, and so enable the distinction between sales due to temperature, and sales due to other seasonal effects, to be more confidently estimated.

7.1.5 Comments on Variables

The constant and seasonal dummies are less significant than one would have thought. This partly reflects the collinearity with temperature, which one would have thought would also be more significant.

Output performs very poorly although it is theoretically *the* most important determinant of electricity sales. East Midland output is less significant than UK output, although that is a fault of the data. Collinearity with capacity reduces the significance of the output coefficient.

Being optimistic one might suggest price is significant in half of the industries, but after correcting for serial correlation the significance of price falls. This is especially true for EM output.

Lagged dependent variables are more important when using EM output. This is expected when one examines the formulation of the EM index of production.

TABLE 7.6 Price Elasticities for EM Unadjusted Models

	fKls		fKc1		fKc4	
	Immediate	Final	Immediate	Final	Immediate	Final
PPS	**-0.50069**	**-0.53540**	**-0.48042**	**-0.53008**	0.02246	0.029241
	-5.94		-5.2		0.17	
GCS	**-0.14936**	**-0.26650**	**-0.18549**	**-0.24060**	-0.067698	-0.12422
	-2.7		-2.21		-0.92	
CHS	**0.33624**	**0.552000**	**0.20437**	**0.605702**	**0.33802**	**0.603187**
	3.38		3.6		2.52	
MES	-0.02528	-0.02585	-0.03107	-0.03252	-0.02613	-0.03145
	-0.36		-0.59		-0.27	
EES	**-0.5411**	**-0.56071**	**-0.5348**	**-0.54408**	0.02732	0.047725
	-5.87		-5.09		0.23	
VES	-0.05091	-0.05747	-0.04256	-0.05234	0.13078	0.137831
	-0.31		-0.31		0.65	
FTS	**-0.43793**	**-0.54185**	-0.05079	-0.31224	0.14545	0.307076
	-4.51		-0.79		1.79	
CFS	**0.3458**	**0.437267**	**0.3443**	**0.442277**	**0.34778**	**0.431510**
	6.49		7.47		5.29	
TFS	**-0.38441**	**-0.45627**	**-0.38307**	**-0.44944**	0.12823	0.187835
	-5.22		-4.55		0.89	
OMS	**-0.3143**	**-0.39569**	**-0.27083**	**-0.34436**	-0.01204	-0.01992
	-3.64		-4.43		-0.09	
MMS	**0.52492**	**0.926225**	**0.95632**	**1.159288**	**0.67307**	**1.410545**
	5.32		4.82		4.63	
IES	**-0.33453**	**-0.51729**	**-0.40035**	**-0.46289**	**-0.13596**	**-0.17350**
	-4.84		-4.16		-1.32	

significant variables in heavy type

TABLE 7.7 - Comparison of Output Elasticity in Logarithmic Model between EM and UK Unadjusted Data

(OLS model)

	EM Output Data		UK Output Data	
	Short-run	Long-run	Short-run	Long-run
PPS*	**0.57**	**0.61**	**0.61**	**0.68**
	3.80		3.05	
GCS	0.04	0.08	**0.52**	**0.65**
	0.45		4.09	
CHS	**0.47**	**0.77**	**0.40**	**0.69**
	2.44		2.15	
MES	**0.98**	**1.00**	**0.96**	**0.99**
	3.83		4.45	
EES	**0.20**	**0.21**	**0.32**	**0.32**
	2.25		2.75	
VES	**0.44**	**0.50**	**1.37**	**1.38**
	2.66		3.19	
FTS	-0.08	-0.09	**1.66**	**1.42**
	-0.46		4.16	
CFS	**0.35**	**0.45**	**0.40**	**0.47**
	2.03		2.78	
TFS	0.32	0.38	**0.70**	**0.74**
	1.85		4.43	
OMS	0.16	0.20	**0.47**	**0.55**
	1.14		2.61	
MMS	-0.07	-0.13	**0.86**	**1.05**
	-0.73		6.15	
IES	**0.22**	**0.34**	0.19	0.31
	3.00		1.24	

Significant variables in heavy type

* Seasonally Adjusted Data

7.2 DYNAMIC LOGARITHMIC MODEL

This model is similar to the dynamic linear model except that the seasonal dummies have been dropped. It allows easier access to the elasticities. It is perhaps also a more appropriate model since the variables in the logarithmic model are multiplicative. If the errors of the linear model were normal, then the residuals of the logarithmic model will be distributed log normally. It is more likely, however, that the residuals of the logarithmic model are normally distributed. The complete set of elasticities is shown in the *F* models of appendix V.

7.2.1 Price Elasticity

Table 7.6 shows the short and long run price elasticities estimated from the OLS model. The *short-run* impact of each variable, that is, in the same time period, and the long-run impact, after all adjustments have been made, are shown for each industry. Significant price effects in the OLS model with a negative sign shows short-run elasticity varying between -0.15 and -0.54, and the long-run elasticity between -0.27 and -0.56. Price is significant and negative in seven of the twelve cases. A similar result hold for first order Cochrane-Orcutt, but amazingly, fourth order Cochrane-Orcutt reveals no significant negative price effects!

7.2.2 Output Elasticity

The logarithmic model gives an opportunity to compare the output elasticities of the EM and UK models. This is shown in table 7.7. The different rates of growth in the UK and EM economy become visible in this table. The output elasticity estimated with a UK index of production and an EM index of production indicate different elasticities. In the case of Vehicles the elasticity using EM output data is 0.50 but using UK data the elasticity is 1.38! In most cases the elasticities are close but the above example indicates what large errors can be made by using inappropriate data. Some of the elasticities may not be true EM elasticities of course, because of problems with industrial classifications in the formulation of an EM index of production.

Clearly, it is beneficial to the accuracy of forecasting industrial electricity sales that *appropriate* output data is used. If not, avoidable errors will compound with each successive year of the forecast. Estimating the correct elasticity enables some of the inevitable forecasting inaccuracy to be eliminated.

7.3 RESPECIFICATION OF MODEL

The linear and logarithmic models with Koyck Transformation highlight some of the problems which need to be overcome. A more sophisticated model can now be formulated by incorporating some of the lessons learnt in the simple linear model. A new model is developed below incorporating the following:

1 Drop Seasonal Dummies

Seasonal variation in electricity sales occur because:

- output varies by season;
- temperature varies by season;
- energy required for lighting varies by season;
- price varies by season.

Energy required for lighting and heating are highly correlated and can thus be represented by one variable, temperature. Output and price are also included in the model. There is no theoretical reason why seasonal dummies should also be included. They are often significant in the linear model, however, and there are several explanations of their significance:

- the different seasonal pattern of production in the UK and the EM may not explain all the seasonal variation in output;

- inappropriate functional form for the temperature variable means that temperature may not fully explain the variation in electricity required for heating;

- mis-specification of the functional form of the model also explains the significance of the seasonal dummies. The model should be multiplicative so that temperature, for example, has a greater effect when output is higher;

- There are measurement errors in the dependent variable. These arise because electricity billed is used as a proxy for electricity sold. Some of these errors will appear in the coefficient of the lagged dependent variable. The errors will *not* be constant, however, but will exhibit seasonal variation themselves. Seasonal dummies will therefore pick up these errors. It is difficult to draw any concrete conclusions about the unbilled from this model since unbilled units are allocated to five variables - the constant, three seasonal dummies, and the lagged dependent variable. Mis-specification of the unbilled effect again induces autocorrelation. This gives fourth order autocorrelation.

2 <u>Specify a more Exact Relationship Between Temperature and Sales</u>

Two effects have to be modelled to account for the effect of temperature on sales. There is a relationship between temperature and the requirement for heat. There is also a relationship between output and electricity required for heating. The latter assumes that more premises are used to produce the increased output and those premises need heating.

- A linear relationship between temperature and sales is inadequate. The relationship is more complex. More heat is needed to maintain an internal temperature of 65^{o}F when the outside temperature drops from 33^{o}F to 32^{o}F than when the outside temperature drops from 61°F to 60°F. A squared or cubic relationship is more appropriate.

- A multiplicative relationship between temperature and sales can be reflected most easily in a double log model. The effect of temperature will then increase and decrease with output.

There is no reason to include a variable to represent the requirement of electricity for lighting since this is highly correlated with temperature. The coefficient of temperature will therefore represent the combined requirement for lighting and heating.

3 Change the Form of the Model

Because the variables are *all* multiplicative a double log model is theoretically the most appropriate model. It also has the neat advantage that elasticities are easily evaluated, as mentioned in section 7.2. Changing from a linear model to a logarithmic model could cause problems with the distribution of the error term. If the residuals were normally distributed in the linear model they will not be in the logarithmic model! It is far more likely that the residuals are normally distributed in the logarithmic model, however, than in the linear model.

4 Allow for Variable Elasticity of Output

One of the major problems with the logarithmic model is that it imposes a constant elasticity of sales with respect to output. The output coefficient is therefore allowed to vary with the degree of capacity utilisation. This allows a more precise estimate to be made of the effect of a change in output on electricity sales. The effect will depend on the amount of plant currently being utilised.

Nothing can be done to account for the difference between UK and

EM seasonal variation in output. The difference will unfortunately be partly incorporated in the temperature variable. This is because temperature varies by season, and quarterly UK data was used for the seasonal pattern in the East Midlands, which may be inappropriate. The errors this creates should be relatively small.

7.3.1 Re-formulated Model

Chapter 5 discussed the formulation of a general model. This was shown to be too demanding to be estimated from the data available at the moment. Some of the most important lessons from that chapter and from the estimation of a simple linear model are incorporated in a refined compromise between the two models. This gives a reasonably sophisticated reflection of reality which can be estimated.

The linear Koyck Model is :

$$S_t = \alpha_0+\alpha_1 S1+\alpha_2 S2+\alpha_3 S4+\alpha_4 O_t+\alpha_5 P_t+\alpha_6 T_t+\alpha_7 C_t+\alpha_8 S_{t-1}$$

Changing to a multiplicative model gives:

$$S_t=A.O_t^{\beta 1}P_t^{\beta 2}T_t^{\beta 3}C_t^{\beta 4}S_{t-1}^{\beta 5}$$

This can be transformed into a linear model by taking logarithms of both sides, and a quadratic term is added for temperature:

$$\log S_t=\Theta_0+\Theta_1\log O_t+\Theta_2\log P_t+\Theta_3\log T_t+\Theta_4\log T_t^2+\Theta_5\log C_t+\Theta_6\log S_{t-1}$$

Output elasticity is implicitly constant in this model. Making the coefficient of output a function of capacity utilisation allows output elasticity to vary according to the stage in the economic cycle. Therefore:

TABLE 7.8 - Number of Significant Variables in OLS Estimation of Preferred Model

(Unadjusted Data)

	East Midland	UK
Constant	12	12
Price	7	7
Temp	6	9
$Temp^2$	7	10
Output	5	8
CapOut	4	3
LDep	3	8
Σ	44	57
1 order LM Test	1	11
4 order LM Test	3	8

TABLE 7.9 Number of Significant Variables in First Order Cochrane-Orcutt Estimation of Preferred Model

	East Midland	UK
Constant	12	12
Price	7	7
Temp	10	8
$Temp^2$	10	8
Output	2	8
CapOut	4	1
LDep	10	4
AR(1)	2	3
Σ	57	51
1 order LM Test	10	10
4 order LM Test	8	9

TABLE 7.10 Number of Significant Variables in Fourth Order Cochrane-Orcutt Estimation of Preferred Model

(Unadjusted Data)

	East Midland	UK
Constant	12	12
Price	6	5
Temp	11	8
$Temp^2$	11	10
Output	3	8
CapOut	3	1
LDep	10	8
AR(1)	0	5
Σ	56	57
1 order LM Test	10	9
4 order LM Test	9	3

$\Theta_1=\Theta_7+\Theta_8 C$

Substituting this into the above, dropping the capacity utilisation variable, and the constant in the above formula for Θ_1 gives the final model to be estimated:

$$\log S_t=\Theta_0+\Theta_7\log O_t+\Theta_8 C\log O_t+\Theta_2\log P_t+\Theta_3\log T_t+\Theta_4\log T_t^2+\Theta_6\log S_{t-1}$$

The final equation above requires only 7 parameters to be estimated so leaves more degrees of freedom. It is also a more precise reflection of the true relationship between variables and remains simple and easily estimated. The model is estimated using EM and UK unadjusted output data.

7.4 RESULTS OF RE-FORMULATED MODEL

The model developed above was estimated and the results describe the electricity consumption characteristics of each industry. The new model is quite successful.

Summary tables of the success of these models are shown in table 7.8 for the OLS model, 7.9 for the first order Cochrane-Orcutt model, and table 7.10 for the fourth order Cochrane-Orcutt model. Autocorrelation is a problem for EM data for OLS estimation, and seems to have been introduced to the UK data by fourth order Cochrane-Orcutt estimation. There is really little to choose between the six models presented, except that OLS estimation and EM data does not produce good statistical results. It has the lowest number of significant t-values and the highest degree of first, and fourth order autocorrelation. The models again illustrate how sensitive they are to the particular output data used and to the choice of estimation technique.

CONSTANT

The constant is significant in every case. These models measure proportionate changes. The changes are not likely to be same over the entire range of values. The models estimate the changes over a fairly narrow range of observations and not the entire set. For example, indices of production may range from 80 to 120 but do not go down to zero. The model may provide a fair approximation to linearity over this range but this would not extend to the extreme values on the variables, especially output. This does not imply any specification error. The model is properly specified for the range of observations. There would not be sufficient variation in the data to estimate the precise relationship between variables over the complete set of possible observations. The constant therefore estimates the starting point for the current set of observations. For example, it represents the fixed element of consumption. In practise if output were zero, there would be no fixed consumption, since all firms would be closed down.

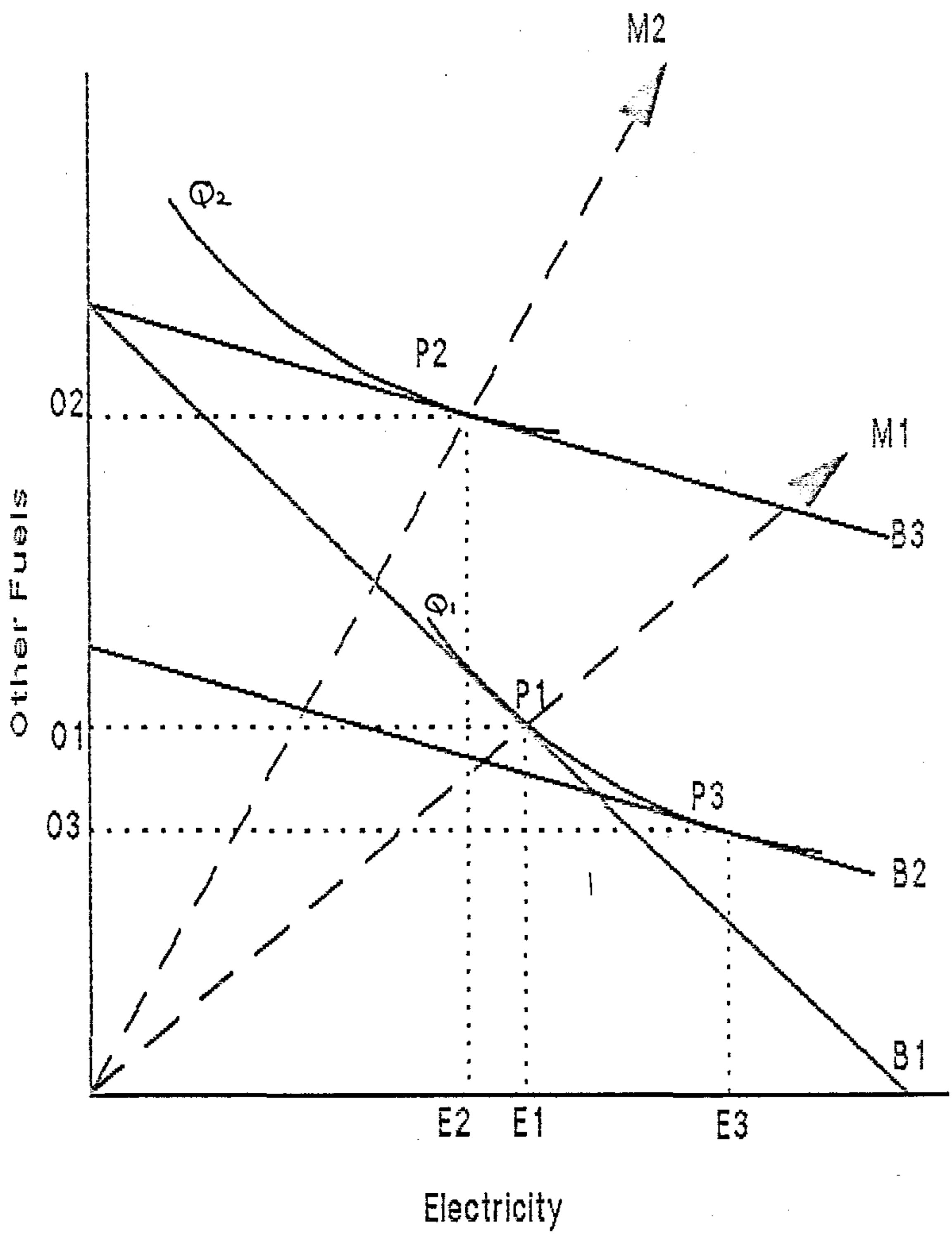
PRICE

Price is significant in over half the cases. It performs much better than in the linear models. In 1985 the price variable falls to half its value in 1975. There is therefore some variation in the price variable I use. Previous studies have suffered from lack of variation in the price variable, and have often given poor significance of the price elasticities. Oil prices have fallen significantly since the models were estimated. This fall in oil prices and the privatisation of British Gas have increased competition and may have a noticeable effect on electricity sales to industry. This will give additional variation to the price variable and will help to improve the significance of price in future models.

Short-run Elasticity

The short-run price effect, no matter how small, is almost certainly negative in all industries. Firms who act rationally will implement electricity saving measures when the price of electricity rises. Similarly, firms will utilise other fuels rather than electricity when the *relative* price of electricity rises - if they own plant utilising substitute fuels. Other

FIGURE 7.1 - Output and Substitution Effects of a Price Change

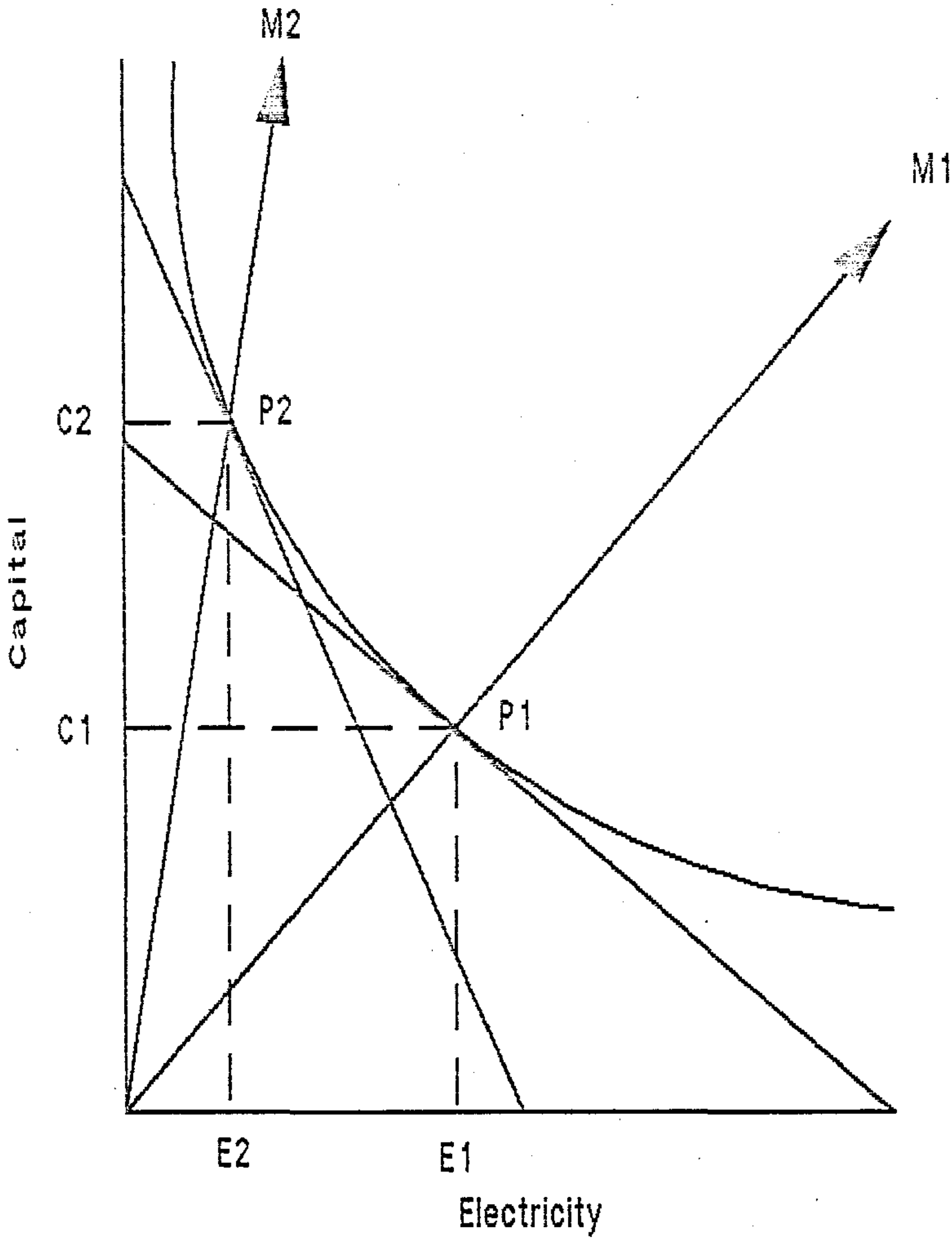


fuels and other factors of production are substitutes for electricity in the short-run, when capital employed is *fixed*. Most changes in the relative price of electricity and other factors of production are small, and slowly drift through time. The effect is therefore difficult to detect in a regression.

A fall in the price of electricity may cause a change in output, since costs will be lower, and firms will be willing to supply more output at each price. A change in output moves the firm onto a new isoquant. The effect of this on electricity consumption is indeterminate. The output effect may be positive, neutral, or negative. It may be greater or less than the substitution effect. When the output effect is more negative than the substitution effect is positive, then a fall in the price of electricity will appear to give a fall in electricity consumed. This is shown in figure 7.1. The initial equilibrium is P_1 on Q_1, using E_1 electricity and O_1 other fuels. The price of electricity falls, so the slope of the budget line changes since more electricity can be purchased from a given budget. The substitution effect causes electricity consumption to rise from E_1 to E_3. The price coefficient in this case is negative. Demand may also change, however. This would be especially likely if the fall in electricity price was passed on in a lower price of the product to the consumer. When demand increases, the firm may increase its output and move to the new isoquant Q_2. The shape and position of the new isoquant curve relative to the original one will determine the sign and magnitude of the output effect. In figure 7.1, the move from Q_1 to Q_2 gives a fall in electricity demanded as a consequence of the fall in electricity prices, by moving from production process M_1 to M_2.

There are documented cases where this characteristic has been observed. A particular customer operated a waste heat recovery system. This collected heat before it could escape into the atmosphere. The heat was used to create steam which fed a generator, making electricity. The lower pressure steam was used

FIGURE 7.2 - Substitution of Electricity and Capital



to heat the plant again. The company decided to insulate its plant. This is a typical response to an increase in fuel prices. Insulation meant that less energy was needed to heat the plant, and so the firm saved money. But it also meant less electricity could be generated themselves, so the company had to increase their purchases of electricity from EMEB. This is not an isolated case.

Long-run Elasticity

Capital can vary in the long-run. This introduces additional complexity. Figure 7.2 is similar to figure 7.1 except that the two factors of production considered are electricity and capital. Initially capital and electricity can be considered as substitutes in the production function. More capital will therefore be employed as the cost of electricity rises compared to capital. This is depicted in Figure 7.2. Firms change from process M_1 to M_2. They use E_2 electricity instead of E_1, and C_2 capital instead of C_1.

The additional complication arises because electricity and capital can be complements, as well as substitutes. In this case, when the cost of capital falls, whether it is relative to electricity or any other input, then more capital will be employed - and thus more electricity will be consumed. The cost of capital model below examines the relationship between electricity consumption and changes in the cost of capital.

In the L-series models of section 7.4, investment is not explicitly considered. Changes in capital is implied from changes in relative fuel prices in the long-run. The short-run elasticity is the immediate impact of a change in relative prices, and is given the coefficient of price. It represents the change to alternative factors of production as a consequence of a change in relative prices. The long-run elasticity is the final impact of a change in relative prices, represented by (price coefficient)/(1-coefficient of lagged dependent variable). The change in capital is implied.

The model developed in 7.5 makes changes in capital explicit.

One would expect most industries to exhibit a trend towards greater electricity efficiency in production. For a negative price coefficient to occur in the estimated equations therefore requires a substitution price effect to be present which is large enough to counteract the increased efficiency/increased output effect.

There are many factors besides the above arguments which determine the effect of a change in price. As electricity becomes more expensive, there is more incentive to reduce its use. Electricity saving investment will have a shorter pay-back period and so plans to conserve electricity will be implemented. The three day working week of the early 1970s showed many firms how much energy they used for non-essential purposes. As a result, many firms became more aware of how to save energy, and there has been a drift towards more efficient use of electricity since then despite the fall in industrial electricity prices. This might also be due to more efficient use of electricity by appliances. Investment is required to change the plant which a firm uses. This takes time, and the time varies between different industries. For example, it takes longer to install an electric arc furnace than it does to install electric water heating. Hendry's *Error Correction Mechanisms*, or polynomial distributed lags can be used to identify the time lag for each industry. Unfortunately, this is a lengthy process to do for each industry. The Koyck lag imposes the same lag structure on each variable. This is often inappropriate, since the adjustment of sales to a change in temperature may be immediate, whilst the adjustment due to a change in price may take over a year.

Even if relative prices change, and it becomes cheaper for firms to switch to oil, they may not if it requires investment in plant. A rational firm will consider the likely relative prices over the period of the investment, or the firm may not have capital to invest. The simple price variable cannot cover the many complex issues of price elasticity, a few of which I have discussed. Firms' perceptions of the future price of gas, oil, coal, and electricity, and the cost of investment, are probably as important as current fuel prices for determining long-run price elasticity. The concept of the cost of investment is examined a little further in 7.5.

Price is insignificant for ME and VE in the EM model. This is a reasonable result. These industries are electricity intensive. They use electricity for motive power for lathes, welding, and driving production line equipment. There is no alternative fuel for motive power - unless they revert to steam, or generating their own electricity, but this seems unlikely unless there are very large increases in relative electricity prices. Self generation is infeasible for most firms in these industries, who are small workshops.

Price sometimes has the wrong sign, suggesting perhaps that electricity is a Giffen *good*, and that as price falls, firms can afford to invest in alternative plant and machinery. This is not true, although it may be true that a fall in the price of fuels to industry boosts company profit, and so allows them to invest in new, more energy efficient plant. All the industries with positive price elasticities in the EM first order Cochrane-Orcutt model, L2KC1 in appendix V, occur in industries who have been hit most severely by recession over the period. They have undergone *severe* rationalisation. The output coefficient of these industries is also insignificant, indicating that there are fundamental changes in these industries. In one industry a firm has actually bought its own power station, hence the fall in its purchases of electricity from EMEB. MM has seen the loss of iron and steel production facilities at Corby which used to be over 5% of total industrial sales. There have been many other bankruptcies and dramatic cutbacks in production capacity. Most firms have not been making profits, and have tried everything within their capability to reduce their energy costs. Energy conservation is taken very seriously by managers in these firms. This perhaps explains why electricity consumption has fallen in this industry whilst relative electricity prices have fallen. It also explains why output bears little relationship to electricity consumption. A similar argument can be applied to CF.

Summarising the section on price elasticities we can say that :

- price substitution elasticities are negative;
- the output effect of a price change may be either negative or positive;
- the output effect may be larger than the substitution effect, making it appear as if electricity is an *inferior good*;
- the output effect exceeds the substitution effect most often in industries which have changed most over the period;
- I have estimated two different long-run effects, one of them based on changes in relative fuel prices and assuming a change in investment, and the other measures the rate of investment in response to changes in the price of electricity.

TEMPERATURE

The temperature variables performs extremely well, and much better than in the linear model. The coefficients are significant and negative in all industries with a space heating requirement, indicating a lower electricity requirement when temperature rises. They are not significant in GC or MM, whose operations are mostly outdoor, with a relatively insignificant space heating requirement for offices, much of which could be satisfied by works arising gas and steam. The temperature variable is degree days, which is specifically designed to measure the heat required to maintain a constant internal temperature. It is not therefore, by design, appropriate to these industries. The quadratic term is significant in all but the two cases above, thus justifying its inclusion. It also reduces the degree of autocorrelation in the model (I have estimated the equation without the quadratic term).

OUTPUT

Output elasticities are not as significant as they should be and give some cause for concern. Tables 7.8 to 7.10 show a maximum of five significant output elasticities (OLS model), although autocorrelation is a problem in this model, giving over-optimistic t-values. Part of the blame for the poor performance of output can be attributed to multicollinearity between log(O) and Clog(O). This cannot take all the blame, since output is not always significant in the simple logarithmic model of 7.2.

If 90% confidence limits are used instead of 95%, then only in three cases were neither log(O) or Clog(O) significant. If the coefficient of Clog(O) (CapOut) is insignificant and the coefficient of log(O) (Output) is significant then constant output elasticity is implied. Conversely, output elasticity varies with capacity utilisation if Output is insignificant and CapOut is significant. If both are significant, one element of consumption exhibits constant elasticity, whilst the elasticity of another element varies with capacity utilisation.
It is not necessarily a criticism of the model, therefore, that one of the output elasticities is insignificant. It is a feature of the model. Output will either be constant, or it will vary (with output in these models). Output elasticity may be changing over time, with changes in technology, for example. This could be tested in a similar way to how we tested whether elasticity varied with capacity utilisation. The output coefficient may be made a function of time.

LAGGED DEPENDENT VARIABLE

The lagged dependent variable is more significant in the EM models (see table 7.9 and 7.10). This must be due to the errors in the EM output variable. The lag in the data is being picked up by the lagged dependent variable. Its significance might also reflect what has been discussed, that price effects have strong lagged effects.

7.5 CHANGES IN THE STOCK OF CAPITAL

Changes in plant and machinery are important determinants of changes in electricity sales. The capital stock may change due to changes in the price of capital or electricity. The long-run effect of a change in electricity price is achieved through investment which changes the stock of electricity consuming plant. Whether this investment takes place will also depend on the cost of investment. These variables are substituted in the model of chapter 7.4 to measure the changes in the capital stock through which both the long-run price effect, and changes in technology take place. A similar variable is used by Kouvaritakis.

7.5.1 USER COST OF CAPITAL

The user cost of capital (LRK) is an index of Gross Fixed Capital Formation (GFCF) multiplied by an annuity factor (AF).

$$LRK = GFCF.AF$$

$$AF = \frac{r_t.e^{rt.T}}{e^{rt.T}-1}$$

GFCF = Gross Fixed Capital Formation deflated by the Wholesale Price Index

r_t = rate of interest on 5 year government bonds

T = the optimum time period for capital depreciation

Under pre-1986 tax legislation (before the scrapping of first year capital allowances) the optimum value of T is 1. The new long-run price variable becomes :

$$\frac{P^e_t}{LRK_t}$$

P^e_t is the price of electricity deflated by the Wholesale Price Index

7.5.2 User Cost of Capital Model (UCC)

These models do not perform as well as the relative fuel price models. In this set of models there is a higher incidence of autocorrelation. Electricity prices relative to the cost of changing technology/capital is less significant than the price of electricity relative to other fuels, and the t-tests are also more prone to over-optimism because of autocorrelation.

The new variable p^e_t/LRK_t is in many ways a better measure of electricity price since it is not consumption weighted like the composite price index of other fuels. The choice of price variable depends what is to be measured - the effect of a change in the price of electricity relative to the price of capital - or its price relative to other fuels. There are thus two price elasticities to consider, but only this one incorporates the technology effect.

TABLE 7.11 Number of Significant Variables in the OLS Koyck Lag Model

	E Midland Not-Adjusted	U K Not-Adjusted
Constant	12	11
Price	4	5
Temperature	3	10
Temperature^2	4	10
Output	8	6
Capacity/Output	3	8
LDep	1	10
Σ	35	60
1 order LM Test	1	8
4 order LM Test	1	5

TABLE 7.12 Number of Significant Variables in First Order Cochrane-Orcutt Estimation of Koyck Lag Model

	E Midland Not-Adjusted	U K Not-Adjusted
Constant	11	10
Price	3	6
Temperature	10	9
Temperature^2	11	9
Output	6	5
Capacity/Output	1	1
LDep	12	9
AR(1)	2	6
Σ	56	55
1 order LM Test	7	9
4 order LM Test	5	4

TABLE 7.13 Number of Significant Variables in Fourth Order Cochrane-Orcutt Estimation of Koyck Lag Model

	E Midland Not-Adjusted	U K Not-Adjusted
Constant	11	12
Price	3	2
Temperature	10	8
Temperature^2	11	8
Output	7	6
Capacity/Output	2	0
LDep	11	8
AR(4)	1	8
Σ	56	52
1 order LM Test	7	8
4 order LM Test	5	9

FIGURE 7.3 - Short-Run Price Elasticities (OLS)

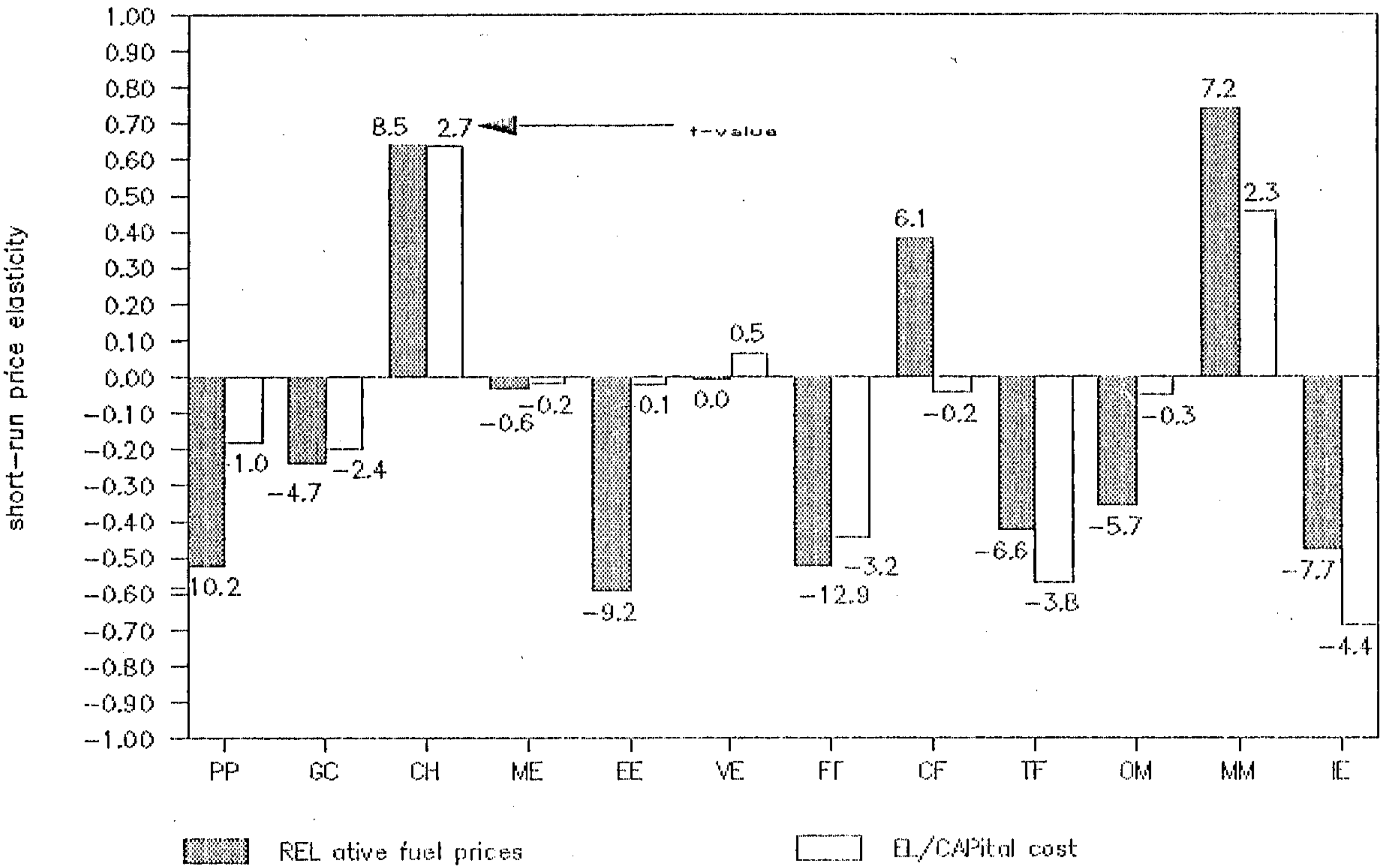


FIGURE 7.4 - Short-Run Relative Price Elasticities

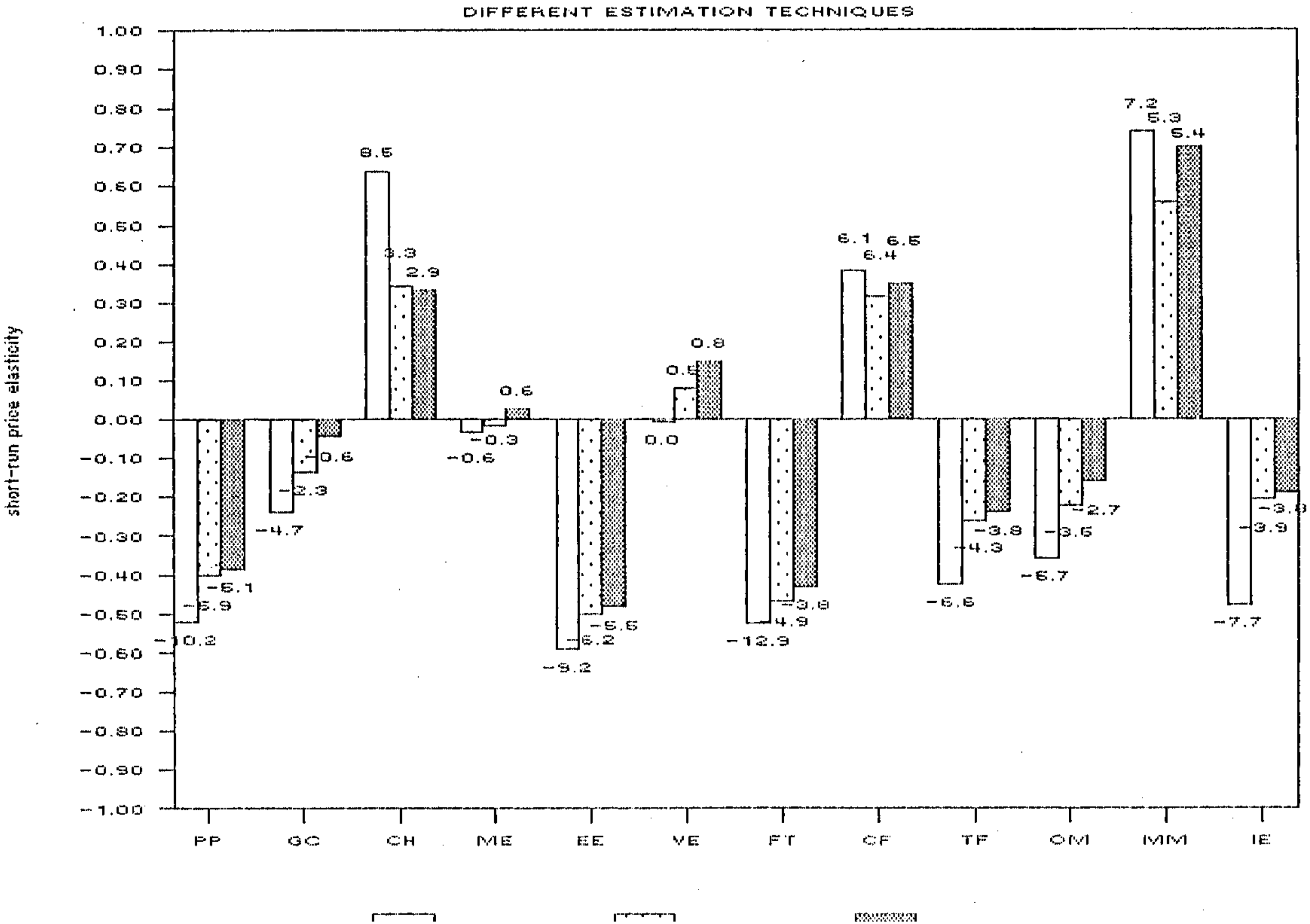


FIGURE 7.5 - Short-Run EL/CAPital Price Elasticities

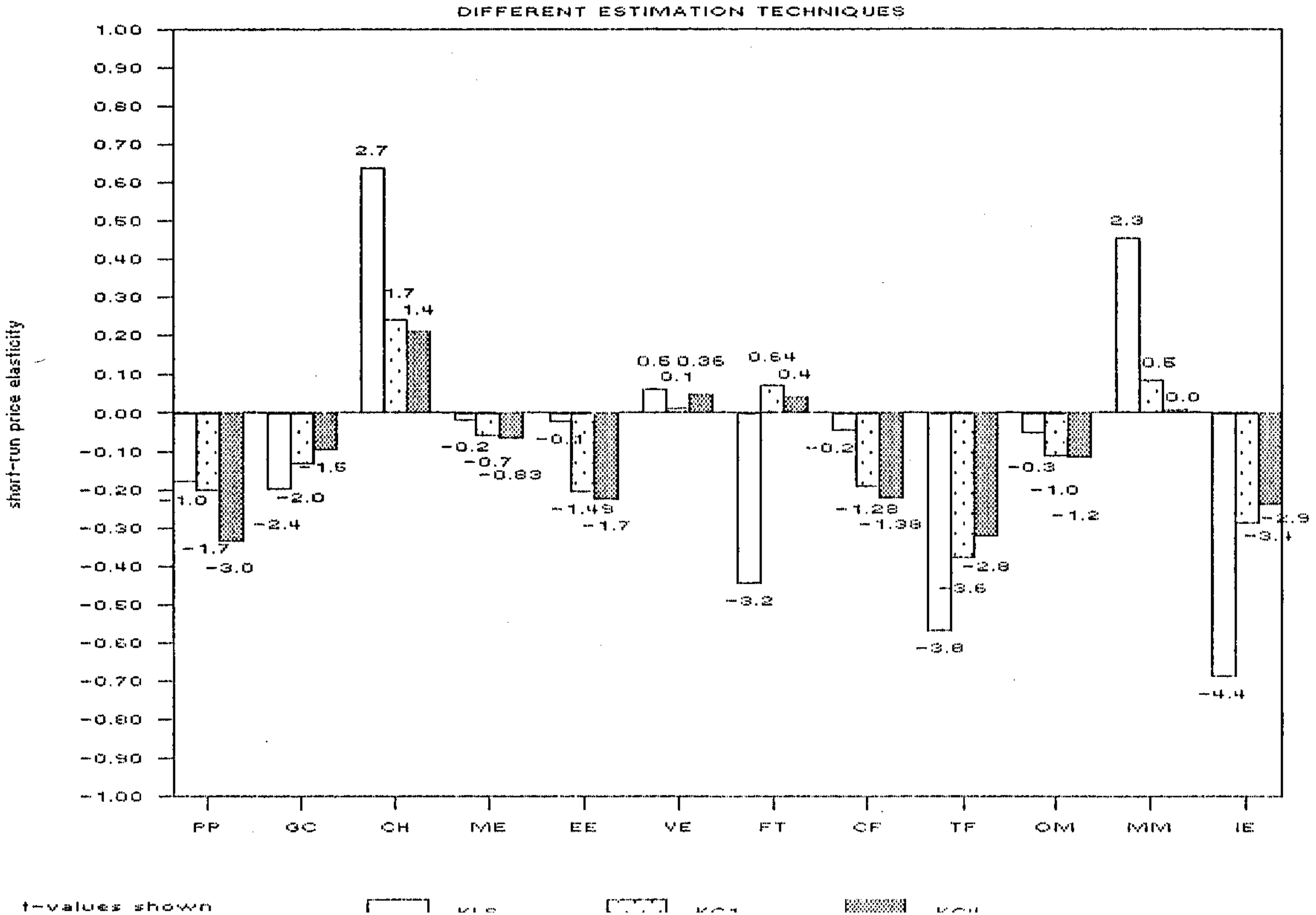


TABLE 7.14 - Short and Long-Run Price Elasticities for REL and UCC Models

KLS

	S-R Rel	S-R Cap	L-R Rel	L-R Cap
PP	**-0.52092**	-0.18008	**-0.52092**	-0.18008
GC	**-0.23672**	**-0.19808**	**-0.17350**	**-0.19808**
CH	0.63896	0.63609	0.12047	0.63609
ME	-0.03222	-0.01753	-0.01364	-0.01753
EE	**-0.59092**	-0.02017	**-0.59092**	-0.02017
VE	-0.00510	0.06299	-0.00165	0.06299
FT	**-0.52413**	**-0.44536**	**-0.16028**	**-0.44536**
LE	0.16186	0.11401	0.16186	0.11401
CF	0.38126	-0.04354	0.38126	-0.04354
TF	**-0.42450**	**-0.56884**	**-0.42450**	**-0.56884**
OM	**-0.35708**	-0.05051	**-0.13128**	-0.05051
MM	0.74117	0.45446	0.11345	0.45446
IE	**-0.47790**	**-0.68708**	**-0.12381**	**-0.68708**

KC1

	S-R Rel	S-R Cap	L-R Rel	L-R Cap
PP	**-0.40048**	-0.20061	**-0.50199**	-0.43381
GC	**-0.13575**	-0.13083	**-0.20226**	-0.23786
CH	0.34396	0.24102	0.67665	1.03790
ME	-0.01556	-0.05707	-0.01756	-0.06506
EE	**-0.50115**	-0.20560	**-0.57071**	-0.35457
VE	0.08027	0.01208	0.09898	0.01474
FT	**-0.46724**	0.07353	**-0.51577**	0.59596
LE	0.15826	0.05028	0.18526	0.05762
CF	0.31535	-0.19237	0.41444	-0.28396
TF	**-0.26199**	**-0.37721**	**-0.33980**	**-0.55852**
OM	**-0.22257**	-0.11089	**-0.31032**	-0.19731
MM	0.55944	0.08609	0.91032	0.22608
IE	**-0.20460**	**-0.28726**	**-0.35343**	**-0.59995**

KC4

	S-R Rel	S-R Cap	L-R Rel	L-R Cap
PP	**-0.38267**	**-0.33543**	**-0.49414**	**-0.82310**
GC	-0.04259	-0.09355	-0.06326	-0.14372
CH	0.33106	0.21139	0.68280	0.96012
ME	0.02744	-0.06653	0.03245	-0.07914
EE	**-0.48176**	-0.22425	**-0.57104**	-0.41291
VE	0.15038	0.04832	0.17965	0.05658
FT	**-0.42881**	0.04272	**-0.57263**	0.85083
LE	0.12205	0.02449	0.14166	0.02787
CF	0.35112	-0.22130	0.45442	-0.32128
TF	**-0.23983**	**-0.32048**	**-0.28647**	**-0.43425**
OM	**-0.15734**	-0.11588	**-0.25843**	-0.24252
MM	0.70180	0.00770	1.16727	0.02008
IE	**-0.18976**	**-0.23825**	**-0.28752**	**-0.45133**

* Significant Variables in Heavy Type

The number of significant variables appear in tables 7.11 to 7.13.

7.5.3 Price Elasticities in UCC Model

Price elasticities are not generally as negative or as significant as in the RELative prices models. This is consistent with the economic theories discussed previously. These models add weight to the argument that short-run changes in electricity consumption through changes in the capital stock are smaller than through changes due to relative fuel price movements. IE and TF are the exceptions to this, as shown in figure 7.3.

There are still some positive price effects, for MM and CH, although in the CF models price elasticity has become negative (although not significant). Short-run price elasticity of the UCC models reaches -0.7 in the case of IE in the OLS case. Table 7.14 shows the short and long-run price elasticities for OLS, first order Cochrane-Orcutt and fourth order Cochrane-Orcutt models. Long-run elasticities are larger than short-run elasticities, although the difference is not always great.

Estimated elasticities vary because of estimation techniques. The variation in elasticities due to technique is shown in figures 7.4 for the REL models, and in 7.5 for the UCC models. T-values are shown for each model, and it is plain that t-values fall when Cochrane-Orcutt estimation is used to overcome autocorrelation. In the OLS models, short and long-run price elasticities vary very little. The Cochrane-Orcutt models are more reliable, and they show a larger variation between short and long-run price elasticity. The variation is still not that large. Typically, the long-run effect is 20% greater than the short-run effect.

In the first order Cochrane-Orcutt model, which is perhaps the most realistic, the long run elasticity of IE and TF are quite large, at around -0.6 whilst the short-run elasticity is small at around -0.2 to -0.38. Large differences between short and long-run price elasticities would be expected. This is also the case for PP in the fourth order Cochrane-Orcutt model.

CHAPTER 8

CONCLUSIONS

Industrial sales models only are estimated since the area for study had to be reduced. The arguments presented apply equally to the commercial sector. For the first time, regional output data has been used in econometric models of electricity sales.

Marginal cost pricing is necessary for achieving optimal allocation of resources and electricity prices attempt to reflect LRMC. Forecasts of LRMC depend on forecasts of sales, and thus accurate forecasting is *vital* to efficient allocation of resources through LRMC pricing. Prices vary from true LRMC pricing because tariffs have to be simplified, and financial targets met. Non-marginal cost pricing may be justified in a "second best" economy, but not using marginal cost pricing because others do not would perpetuate sub-optimal pricing.

Estimates of price elasticity are necessary for the welfare maximising choice of tariff complexity.

Previous studies of UK industrial electricity sales highlighted problems with the choice of price variable, changes in industrial structure, changes in technology, and varying elasticity of output. I have overcome changes in industrial structure by forecasting by industry, rather than in aggregate. Changes in technology have been represented by the user cost of capital. Output elasticity has been allowed to vary with the degree of capacity utilisation, allowing industry to have increasing, decreasing, or constant elasticity of output. The problem of the price variable has not been solved.

A major feature of the study has been the extensive examination of the data used, and its consequences for the econometric properties of the models. EM output is preferred to UK output in the models to avoid biased, inefficient and inconsistent parameter estimates. There are tremendous problems with constructing a quarterly EM IIP but there are also problems with the UK IIP. This latter point is often overlooked. The EM output data from the *Annual Census of Production* is interpolated using UK published UK output data. An independent EM quarterly pattern of output is not available. The choice of deflator for the Census data adds to the errors in the EM (and UK) output data. Using EM data reduces the number of industries that can be examined with the models since data is not available for each industry.

There are also problems of classification. The reclassification of SICs in 1980 creates particular problems. It also unlikely that EMEB's classification of customers by MLH or SIC code corresponds the government classification. EMEB's forecasting codes differ from the current industry classes used, and this creates extra difficulties. The problems can be overcome, and are in most cases.

UK data for price, and capacity utilisation has to be used, whilst the data for degree days is for Birmingham.

EMEB sales data is not always from the same period due to lags in the billing cycle through early or late billing, or from the quarterly billing problem. These problems are likely to be small in the industrial models, although larger in some industries than in others.

The data problems above indicate that autocorrelation is a problem. This gives inefficient estimates and the statistical tests are overoptimistic, although parameters are unbiased and consistent. Parameter estimates will be biased and inconsistent as well if a lagged dependent variable is present. Models are therefore best estimated by a technique such as Cochrane-Orcutt, which corrects for autocorrelation. The Koyck transformation is used to include the dynamic effects of the model. It induces autocorrelation when none was present but will help to reduce it if autocorrelation is present, as in my models. Lagged dependent variables are more significant for EM models, because of the problems in the data.

Non-seasonally adjusted data is preferred to seasonally adjusted data. Seasonal dummies become insignificant when temperature is introduced into the models. This alleviates the need for the seasonal dummies. Seasonal adjustment of data induces autocorrelation and adds to difficulties of estimation.

Multicollinearity is present in the data sample, making estimates inefficient. This is not necessarily a problem when forecasting, since parameter estimates will still be unbiased. The nature of the multicollinearity means that it can be reduced by increasing the sample size. If a variable should be included on theoretical grounds then it should not be discarded because it is insignificant. This will cause specification error and parameter estimates will be biased.

Output, price of electricity, price of other fuels, user cost of capital, temperature, and capacity utilisation are all used in the models. Several models were evaluated, but the most successful model overall was the Koyck transformation model with quadratic temperature variable, output elasticity dependent on capacity utilisation, no seasonal dummies, and RELative fuel prices. It is best evaluated by first-order Cochrane-Orcutt. These models are referred to as L2KC1 in appendix V. A typical equation is :

$$\underset{6.92}{PPX = 7.78} - \underset{-6.65}{0.51\log(Price)} + \underset{9.71}{0.12\log(Temp)} + \underset{2.55}{0.36\log(Output)} +$$
$$\underset{2.71}{0.01\log(CapOut)} + \underset{0.83}{0.08\log(LDep)} - \underset{-1.40}{0.27AR1} \quad R^2 = 0.92$$

Although EM data should be used on theoretical grounds, it does not necessarily give the best statistical results. This does not matter since parameters are more likely to be unbiased, which is very important for forecasting.

Output elasticities are smaller in my models than in previous studies but this is because of the period covered by my study. Short and long-run output elasticity varies from 0.2 to 1. In some industries output elasticity is constant but in others it varies.

Price elasticities also are smaller in my models, but no less significant. My price elasticities vary across industries but are generally between -0.2 and -0.7. In some industries the price elasticities are positive. This occurs because of very unusual circumstances in these industries which have been hit particularly hard by recession. The output effect of a price change in these industries is larger than the substitution effect.

Price elasticities in the relative prices model can be interpreted as short-run price effects, since they model the effect of changing to other fuels when a firm has the equipment to do so. The long-run price elasticity of this model assumes implicit changes in the capital stock.

In the long-run, changes in price may only achieve their full effect through alterations in the capital stock. The cost of capital represents firms' willingness to invest in new plant. The user cost of capital is a variable used to incorporate this effect into the models. The payback period for investment depends on the price of capital and the price of fuels. As capital becomes cheaper, or as electricity becomes more expensive, the payback period will be shorter, thus encouraging firms to invest in new, electricity efficient plant. This long-run effect is reflected by my user cost of capital models. This is not significant in as many industries as relative prices. But this does not mean it is a worse measure of price elasticity. A *different* elasticity is being measured; this elasticity does not account for changes in the price of fuels other than electricity.

The lagged effect of price in the Koyck transformation model gets confused with other lagged effects. A polynomial distributed lag on price is one way to separate out these effects.

Current prices are important determinants of investment decisions but expected future prices are more relevant since these determine the viability of investment projects. This is more difficult to model and has not been attempted in the current project.

8 CONCLUSIONS

This thesis has made a significant improvement to EMEB's industrial sales forecasting models. Each industry is now analysed in detail using EM output data so that unbiased output elasticities can now be used for forecasting. Forecasts will not suffer the problem of changing industrial structure and the rate of change in technology is now quantified. Several different price effects have been identified, and each industry reacts in its own way to changes in the price of electricity. In some industries price is not a significant determinant of electricity consumed. The rate of capacity utilisation is incorporated into the models and allows output elasticity to vary, thus preventing bias in the estimate of output elasticity. The effect of temperature is now known by industry, and the effect of the weather can be evaluated for total industrial sales - this had not previously been estimated.

Despite the enormous improvements that have been made to the industrial sales models there are still many modifications which would improve the models further:

- Regional data can be improved by obtaining more appropriate output statistics by EMEB trade code, and precise EMEB region. This may make EM data available which could not be published because of protecting confidentiality.

- The unbilled calculation could be examined in more detail to see if it can be improved at a reasonable cost.

- A temperature variable for the EMEB region could perhaps be calculated. This is unlikely to make a substantial improvement to the models but may make the models more efficient.

- The price variable could be developed using EM data and different combinations of variables to represent the different price effects. These could be estimated using polynomial distributed lags so that the precise lag structure of the price effect can be found.

APPENDIX I
BULK SUPPLY TARIFF

CENTRAL ELECTRICITY GENERATING BOARD

BULK SUPPLY TARIFF (BST) 1987/88
TARIFF FOR BULK SUPPLIES TO AREA BOARDS

Fixed by the Central Electricity Generating Board (CEGB) pursuant to Section 37(1) of the Electricity Act 1947.
Each Area Electricity Board (Area Board) in England and Wales shall pay CEGB for electricity supplied in the year ending 31 March 1988 in accordance with the following charges, rates, and adjustments.

CHARGES

SYSTEM SERVICE CHARGE

1. Each Area Board shall pay the charge indicated in the following schedule, related to costs and expenses incurred in respect of the bulk supply points, and other services.

	£m
London	64.431
South Eastern	55.556
Southern	81.105
South Western	36.485
Eastern	88.392
East Midlands	66.473
Midlands	71.469
South Wales	33.480
Merseyside and North Wales	49.106
Yorkshire	71.754
North Eastern	44.213
North Western	63.064

CAPACITY CHARGES

2. For the purpose of this BST kW means twice the number of kWh measured over thirty consecutive minutes starting either on, or thirty minutes after, the hour.

3. The Capacity Charges set out in paragraphs 4 and 5 relate to kW taken during half hours when System Demand attains the respective levels specified in those paragraphs. System Demand means the kW sent out from CEGB plus the kW acquired by CEGB from other sources minus the kW supplied by CEGB outside England and Wales during any half hour.

PEAK CAPACITY CHARGE

4. The peak capacity charge shall be £23½ for the average kW taken by the Area Board at Times of Chargeable Peak System Demand. Chargeable Peak System Demand means the average of System Demand prevailing during the following half hours:
(a) the half hour of the highest System Demand;
(b) the half hour of the highest System Demand occuring other than on the day identified under (a) above or within ten days thereof;
(c) the half hour of the highest System Demand occurring other than on either of the days identified under (a) or (b) above or within ten days of those days.

BASIC CAPACITY CHARGE

5. The basic capacity charge shall be £10½ for each kW taken by the Area Board on average at times of Basic Demand. Basic Demand means the average System Demand over those 300 half hours for which System Demands have been recorded at the highest level, and which occur in the period 0800 hours to 2000 hours on all days from 26 October 1987 to 26 February 1988 inclusive, but excluding the three half hours of Chargeable Peak System Demand and weekends and public holidays.

RATES

UNIT RATES

6. RATE p/kWh

Times Days and half hours applicable each day	Summer Period 25 May to 27 September inclusive	Periods other than Summer 1 April to 24 May and 28 September to 31 March, inclusive
WEEKDAYS		
2400 – 0100	1.78	1.88
0100 – 0400	1.51	1.61
0400 – 0600	1.51	1.54
0600 – 0800	2.05	2.05
0800 – 1300	2.57	2.35
1300 – 1600	2.26	2.35
1600 – 1800	2.26	2.35
1800 – 2100	2.21	2.35
2100 – 2400	2.21	2.23

RATE p/kWh

Times Days and half hours applicable each day	Summer Period 25 May to 27 September inclusive	Periods other than Summer 1 April to 24 May and 28 September to 31 March, inclusive
SATURDAYS, SUNDAYS & PUBLIC HOLIDAYS		
2400 – 0100	1.82	1.87
0100 – 0300	1.49	1.55
0300 – 0700	1.49	1.49
0700 – 0800	1.73	1.64
0800 – 1330	2.15	2.17
1330 – 1400	2.15	1.99
1400 – 1630	1.99	1.99
1630 – 1700	1.99	2.15
1700 – 2400	2.10	2.15

In addition to the above rates a peak surcharge rate of 1.0 p/kWh applies in the half hour of highest System Demand in the period 0830 – 2330 and in each immediately adjacent half hour on each day except on weekdays in the Summer Period.

NON-MARGINAL ENERGY CHARGE

7. Each Board shall pay the charge indicated in the following schedule, related to costs and expenses incurred in providing core supplies of energy on a secure basis over the longer term.

	£m
London	111.658
South Eastern	102.223
Southern	145.184
South Western	70.837
Eastern	164.282
East Midlands	124.710
Midlands	130.259
South Wales	63.803
Merseyside and North Wales	96.679
Yorkshire	128.829
North Eastern	83.305
North Western	123.165

FUEL PRICE ADJUSTMENT

8. All the above rates, except the peak surcharge rate, shall be increased or reduced in their application to supplies provided in each month of the year by 0.008p for each £0.25 by which the national fuel price per tonne in the relevant month (rounded to the nearest £0.25) differs from £52.00.

9. *"National fuel price per tonne"* means the replacement value of fuels consumed in the relevant month, less such tonnage of coal as is used to satisfy the Qualifying Industrial Consumers' Scheme, multiplied by 25 and divided by the net heat content of such fuel in gigajoules.

10. *"Replacement value of fuels consumed in the relevant month"* means the sum of the product for each Generating Board station of the net heat content in gigajoules of coal, coke, oil and gaseous fuels consumed in the relevant month and the average delivered price per gigajoule of fuels of a like kind delivered to the station in that month, or in the month when last there were deliveries.

11. The national fuel price per tonne shall be estimated by the Generating Board in the relevant month and corrected if necessary to take account of any differences between actual and estimated value not already taken into account for any month previous to the relevant month.

ADJUSTMENTS

LOAD MANAGEMENT ADJUSTMENT

12. When an Area Board adopts Load Management, the total of the sums payable by the Area Board pursuant to paragraphs 1 to 11 above shall be adjusted as set out below. Load management means the reduction, on a Notice issued by CEGB to the Area Boards, of the kW take by the Consumers registered by Area Boards in accordance with paragraphs 16 and 20. There are three Categories of Load Management, A, B and C as follows:

CATEGORIES A AND B

13. Category A Load Management is that in respect of which CEGB has by 1700 hours issued a Category A Notice that Load Management is required on specified hours the following day. Where such a Notice calls for Load Management to be implemented after 1300 hours it may be cancelled by CEGB no later than 0900 hours on that day.

14. Category B Load Management is that for which CEGB has by 0900 hours issued a Category B Notice that Load Management is required at specified times not earlier than 1600 hours on the day on which the Notice is given.

15. Category A or B Notices shall be confined to implementation within 1 October 1987 to 31 March 1988 and shall not be issued in respect of Saturdays, Sundays or Public Holidays. The aggregate number of hours for each Category for which Notices may be issued shall not exceed 50 except that a period for which a Category A Notice is cancelled shall count as only half of the period for which the Notice was issued.

16. The adjustment referred to in paragraph 12 shall be in respect of each Consumer:

(a) who has by 31 March 1987 been registered by the Area Board with CEGB as likely to reduce his load significantly in response to Category A or B Load Management Notices as appropriate;

(b) whose take of kW during Category A or B Load Management periods and at times of Chargeable Peak System Demand is measured and certified by the Area Board;

(c) in respect of whom the Area Board indicates to CEGB by 31 March 1987 the reduction in the take of kW expected in response to Category A or Category B Notices.

17. The above adjustments shall be a rebate (charge) of £23½ times the number of kW by which (i) below exceeds (falls short of) (ii) below:

(i) the average kW taken by the Area Board's Category A or Category B Consumers at times of Chargeable Peak System Demand;

(ii) the average kW taken by those Consumers in Category A or Category B Notice periods as appropriate.

CATEGORY C

18. Category C Load Management is that in respect of which CEGB has issued a Category C Notice requesting load reduction no sooner than fifteen minutes after receipt of the Notice.

19. The aggregate number of hours for which such Notices may be issued shall not exceed two on any one day or 277 in the year. Notices will not be issued for implementation on Summer Weekdays as defined in paragraph 6.

20. The adjustments referred to in paragraph 12 shall in the case of Category C Load Management be in respect of each Consumer;

(a) who is also a Category A or B consumer;

(b) who has by 31 March 1987 been registered by the Area Board with CEGB as likely to reduce his load in response to Category C Load Management Notices by no less than 2 MW in normal circumstances;

(c) whose take of kW during times of Basic Capacity and Peak Surcharge is measured and certified by the Area Board;

(d) in respect of whom the Area Board indicates to CEGB by 31 March 1987 the reduction in kW expected in response to Category C Notices.

21. The above adjustments shall be:

(a) a rebate (charge) of £10½ times the number of kW by which

(i) the average kW taken by the Area Board's Category C consumers at times of Basic Demand exceeds (falls short of)

(ii) the average kW taken by those Consumers in Category C Notice periods;

(b) a rebate of 1.0p for each kWh taken by the Area Board's Category C consumers at times of Peak Surcharge;

(c) a surcharge of 1.5p for each kWh taken by those consumers in Category C Notice periods.

CONTRACTED CONSUMER ADJUSTMENTS

22. The total of the sums payable by the Area Board under paragraphs 1—21 above shall, in respect of the loads of Contracted Consumers (as defined in paragraphs 22—26 inclusive in the Bulk Supply Tariff published by the CEGB for the year 1982/83) be subject to adjustment as provided by the following paragraph. In the year ending 31 March 1988, Notification Periods are for periods not exceeding two hours a day or 60 hours in aggregate.

23. The adjustments shall be as follows:

(a) CONTRACTED CONSUMER SERVICE CHARGE
A payment in respect of each kW of the Contracted Load declared by 31 March 1985 of £8.50/kW, subject to a minimum payment of £25,500 for each contracted consumer.

(b) CONTRACTED CONSUMER DEMAND CHARGES
A payment of £23½/kW in respect of the average number of kW taken by Contracted Consumers in Contracted Load Notification Periods.

(c) A payment of £26/kW in respect of each kW by which the average number of kW taken by a Contracted Consumer under paragraph 23(b) exceeds his Contracted Load.

(d) CONTRACTED CONSUMER REBATES
Area Boards shall be entitled to rebates as specified hereunder, the same to be credited to the Area Boards in the invoices issued in respect of supplies taken in the month ending 31 March 1988.

(i) £23½/kW for the average kW taken by Contracted Consumers at peak capacity times.

(ii) £26/kW for the average kW taken by Contracted Consumers at basic capacity times.

(iii) The peak surcharge rate per kWh taken during peak surcharge times.

provided however that where a Contracted Consumer does not achieve the Minimum Load Reduction specified in paragraph 24 of the 1982/83 BST, the rebate in paragraph 23(d)(i) above only shall be payable in respect of that Contracted Consumer, and in such circumstances no charge shall be payable under paragraph 23(c) in respect of that Contracted Consumer.

QUALIFYING INDUSTRIAL CONSUMERS' SCHEME

24. The total of the sums payable by the Area Board under paragraphs 1 to 23 above shall, in respect of the loads of Qualifying Industrial Consumers, be subject to adjustment as provided in paragraphs 25 to 27 below.

25. A Qualifying Industrial Consumer is an industrial consumer:

(a) who has by 30 April 1987 been registered by the Area Board and CEGB as having a reasonable expectation of achieving an annual consumption of energy of 25 GWh at the site concerned in the present financial year and in each of the following four financial years.

(b) who has his take in kW measured and certified by the Area Board during all relevant times.

26. The Area Board shall be entitled to rebates as specified hereunder for each Qualifying Industrial Consumer on that number of units (hereinafter called 'qualifying units') in the appropriate time periods taken in each month from 1 April 1987 to 31 March 1988 which is given by the following computation relating to each Qualifying Industrial Consumer:

> The excess, if any, of his total monthly take in kWh, over the total number of kWh given by 2.2 million kWh plus 165 times his registered maximum demand.

"Registered maximum demand" means the average of the twelve monthly maximum demands in kW taken by that consumer between the hours of 0800 to 2000 on all days exclusive of weekends and public holidays in the twelve consecutive months ending March 1987.

27. The rebates shall be as follows:

(i) 0.06 p/kWh for all qualifying units taken during the period 2400 — 0800 hours

(ii) 0.08 p/kWh for all qualifying units taken during the period 0800—2400 hours

(iii) a reduction in the Non-Marginal Energy Charge given by multiplying by 0.52p the total of day qualifying units determined for each Qualifying Industrial Consumer for the twelve months of 1986/87. For this purpose the procedure and registered maximum demand determined in paragraph 26 shall be used

28. Each Area Board shall send to CEGB adequate data at the end of each month to enable the appropriate rebates, if any, to be calculated

APPENDIX II
DOMESTIC BUILD-UP MODEL

Domestic Build Up Model

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Ownership Levels

	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
Dishwashers	1	1	1	1	1	1	1	1	1	1	2	2	2
Freezers	1	2	3	4	5.8	7	9	11	15	20	25	25	26
Fridges	58	59	60	61	62.4	65	72	75	75	75	72.6	71	70
Fridge/Freezers					1	1	2	4	6	9	14.7	16	18
Wash Machines	69	69	70	70	71.3	74	76	77	79	80	78.9	81	82
Wash boiler	14	14	14	13	11.8	11	10	9	8	7	6.3	6	5
Microwaves												1	3
Tumble Dryers		1	1	2	2.5	4	5	6	8	9	11.4	15	17
Spin Dryers	23	26	23	22	21	21	20	21	20	20	23.3	18	17
Rack/cabinet	8	8	7	7	6.4	6	5	4	4	4	4.3	4	4
Toaster	16	16	17	17	18.3	20	20	21	24	28	27.7	29	32
Food/Drink Mixers	13	18	22	26	25.1	35	37	39	46	45	46.6	52	55
Kettles	46	49	52	55	59.7	62	65	67	69	72	74.6	74	76
Irons	96	98	96	98	95.7	100	99	97	96	97	96	97	97
Tea makers	2	2	3	3	3.7	5	5	6	7	8	13.4	12	14
Coffee percolators	7	7	8	9	9.6	9	11	10	10	13	15.9	12	15
Slow Cookers								1	2	2	2.9	3	4
Colour T.V.	1	2	4	7	9.5	15	23	33	42	50	57.4	65	70
B/W T.V.	94	93	90	88	85.2	81	77	70	64	58	53	46	42
Floor polishers	2	3	2	2	1.7	2	2	2	2	2	2.2	2	2
Vacuum cleaners	80	83	83	84	84.4	88	88	90	91	93	91	92	93
Electric blankets	42	46	46	48	49	50	46	46	48	49	46	44	42
Hair dryers	38	40	42	43	43.1	47	47	52	54	60	62.7	60	61
Extractor fans	9	9	10	10	10.6	10	10	12	11	12	15	14	14
Lighting	99	99	99	99	99.1	99	99	99	99	99	99.2	99	99
R'gram/Record player	48	49	50	52	53.6	57	59	62	64	67	71.6	73	75
Mains Radio	24	25	26	28	31.1	33	35	37	42	43	44.5	46	48
Tape recorder	11	13	15	17	18.9	21	24	27	30	33	36.1	40	43
Sewing Machine	26	27	28	29	29.6	32	34	36	38	39	39	39	40
Lawn Mower	5	5	6	6	6.8	8	11	15	19	23	27	31	35

Fuel Price Competitive items

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Direct Space Heating	75	74	73	72	72.1	75	78	72	69	65	71.9	59	55
Central Heating	8	8	8	8	7.6	9	9	9	9	9	9.2	9	8
Water Heating	60	60	60	60	57.7	60	64	65	64	64	67.2	59	64
Instant Showers	1	1	1	1	2	2	2	3	3	4	7.4	5	2
Cookers	40	40	40	40	40.1	39	37	36	37	37	41.6	42	43

Domestic Build Up Model

Mean Consumption per Appliance

	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
Dishwashers	500	500	500	500	500	500	500	500	500	500	500	500	500
Freezers	1000	1000	1000	1000	1000	1000	950	950	900	850	800	800	800
Fridges	300	300	300	312	298	325	300	300	300	300	300	300	300
Fridge/Freezers	525	525	550	550	575	575	600	600	600	600	630	650	670
Wash Machines	150	150	175	175	175	200	200	200	200	200	200	200	200
Wash boiler	50	50	50	50	50	50	50	45	45	45	45	45	45
Microwaves	90	90	90	90	90	90	90	90	90	90	90	90	90
Tumble Dryers	350	350	350	350	350	350	350	350	350	350	350	350	350
Spin Dryers	10	10	10	10	10	10	10	10	10	10	10	10	10
Rack/cabinet	700	700	700	700	700	700	700	700	700	700	700	700	700
Toaster	10	10	10	10	10	10	10	10	10	10	10	10	10
Food/Drink Mixers	5	5	5	5	5	5	5	5	5	5	5	5	5
Kettles	250	250	250	250	250	250	250	250	250	250	250	250	250
Irons	75	75	75	75	75	75	75	75	75	75	75	75	75
Tea makers	10	10	10	10	10	10	10	10	10	10	10	10	10
Coffee percolators	50	50	50	50	50	50	50	50	50	50	50	50	50
Slow Cookers	40	40	40	40	40	40	40	40	40	40	40	40	40
Colour T.V.	500	500	500	500	500	500	500	500	500	475	450	425	412
B/W T.V.	250	250	250	250	250	250	250	250	250	240	225	210	200
Floor polishers	25	25	25	25	25	25	25	25	25	25	25	25	25
Vacuum cleaners	25	25	25	25	25	25	25	25	25	25	25	25	25
Electric blankets	60	60	60	60	60	60	60	60	60	60	60	60	60
Hair dryers	25	25	25	25	25	25	25	25	25	25	25	25	25
Extractor fans	3	3	3	3	3	3	3	3	3	3	3	3	3
Lighting	265	275	290	310	325	270	300	270	280	290	300	310	320
R'gram/Record player	30	30	30	30	30	25	25	25	20	20	20	20	15
Mains Radio	40	40	40	40	40	40	39	38	37	36	35	34	33
Tape recorder	6	6	6	6	6	6	6	6	6	6	6	6	6
Sewing Machine													
Lawn Mower													

Fuel Price Competitive items

Direct Space Heating	1000	1000	950	900	1000	850	900	700	480	434	450	440	430
Central Heating	7000	7000	7000	7000	8000	7000	6500	5200	4090	3775	4000	3900	3800
Water Heating	1600	1600	1547	1516	1560	1450	1500	1350	1300	1250	1200	1150	1100
Instant Showers	130	130	130	130	130	130	130	130	130	130	130	135	135
Cookers	1210	1200	1200	1190	1210	1093	1080	1060	1040	1020	1000	980	950

Domestic Build Up Model

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Consumption per "Average" Customer

	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
Dishwashers	5	5	5	5	5	5	5	5	5	5	10	10	10
Freezers	10	20	30	40	58	70	86	105	135	170	200	200	208
Fridges	174	177	180	190	186	211	216	225	225	225	218	213	210
Fridge/Freezers	0	0	0	0	6	6	12	24	36	54	93	104	121
Wash Machines	104	104	123	123	125	148	152	154	158	160	158	162	164
Wash boiler	7	7	7	7	6	6	5	4	4	3	3	3	2
Microwaves	0	0	0	0	0	0	0	0	0	0	0	1	3
Tumble Dryers	0	4	4	7	9	14	18	21	28	32	40	53	60
Spin Dryers	2	3	2	2	2	2	2	2	2	2	2	2	2
Rack/cabinet	56	56	49	49	45	42	35	28	28	28	30	28	28
Toaster	2	2	2	2	2	2	2	2	2	3	3	3	3
Food/Drink Mixers	1	1	1	1	1	2	2	2	2	2	2	3	3
Kettles	115	123	130	138	149	155	163	168	173	180	187	185	190
Irons	72	74	72	74	72	75	74	73	72	73	72	73	73
Tea makers	0	0	0	0	0	1	1	1	1	1	1	1	1
Coffee percolators	4	4	4	5	5	5	6	5	5	7	8	6	8
Slow Cookers	0	0	0	0	0	0	0	0	1	1	1	1	2
Colour T.V.	5	10	20	35	48	75	115	165	210	238	258	276	288
B/W T.V.	235	233	225	220	213	203	193	175	160	139	119	97	84
Floor polishers	1	1	1	1	0	1	1	1	1	1	1	1	1
Vacuum cleaners	20	21	21	21	21	22	22	23	23	23	23	23	23
Electric blankets	25	28	28	29	29	30	28	28	29	29	28	26	25
Hair dryers	10	10	11	11	11	12	12	13	14	15	16	15	15
Extractor fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting	262	272	287	307	322	267	297	267	277	287	298	307	317
R'gram/Record player	14	15	15	16	16	14	15	16	13	13	14	15	11
Mains Radio	10	10	10	11	12	13	14	14	16	15	16	16	16
Tape recorder	1	1	1	1	1	1	1	2	2	2	2	2	3
Sewing Machine	0	0	0	0	0	0	0	0	0	0	0	0	0
Lawn Mower	0	0	0	0	0	0	0	0	0	0	0	0	0

Fuel Price Competitive items

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Direct Space Heating	750	740	694	648	721	638	702	504	331	282	324	260	237
Central Heating	560	560	560	560	608	630	585	468	368	340	368	351	304
Water Heating	960	960	928	910	900	870	960	878	832	800	806	679	704
Instant Showers	1	1	1	1	3	3	3	4	4	5	10	7	3
Cookers	484	480	480	476	485	426	400	382	385	377	416	412	409

Computed Use	3889	3918	3889	3887	4061	3947	4122	3755	3540	3512	3725	3532	3525
Domestic Customers	NA	NA	NA	1520950	1548092	1572459	1601279	1626732	1653641	1686904	1686904	1712737	1735517
Tot Domestic	NA	NA	NA	5912	6288	6206	6601	6109	5853	5925	6284	6049	6118

APPENDIX III

CONVERTING UNITS BILLED TO SOLD

Electricity consumed is not always billed in the same financial year. An assessment of these "unbilled" units is made each year. Unbilled units occur principally on quarterly billed tariffs.

EMEB is notified each month of its purchases from CEGB. This data is reasonably accurate and only subject to small metering errors. Units purchased is therefore known. Units sold equals units purchased minus losses. Unfortunately neither losses or units sold are known. Both must be estimated in some way. There are three basic ways to determine losses and the unbilled:

1. assess engineering losses and solve for the unbilled;
2. assess the unbilled and derive losses;
3. solve for losses and the unbilled simultaneously.

<u>Billed Data</u>

At EMEB monthly billed customers are billed on a review period basis. In the final month of the financial year the bills of monthly customers are adjusted pro-rata to the number of days in the calendar month. Account is taken of the number of Saturdays, Sundays and Bank Holidays. Any late billing is also accounted for. The errors in converting monthly billed customers' bills into units sold are really quite small compared to consumption in the full year.

Quarterly billed customers are billed on the General Purpose, Domestic or Restricted Hour Tariffs. Cyclic billing is reported on a calendar month basis. The stages of converting billed into sold are similar to those for monthly billed customers, but the method is more complex and gives larger errors.

APPENDIX III

TABLE A3.1 - MONTHLY DISTRIBUTION LOSSES

MONTH	PURCHASES	$(P)^2$ 1000	VARIABLE LOSSES K1.(2)	MONTHLY SALES	P-M	$(P-M)^2$ 1000	VARIABLE LOSSES K2.(6)	FIXED LOSSES	TOTAL LOSSES	CYCLIC CONSUMPTION	TOTAL CONSUMPTION
	1	2	3	4	5	6	7	8	9	10	11
JANUARY	2000	4000	40	800	1200	1440	72	20	142	1058	1858
FEBRUARY	2000	4000	40	800	1200	1440	72	20	142	1058	1858
MARCH	1800	3240	32	800	1000	1000	50	20	102	898	1698

where K1 : 0.01

K2 : 0.05

K1, K2 are engineering constants representing iron and copper losses

P : total units purchased

M : total monthly sales

TABLE A3.2 - DERIVATION OF UNBILLED

MONTH	CYCLIC CONSUMPTION	BILLED IN APRIL	MAY	JUNE	TOTAL
JANUARY	1058	176	-	-	176
FEBRUARY	1058	353	176	-	529
MARCH	898	300	300	150	750
		CYCLIC UNBILLED			1455
		PLUS MONTHLY UNBILLED			50
		PREVIOUS YEAR'S UNBILLED			(1400)
		CHANGE IN UNBILLED			105
		TOTAL BILLED UNITS			19895
		EQUALS TOTAL ANNUAL SALES			20000

APPENDIX III

Each EMEB district gives details of their position in the billing cycle together with an associated assessment of late billing in money terms. The late billing is split over consumer classes pro-rata to the bills sent out in March. Average prices for each class are then applied to derive units. If the billing has fallen behind schedule in a quarter there will be extra consumption on each bill since the bill covers a longer period. This will introduce additional inaccuracies and is not allowed for in the unbilled calculation.

Fixed losses are calculated by the Engineering Department based upon metering and time switch losses, and transformer iron losses. Variable losses are then calculated for January, February, and March based on the formula I^2R. Variable losses are influenced by the relationship between the low and high voltage network, and the overall load pattern, reflecting the loading of the system. Use is made of a broad relationship between variable losses and the square of units purchased for the calculation of variable losses. This fails to account for the overall load pattern but this changes only slowly through time. Units used on Board's premises can be added to the assessment of fixed losses. An example of the unbilled/losses calculation is shown in Table A3.1.

$$\text{Variable losses} = (P/10^3)^2.K1 + ((P-M)/10^3).K2$$

where : P is monthly purchases (calendar)

M is monthly billed sales (calendar)

K1 and K2 are engineering constants

When cyclic sales have been calculated for January, February and March it is relatively simple to calculate the unbilled. $^1/_6$ of cyclic sales in January are billed in April. Similarly, $1/3$ of February's cyclic billed sales are billed in April, and $^1/_6$ in May. For March's cyclic billed sales $^1/_3$ are billed in April, $^1/_3$ are billed in May, and $^1/_6$ are billed in June. Summing these as in Table A3.2 gives total unbilled to be carried forward. The previous year's unbilled is then subtracted from the current unbilled to derive net unbilled. Net unbilled plus billed equals sales. The ratio of sales to purchases is the efficiency level. One minus the efficiency level gives losses.

There are of course several approximations made in this approach. The March and April billing figures can be distorted by Christmas holidays. Also, no assessment is made of theft which will introduce cumulative errors. It is not possible to calculate theft however, and it is assumed that the errors this creates are small.

In the above discussion of the losses/unbilled calculation the approximateness of the split of units across premises class was revealed. The best estimate of the split into trade codes therefore seems to be a similar pro-rata adjustment.

Without a proper unbilled assessment autocorrellation is likely to be present in the models. Hopefully, the randomness of the unbilled calculation across classes will avoid systematic bias but will unfortunatley reduce the precicion of the models.

APPENDIX IV

CBI Industrial Trends Survey

SURVEY 104 - APRIL 1987

TABLE 1 - TOTAL SAMPLE (NEW DEFINITION)

Number of respondents:	Total Trade Questions	1463
	Export Trade Questions	939

All figures are percentages based on a weighted sample

1 Are you more, or less, optimistic than you were four months ago about THE GENERAL BUSINESS SITUATION IN YOUR INDUSTRY

More	Same	Less
37	56	8

2 Are you more, or less, optimistic about your EXPORT PROSPECTS for the next twelve months than you were four months ago

More	Same	Less	N/A
35	53	11	1

3 Do you expect to authorise more or less capital expenditure in the next twelve months than you authorised in the past twelve months on:

	More	Same	Less	N/A
a. buildings	21	38	24	16
b. plant & machinery	35	42	22	1

4 Is your present level of output below capacity (i.e., are you working below a satisfactory full rate of operation)

Yes	No	N/A
49	51	1

5 Excluding seasonal variations, do you consider that in volume terms:

	Above Normal	Normal	Below Normal	N/A
a. Your present total order book is	23	54	22	1
b. Your present export order book is *(firms with no order book are requested to estimate the level of demand)*	21	51	27	2

	More than Adequate	Adequate	Less than Adequate	N/A
c. Your present stocks of finished goods are	14	63	9	15

Excluding seasonal variations, what has been the trend over the PAST FOUR MONTHS, and what are the expected trends for the NEXT FOUR MONTHS, with regard to:

	Trend over PAST FOUR MONTHS				Expected trend over NEXT FOUR MONTHS			
	Up	Same	Down	N/A	Up	Same	Down	N/A
6 Numbers employed	22	46	32	+	19	57	23	1
7 Volume of total new orders	43	38	17	3	33	56	8	3
of which: a. domestic orders	37	42	18	3	29	60	7	3
b. export orders	35	44	20	1	28	63	8	1
8 Volume of output	38	48	14	+	35	55	10	+
9 Volume of: a. domestic deliveries	38	45	15	2	36	55	8	2
b. export deliveries	33	48	18	2	33	54	11	2

APPENDIX V
SUMMARY OF REGRESSION RESULTS

MIKLS

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	27816	-2042	-2990	-1597	94	-3786	12	-23	0.32	0.942	1881	2.00	0.919	5.128	12.539
	2.17	-0.49	-1.43	-0.54	1.43	-3.09	2.64	-1.37	1.78						
GC	73849	-3763	-520	-1596	241	-4450	22	-108	0.35	0.838	5040	2.12	0.721	15.342	27.617
	2.40	-0.34	-0.11	-0.19	1.52	-2.18	1.78	-2.40	1.93						
CH	-14510	-27403	-17776	-26160	313	11251	45	-69	0.49	0.870	7886	2.72	11.853	15.713	16.759
	-0.58	-1.60	-2.54	-2.13	1.26	3.77	2.44	-1.01	4.37						
ME	-56402	8988	-3993	7062	1434	-1814	40	-2	0.22	0.941	5447	2.22	0.959	10.901	18.442
	-2.35	0.76	-0.67	0.80	4.62	-1.09	3.08	-0.03	1.84						
EE	29775	-2493	-6655	824	104	-4224	24	-12	0.48	0.960	2802	2.39	5.268	8.576	18.676
	1.75	-0.40	-2.00	0.19	2.15	-2.41	3.62	-0.50	3.00						
VE	39968	24388	7576	18265	669	971	35	-64	0.19	0.839	13255	2.16	1.214	3.829	19.479
	1.87	0.86	0.60	0.84	2.09	0.14	1.13	-0.84	1.03						
FT	99577	-27509	-18113	-28753	645	-12819	34	-132	0.32	0.881	7244	2.12	1.108	20.310	33.266
	2.01	-1.73	-2.65	-2.43	2.18	-3.04	1.90	-2.30	1.84						
LE	2123	872	317	747	4	329	1	-1	0.20	0.901	357	1.64	5.217	7.484	13.692
	1.98	1.06	0.73	1.34	1.50	2.10	1.62	-0.88	1.14						
CF	2789	-1385	-1156	329	-20	1271	11	-9	0.43	0.943	994	2.55	8.012	12.557	11.119
	0.55	-0.61	-1.04	0.21	-0.42	3.30	4.48	-1.52	3.48						
TF	8265	2373	-311	2350	21	-964	4	-10	0.40	0.924	1003	2.14	3.184	12.315	23.193
	2.02	1.10	-0.31	1.43	0.81	-2.76	1.84	-1.78	2.77						
OM	126046	-13284	-21977	-14022	85	-10762	74	-112	0.36	0.928	9286	2.60	5.813	21.732	24.563
	3.81	-0.65	-2.33	-0.97	0.44	-3.50	3.31	-2.17	3.73						
MM	-84456	-19805	-4008	14222	210	24109	79	5	0.69	0.917	18050	2.59	6.196	15.902	19.529
	-1.22	-0.48	-0.24	0.46	0.52	3.10	1.74	0.03	3.93						
IE	22010	2021	-4557	2230	97	-3411	18	39	0.55	0.939	2995	2.69	7.858	11.212	15.889
	2.03	0.31	-1.58	0.47	2.30	-2.79	2.51	0.95	5.37						
GC	54563	3143	485	3946	271	-3368	14	-61	0.44	0.833	5130	2.05	0.088	18.104	30.146
	1.93	0.27	0.10	0.46	1.61	-1.73	1.11	-2.11	2.54						
MM	-7374	-15393	4329	-6401	-13	42492	81	-558	0.29	0.948	14253	1.94	0.261	9.974	20.271
	-0.15	-0.50	0.35	-0.26	-0.04	5.89	2.37	-4.33	1.91						

MPKLS

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	27816	-2042	-2990	-1597	94	-3786	12	-23	0.32	0.942	1881	2.00	0.919	5.128	12.539
	2.17	-0.49	-1.43	-0.54	1.43	-3.09	2.64	-1.37	1.78						
GC	74295	-4183	-1404	-1820	235	-4483	22	-106	0.36	0.838	5041	2.11	0.636	15.668	26.531
	2.42	-0.38	-0.30	-0.22	1.51	-2.20	1.80	-2.38	1.94						
CH	-16195	-29644	-19592	-27448	343	11159	46	-64	0.49	0.871	7849	2.70	11.810	15.831	16.764
	-0.66	-1.72	-2.77	-2.23	1.37	3.75	2.46	-0.93	4.40						
ME	-45618	-1056	-11208	-619	1355	-1573	42	-11	0.23	0.946	5238	2.20	0.716	9.914	17.844
	-2.21	-0.09	-1.97	-0.07	5.06	-1.01	3.32	-0.18	2.04						
EE	28468	-3710	-6823	317	115	-4034	23	-9	0.48	0.962	2735	2.34	4.460	7.528	18.396
	1.71	-0.63	-2.13	0.08	2.53	-2.35	3.61	-0.38	3.13						
VE	46475	22391	5461	10909	688	945	32	-78	0.17	0.846	12944	2.12	0.646	2.740	17.884
	2.16	0.81	0.45	0.50	2.47	0.16	1.07	-1.05	0.98						
FT	94917	-29535	-19956	-34397	668	-12373	34	-131	0.33	0.884	7169	2.18	1.833	20.301	33.159
	1.92	-1.87	-2.94	-2.86	2.34	-2.95	1.95	-2.33	1.98						
LE	2182	846	321	720	4	321	1	-1	0.19	0.902	355	1.61	4.703	7.253	13.714
	2.07	1.04	0.75	1.30	1.61	2.06	1.65	-0.86	1.12						
CF	2222	-1216	-1143	448	-15	1288	11	-9	0.43	0.943	995	2.54	8.069	12.769	11.338
	0.48	-0.56	-1.02	0.29	-0.33	3.36	4.47	-1.49	3.46						
TF	7519	2094	-498	2047	30	-978	5	-9	0.40	0.926	992	2.11	2.686	12.287	22.874
	1.85	0.97	-0.50	1.23	1.16	-2.85	1.91	-1.62	2.82						
OM	124417	-14113	-22555	-15012	103	-10672	75	-110	0.36	0.929	9272	2.58	5.628	21.843	24.429
	3.76	-0.69	-2.42	-1.04	0.54	-3.46	3.33	-2.12	3.76						
MM	-89236	-23155	-6623	12552	252	23731	78	14	0.71	0.918	18011	2.59	6.096	15.321	19.208
	-1.37	-0.56	-0.37	0.41	0.64	3.04	1.74	0.08	4.04						
IE	21590	700	-4789	1672	106	-3401	17	45	0.55	0.942	2930	2.63	6.514	10.059	14.340
	2.04	0.11	-1.72	0.36	2.63	-2.89	2.47	1.12	5.59						
GC	55316	2527	-536	3497	278	-3412	15	-62	0.43	0.834	5113	2.02	0.020	18.224	30.013
	1.97	0.22	-0.11	0.41	1.67	-1.77	1.16	-2.15	2.49						
MM	-13499	-15020	4024	-5506	29	42196	80	-555	0.31	0.948	14251	1.94	0.265	9.816	20.045
	-0.29	-0.49	0.31	-0.23	0.10	5.83	2.34	-4.30	2.02						

MBKLS

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	36930	-2587	-3363	-1663	-20	-3920	12	-33	0.38	0.938	1940	2.24	2.416	5.445	17.648
	2.61	-0.60	-1.57	-0.55	-0.24	-3.03	2.65	-1.61	2.12						
GC	77416	-4708	-1098	-2789	558	-12870	22	-18	0.27	0.851	4835	1.91	0.099	6.878	19.194
	2.67	-0.45	-0.25	-0.35	2.28	-3.29	1.91	-0.36	1.46						
CH	-21524	-26773	-17815	-25836	300	12382	45	-58	0.51	0.868	7926	2.69	11.217	14.255	14.523
	-0.64	-1.56	-2.53	-2.10	1.12	4.10	2.41	-0.74	4.56						
ME	3662	1806	-7868	6028	962	-11472	44	32	0.31	0.926	6114	2.14	0.495	12.360	20.339
	0.20	0.13	-1.19	0.60	3.25	-2.52	3.03	0.38	2.45						
EE	27140	-459	-4569	1299	246	-5652	21	24	0.37	0.965	26233	2.26	3.228	8.260	21.692
	1.70	-0.08	-1.40	0.32	3.11	-3.42	3.41	0.93	2.34						
VE	-96012	31668	11517	20394	2165	3479	30	-74	0.07	0.855	12572	2.03	0.205	4.483	15.353
	-2.15	1.19	0.95	1.00	2.89	0.71	1.00	-1.03	0.40						
FT	-2761	-25303	-17553	-27321	1588	-10159	32	-29	0.29	0.878	7342	1.89	1.042	24.133	32.394
	-0.03	-1.57	-2.53	-2.28	1.95	-2.21	1.77	-0.46	1.60						
LE	30	808	147	818	14	395	1	0	0.30	0.897	365	1.74	7.761	8.514	15.421
	0.03	0.96	0.35	1.43	0.94	2.57	1.62	-0.07	1.97						
CF	-1214	234	-104	747	54	1161	9	-3	0.29	0.945	972	2.44	7.869	12.560	11.383
	-0.51	0.10	-0.08	0.49	1.26	3.18	3.70	-0.43	1.85						
TF	13087	2895	1210	1586	94	-2499	4	-12	0.03	0.942	877	1.78	2.200	11.585	24.872
	4.01	1.54	1.21	1.09	3.22	-4.32	1.87	-2.47	0.20						
CM	134214	-9179	-18708	-11672	277	-15192	69	-110	0.31	0.930	9154	2.56	5.495	18.950	23.577
	4.80	-0.45	-1.89	-0.81	1.05	-3.09	3.04	-2.34	2.85						
MM	-143022	-18290	1822	-2095	2097	14479	79	119	0.22	0.953	13670	2.17	0.755	5.168	19.310
	-5.51	-0.58	0.14	-0.09	4.85	2.40	2.31	0.95	1.94						
IE	-5179	-519	-6609	863	180	-371	21	60	0.65	0.936	3071	2.72	8.970	10.187	17.671
	-0.27	-0.08	-2.31	0.18	1.88	-0.25	2.92	1.15	6.78						
GC	70321	-6214	-1903	-3971	636	-13606	24	5	0.27	0.851	4842	1.93	0.074	6.822	20.647
	2.72	-0.53	-0.40	-0.45	2.59	-3.34	1.83	0.17	1.49						
MM	-77495	-8245	7248	-2388	1314	29106	72	-319	0.17	0.958	12932	1.88	0.366	6.314	18.443
	-2.52	-0.30	0.63	-0.11	2.58	3.59	2.36	-2.16	1.53						

MHKLS

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	36930	-2587	-3363	-1663	-20	-3920	12	-33	0.38	0.938	1940	2.24	2.416	5.445	17.648
	2.61	-0.60	-1.57	-0.55	-0.24	-3.03	2.65	-1.61	2.12						
GC	78369	-5648	-3373	-3313	528	-12463	23	-20	0.28	0.852	4829	1.87	0.162	5.832	18.631
	2.71	-0.53	-0.72	-0.42	2.30	-3.34	1.98	-0.40	1.53						
CH	-25670	-28936	-19643	-27031	344	12366	45	-48	0.52	0.870	7890	2.68	11.294	14.356	14.396
	-0.76	-1.67	-2.75	-2.19	1.25	4.13	2.42	-0.59	4.62						
ME	9767	-5789	-13053	-282	934	-11038	46	24	0.31	0.930	5952	2.05	0.184	12.949	23.883
	0.59	-0.43	-1.99	-0.03	3.58	-2.73	3.20	0.30	2.48						
EE	25443	-3869	-5409	-113	255	-5412	21	29	0.39	0.968	2509	2.22	2.324	6.600	21.908
	1.67	-0.71	-1.80	-0.03	3.67	-3.45	3.46	1.18	2.68						
VE	-46930	25709	3093	7007	1470	6855	25	-87	0.16	0.851	12745	2.11	0.436	4.221	12.120
	-1.49	0.95	0.26	0.32	2.70	1.57	0.84	-1.17	0.97						
FT	5533	-30256	-21980	-40156	1432	-9569	33	-30	0.35	0.880	7271	2.09	3.195	25.186	32.417
	0.07	-1.88	-3.11	-3.04	2.11	-2.07	1.88	-0.49	2.03						
LE	-193	704	164	720	18	366	1	0	0.30	0.899	361	1.70	7.172	7.805	15.204
	-0.18	0.86	0.40	1.28	1.25	2.40	1.63	0.15	2.01						
CF	-1066	-145	-61	418	53	1167	9	-3	0.29	0.946	969	2.44	7.843	12.165	11.273
	-0.48	-0.07	-0.05	0.28	1.33	3.25	3.78	-0.47	1.92						
TF	13127	2107	624	697	100	-2568	4	-11	0.04	0.946	842	1.67	2.092	10.406	24.539
	4.22	1.16	0.71	0.48	3.72	-4.83	2.06	-2.42	0.24						
OM	134174	-11409	-20325	-14365	315	-15690	69	-108	0.31	0.931	9096	2.52	4.490	18.231	23.039
	4.83	-0.57	-2.18	-1.02	1.23	-3.29	3.11	-2.28	2.93						
MM	-118731	-54400	-22245	-27473	2055	14198	81	106	0.23	0.955	13328	2.19	0.787	5.026	21.226
	-5.47	-1.73	-1.71	-1.17	5.13	2.42	2.44	0.87	2.13						
IE	-11185	-3275	-7333	-318	213	146	21	75	0.67	0.941	2958	2.61	6.779	8.271	15.918
	-0.64	-0.51	-2.63	-0.07	2.49	0.10	2.95	1.54	7.22						
GC	72431	-6223	-4047	-3729	577	-12860	24	-1	0.29	0.851	4841	1.88	0.180	5.834	20.461
	2.80	-0.53	-0.81	-0.42	2.59	-3.38	1.82	-0.03	1.60						
MM	-66372	-32759	-8945	-19848	1380	28081	74	-308	0.17	0.960	12530	1.86	0.481	6.695	20.465
	-2.74	-1.20	-0.75	-0.96	3.02	3.64	2.50	-2.22	1.56						

MKC1

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	17850	-2534	-4523	-1223	74	-2731	12	-16	0.52	-0.21	0.942	1876	1.93	0.326	2.759	12.560
	1.30	-0.59	-1.94	-0.40	1.21	-1.95	2.59	-0.96	2.36	-0.94						
GC	63143	-5189	-1788	-1878	202	-3930	23	-100	0.44	-0.16	0.835	5172	1.95	0.342	16.660	25.357
	1.66	-0.45	-0.36	-0.21	1.28	-1.65	1.79	-2.12	1.87	-0.64						
CR	-18748	-25825	-16860	-23500	251	8248	44	-62	0.65	-0.58	0.909	6805	2.20	2.648	6.134	10.581
	-1.18	-1.73	-2.25	-2.03	1.57	4.30	2.66	-1.37	9.01	-3.69						
ME	-51869	5713	-7249	7546	1242	-1673	43	-16	0.33	-0.25	0.944	5523	2.06	0.108	11.260	16.933
	-2.45	0.46	-1.12	0.82	3.96	-1.17	3.14	-0.27	2.45	-1.16						
EE	8012	-2935	-10424	2844	72	-2113	23	-3.8	0.74	-0.44	0.967	2591	2.03	0.391	4.001	13.088
	0.58	-0.53	-3.31	0.69	2.17	-1.52	3.79	-0.21	5.45	-2.57						
VE	14266	26754	1729	28657	417	2337	31	-51	0.45	-0.35	0.850	13223	2.07	0.381	4.142	19.016
	0.68	0.91	0.13	1.17	1.51	0.41	0.92	-0.77	2.19	-1.59						
FT	338	-24774	-24899	-33591	275	-1260	31	-9	0.88	-0.65	0.900	6617	1.83	2.613	15.409	28.758
	0.01	-1.76	-3.02	-2.86	1.43	-0.40	1.99	-0.20	6.37	-4.36						
LE	1089	634	-218	959	2	175	1	-1	0.48	-0.21	0.929	304	1.90	0.161	3.368	7.742
	0.94	0.90	-0.51	1.87	1.08	1.46	1.96	-0.73	2.27	-0.93						
CF	1932	-2186	-2322	726	-32	790	11	-9	0.61	-0.47	0.953	926	2.32	2.597	9.469	10.162
	0.52	-1.07	-2.21	0.46	-0.86	2.67	5.05	-2.01	6.10	-2.65						
TF	1515	3002	-1515	3811	18	-459	3	-6	0.73	-0.44	0.939	922	1.71	3.342	7.117	20.525
	0.46	1.48	-1.54	2.37	0.95	-1.79	1.43	-1.32	6.20	-2.75						
CM	105671	-16026	-26721	-13880	24	-8866	76	-109	0.47	-0.39	0.929	8995	1.99	0.894	16.462	21.883
	3.65	-0.80	-2.68	-0.95	0.16	-3.45	3.45	-2.54	4.55	-2.06						
MM	-96458	-36741	-11469	9566	286	15396	96	-25	0.84	-0.50	0.932	16797	1.80	2.109	10.859	16.318
	-1.86	-0.90	-0.62	0.30	0.95	2.63	2.13	-0.19	6.07	-2.97						
IE	9131	-3	-7382	1797	68	-1988	20	33	0.70	-0.50	0.948	2732	1.90	0.667	8.103	13.904
	1.15	0.00	-2.52	0.39	2.31	-2.30	3.01	1.14	9.05	-3.12						
GC	49689	2377	-4	3696	255	-3116	15	-58	0.48	-0.06	0.827	5299	1.97	0.265	19.991	29.516
	1.15	0.20	0.00	0.41	1.36	-1.19	1.11	-1.61	1.63	-0.19						
MM	-39222	16544	20127	2519	269	62948	51	-628	0.04	0.56	0.951	14267	2.22	4.662	8.741	15.395
	-0.57	0.66	1.90	0.13	0.70	6.11	1.86	-4.35	0.28	3.14						

APPENDIX V

LINEAR MODEL

MPKC1

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	R̄	S.E.R.	Durbin Watson	Lagrange Multiplier Tests <-- L1	L4	L8 -->
PP	17850	-2534	-4523	-1223	74	-2731	12	-16	0.52	-0.21	0.942	1876	1.93	0.326	2.759	12.560
	1.30	-0.59	-1.94	-0.40	1.21	-1.95	2.59	-0.96	2.36	-0.94						
GC	64093	-5481	-2486	-2051	198	-3990	24	-100	0.44	-0.15	0.835	5177	1.95	0.277	16.564	24.161
	1.67	-0.47	-0.48	-0.23	1.27	-1.67	1.80	-2.12	1.87	-0.61						
CH	-18342	-27236	-18124	-24316	256	8254	44	-62	0.65	-0.58	0.909	6796	2.20	2.650	5.924	10.294
	-1.18	-1.81	-2.40	-2.09	1.59	4.30	2.66	-1.35	8.99	-3.65						
ME	-44414	-3112	-13128	116	1233	-1551	44	-23	0.31	-0.21	0.948	5329	2.06	0.080	10.395	16.476
	-2.37	-0.26	-2.18	0.01	4.49	-1.12	3.34	-0.40	2.48	-1.00						
EE	8392	-3750	-10406	2474	76	-2105	23	-3.01	0.73	-0.42	0.968	2563	2.03	0.335	3.561	12.854
	0.61	-0.69	-3.35	0.60	2.31	-1.52	3.77	-0.17	5.40	-2.45						
VE	22511	23024	825	20392	480	2024	31	-63	0.39	-0.30	0.855	13020	2.05	0.259	3.416	17.930
	1.01	0.79	0.06	0.82	1.83	0.37	0.97	-0.94	1.88	-1.32						
FT	-5153	-25822	-25700	-36483	350	-1142	32	-15	0.88	-0.66	0.905	6434	1.77	2.776	14.352	28.391
	-0.16	-1.89	-3.17	-3.16	1.96	-0.38	2.07	-0.36	6.68	-4.51						
LE	1202	621	-197	929	3	169	1	-1	0.47	-0.19	0.930	303	1.90	0.100	3.544	8.043
	1.01	0.89	-0.46	1.80	1.17	1.40	1.99	-0.71	2.13	-0.82						
CF	1679	-1953	-2352	924	-30	789	11	-9	0.61	-0.47	0.953	926	2.32	2.606	9.494	9.985
	0.49	-0.99	-2.21	0.60	-0.86	2.67	5.06	-2.03	6.10	-2.66						
TF	1461	2835	-1619	3621	20	-466	3	-6	0.72	-0.44	0.939	919	1.71	3.288	7.030	20.998
	0.45	1.39	-1.64	2.23	1.04	-1.81	1.46	-1.27	6.16	-2.68						
CM	105587	-16231	-26844	-14132	27	-8863	76	-108	0.47	-0.39	0.929	8994	1.99	0.922	16.813	21.879
	3.67	-0.81	-2.71	-0.96	0.18	-3.45	3.45	-2.52	4.54	-2.05						
MM	-96019	-40761	-14336	6988	299	15204	95	-21	0.85	-0.50	0.932	16770	1.80	1.975	10.400	16.147
	-1.96	-1.01	-0.77	0.22	1.00	2.59	2.13	-0.15	6.14	-2.97						
IE	9461	-900	-7467	1414	70	-1996	20	36	0.70	-0.49	0.949	2713	1.90	0.781	7.553	13.077
	1.19	-0.15	-2.60	0.31	2.41	-2.31	2.96	1.22	9.00	-2.98						
GC	53583	2207	-679	3347	275	-3310	15	-61	0.44	-0.02	0.828	5285	1.98	0.169	19.725	28.964
	1.17	0.18	-0.12	0.37	1.48	-1.20	1.13	-1.66	1.45	-0.07						
MM	-44163	14338	17947	634	324	64158	49	-607	0.03	0.61	0.951	14205	2.23	4.960	8.893	14.989
	-0.70	0.58	1.60	0.04	0.92	6.10	1.83	-4.17	0.21	3.64						

MBKC1

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	21463	-3854	-5474	-1689	-31	-2292	13	-21	0.64	-0.33	0.940	1912	1.99	0.087	4.214	20.250
	1.51	-0.90	-2.42	-0.54	-0.47	-1.75	2.83	-1.10	3.33	-1.68						
GC	79473	-4480	-1216	-2684	572	-13309	22	-21	0.26	0.02	0.848	4967	1.97	0.022	7.468	16.927
	1.85	-0.41	-0.26	-0.31	2.14	-2.61	1.80	-0.39	0.89	0.09						
CH	-18946	-25070	-17116	-23242	195	8992	43	-61	0.67	-0.57	0.905	6954	2.16	2.743	6.264	11.391
	-0.82	-1.63	-2.25	-1.96	1.05	4.62	2.56	-1.06	9.00	-3.55						
ME	-1576	-1668	-11808	6662	782	-9427	47	14	0.44	-0.25	0.929	6213	1.97	0.260	12.205	23.137
	-0.10	-0.12	-1.67	0.64	2.74	-2.24	3.11	0.18	3.25	-1.18						
EE	6317	-1300	-8806	3385	171	-3167	21	25.73	0.66	-0.42	0.970	2474	1.96	0.456	2.785	18.213
	0.47	-0.24	-2.79	0.85	2.80	-2.28	3.56	1.23	4.78	-2.45						
VE	-90761	30059	12580	18562	2064	5020	32	-77	0.06	-0.01	0.859	12838	2.02	0.650	3.978	14.554
	-1.93	1.08	0.86	0.87	2.63	0.81	1.05	-1.04	0.23	-0.03						
FT	-47045	-24207	-25350	-33503	677	193	31	41	0.89	-0.63	0.897	6700	1.78	4.181	20.107	28.147
	-0.75	-1.69	-3.12	-2.84	1.11	0.06	1.92	0.97	6.00	-4.03						
LE	-821	734	-328	1127	16	144	1	1	0.57	-0.26	0.931	301	1.95	0.437	3.383	10.780
	-1.01	1.05	-0.90	2.24	1.36	1.18	1.73	0.52	3.82	-1.40						
CF	-2202	-512	-1258	1184	39	804	10	-2	0.48	-0.42	0.954	918	2.29	4.000	9.413	8.894
	-1.31	-0.24	-1.01	0.76	1.08	2.85	4.12	-0.51	3.08	-2.11						
TF	10219	3380	560	2472	89	-2271	3	-12	0.19	-0.15	0.953	811	1.79	1.073	11.545	26.968
	2.64	1.88	0.49	1.70	2.73	-3.12	1.55	-2.77	0.86	-0.63						
OM	112146	-12059	-23622	-11697	143	-11387	72	-107	0.42	-0.37	0.930	8931	2.00	0.983	13.791	22.062
	3.87	-0.58	-2.14	-0.79	0.66	-2.42	3.13	-2.74	3.32	-1.86						
MM	-114617	-45047	-9419	-11663	1391	12250	107	55	0.44	-0.49	0.957	13372	1.94	1.315	4.609	16.151
	-5.38	-1.40	-0.64	-0.47	4.11	2.80	3.03	0.52	4.61	-2.81						
IE	-15457	-1829	-9159	899	147	523	22	61	0.79	-0.51	0.947	2752	1.96	0.432	6.962	17.136
	-1.11	-0.31	-3.16	0.19	2.22	0.48	3.36	1.58	11.12	-3.27						
GC	70628	-5854	-2063	-3684	643	-13850	23	4	0.27	0.01	0.848	4979	1.97	0.015	7.437	18.533
	1.69	-0.49	-0.41	-0.40	2.49	-2.81	1.74	0.12	0.98	0.03						
MM	-121890	23440	25089	-643	2300	44658	43	-314	-0.29	0.70	0.966	11832	1.85	3.117	8.059	19.329
	-2.23	1.20	3.05	-0.04	3.38	4.21	2.02	-2.18	-2.53	4.77						

MHKC1

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	21463	-3854	-5474	-1689	-31	-2292	13	-21	0.64	-0.33	0.940	1912	1.99	0.087	4.214	20.250
	1.51	-0.90	-2.42	-0.54	-0.47	-1.75	2.83	-1.10	3.33	-1.68						
GC	83111	-5497	-3448	-3417	554	-13211	23	-23	0.24	0.06	0.849	4959	1.96	0.092	6.703	16.554
	1.97	-0.51	-0.70	-0.41	2.29	-2.87	1.91	-0.43	0.90	0.21						
CH	-20036	-26265	-18211	-23905	211	8958	43	-57	0.67	-0.57	0.905	6945	2.16	2.745	5.994	11.166
	-0.86	-1.69	-2.35	-2.01	1.09	4.61	2.56	-0.96	9.02	-3.53						
ME	5792	-7369	-14595	351	853	-10117	48	11	0.38	-0.14	0.931	6088	1.99	0.087	13.047	25.781
	0.35	-0.52	-2.04	0.03	3.18	-2.53	3.16	0.15	2.59	-0.62						
EE	7387	-3554	-8976	2314	178	-3222	20	28	0.65	-0.40	0.972	2419	1.97	0.382	2.228	18.361
	0.55	-0.69	-2.95	0.60	3.04	-2.32	3.53	1.33	4.74	-2.21						
VE	-48941	22614	354	10477	1268	6495	29	-76	0.28	-0.19	0.857	12895	2.01	0.345	3.977	11.233
	-1.53	0.80	0.03	0.43	2.23	1.35	0.92	-1.09	1.33	-0.79						
FT	-94363	-27238	-28730	-43272	1120	1783	31	63	0.89	-0.66	0.911	6230	1.65	4.375	19.868	28.224
	-1.77	-2.05	-3.63	-3.70	2.37	0.59	2.11	1.61	7.16	-4.54						
LE	-731	597	-316	1012	15	153	1	1	0.57	-0.25	0.931	302	1.94	0.404	3.236	10.737
	-0.93	0.87	-0.85	2.00	1.31	1.27	1.79	0.47	3.78	-1.31						
CF	-1993	-893	-1304	934	35	824	10	-3	0.49	-0.42	0.953	920	2.28	3.666	9.216	8.758
	-1.24	-0.43	-1.05	0.60	1.03	2.95	4.26	-0.65	3.29	-2.14						
TF	14390	2312	761	536	121	-3034	4	-13	-0.05	0.16	0.956	785	1.80	0.751	10.300	25.317
	3.81	1.42	0.81	0.38	3.73	-4.44	2.10	-2.87	-0.23	0.68						
OM	113239	-13136	-24297	-13034	151	-11552	72	-106	0.42	-0.36	0.930	8926	2.01	0.874	13.750	22.025
	3.81	-0.65	-2.31	-0.89	0.68	-2.40	3.17	-2.70	3.24	-1.78						
MM	-100259	-67880	-25274	-28406	1427	12006	106	49	0.43	-0.47	0.958	13103	1.94	1.136	4.800	19.016
	-5.46	-2.12	-1.74	-1.14	4.30	2.76	3.06	0.48	4.56	-2.67						
IE	-15923	-3649	-9404	165	153	625	22	65	0.80	-0.48	0.948	2719	1.97	0.568	6.692	16.308
	-1.18	-0.62	-3.32	0.04	2.38	0.58	3.30	1.69	11.06	-3.02						
GC	77381	-5707	-3981	-3557	599	-13539	23	-4	0.25	0.06	0.848	4974	1.97	0.079	6.771	18.324
	1.73	-0.47	-0.73	-0.39	2.61	-3.00	1.72	-0.10	0.90	0.19						
MM	-80148	-12631	1677	-24122	1878	46269	48	-357	-0.22	0.65	0.967	11666	1.97	3.928	8.369	22.632
	-2.01	-0.59	0.17	-1.49	3.69	4.75	2.26	-2.65	-2.09	4.44						

MIKCH

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR4	F	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	15253	-774	-3596	-932	156	-2865	11	-12	0.40	0.25	0.934	1889	1.95	1.348	12.125	13.194
	1.17	-0.18	-1.65	-0.30	1.87	-2.32	2.43	-0.69	2.22	1.26						
GC	57460	-1835	-88	-2219	459	-2479	21	-110	0.28	-0.19	0.834	4999	2.09	0.728	11.144	17.849
	1.57	-0.17	-0.02	-0.27	2.29	-0.95	1.74	-2.27	1.36	-0.99						
CH	-13788	-21598	-15526	-24528	274	13855	40	-74	0.45	0.23	0.892	7659	2.58	10.190	10.775	14.286
	-0.54	-1.23	-2.04	-1.96	1.17	3.77	2.17	-1.10	3.82	1.26						
TX	30168	7468	1655	8699	191	2702	23	12	0.40	0.18	0.944	3518	1.95	0.203	13.252	16.664
	2.50	0.92	0.44	1.43	1.87	1.08	2.58	0.36	3.59	0.93						
ME	-51739	21267	-871	12718	1304	45	29	-5	0.24	0.23	0.971	4083	1.76	0.811	1.858	13.677
	-2.78	2.22	-0.17	1.86	5.50	0.03	2.87	-0.08	2.59	1.60						
EE	16968	-372	-8210	2645	93	-2891	22	-2.83	0.61	0.23	0.965	2679	2.51	4.756	9.515	16.272
	0.97	-0.06	-2.31	0.61	1.94	-1.49	3.40	-0.12	3.74	1.30						
VE	40536	21999	10992	8631	528	12114	40	-75	0.02	0.24	0.855	13285	2.11	1.920	9.262	20.450
	1.69	0.71	0.78	0.37	1.62	1.46	1.23	-1.02	0.11	1.22						
FT	62721	1022	-35142	-49452	320	5126	23	-45	0.55	0.90	0.960	3990	1.68	6.271	21.275	24.604
	0.91	0.04	-1.60	-1.88	2.12	1.89	2.82	-1.28	2.82	10.97						
LE	1882	675	-46	816	4	156	2	-1	0.35	-0.06	0.921	322	2.05	1.070	5.833	10.876
	1.40	0.85	-0.10	1.55	1.35	0.90	1.81	-0.45	1.70	-0.33						
CF	2924	-1380	-1351	711	-28	1247	11	-10	0.47	-0.16	0.948	993	2.67	8.633	9.158	13.070
	0.54	-0.59	-1.18	0.45	-0.54	2.83	4.34	-1.52	3.51	-0.85						
TF	4908	4225	-257	3392	40	-415	3	-7	0.40	0.40	0.952	796	1.98	0.439	10.080	17.845
	1.39	2.31	-0.26	2.43	1.81	-1.03	1.34	-1.57	2.98	2.59						
OM	62615	-3473	-29105	-10576	120	-6267	69	-49	0.58	0.41	0.963	6435	2.50	5.253	11.838	23.948
	1.77	-0.22	-3.00	-0.98	0.77	-2.06	4.27	-1.39	4.57	3.59						
MM	-191266	1625	-705	25012	758	41643	60	-18	0.68	0.13	0.935	16987	2.51	4.205	8.835	15.400
	-2.58	0.04	-0.04	0.78	1.81	3.88	1.28	-0.12	4.16	0.75						
IE	38882	4965	-2366	2142	73	-3361	16	3	0.38	0.08	0.934	2736	2.32	3.957	11.497	13.630
	2.71	0.80	-0.78	0.47	1.84	-2.60	2.32	0.07	2.82	0.48						
GC	31455	5477	808	3076	548	-601	14	-64	0.35	-0.08	0.834	4990	1.98	0.134	9.443	21.853
	1.01	0.48	0.17	0.36	2.51	-0.24	1.08	-2.24	1.90	-0.47						
MM	-109421	2175	7065	5719	495	54067	65	-497	0.35	0.09	0.960	13347	2.04	0.212	7.331	13.922
	-1.90	0.07	0.56	0.23	1.51	6.66	1.88	-4.03	2.39	0.54						

MEKO4

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	15253	-774	-3596	-932	156	-2855	11	-12	0.40	0.25	0.934	1889	1.95	1.348	12.125	13.194
	1.17	-0.18	-1.65	-0.30	1.87	-2.32	2.43	-0.69	2.22	1.26						
GC	59673	-2867	-1744	-2875	457	-2646	23	-111	0.27	-0.20	0.835	4979	2.07	0.634	11.559	17.550
	1.64	-0.26	-0.38	-0.34	2.36	-1.03	1.83	-2.28	1.31	-1.09						
CH	-14770	-23245	-16987	-25471	295	13838	40	-71	0.45	0.22	0.892	7627	2.57	10.256	10.864	14.078
	-0.60	-1.32	-2.23	-2.04	1.26	3.79	2.17	-1.05	3.83	1.21						
TX	31854	5956	734	6366	206	2342	22	17	0.40	0.15	0.946	3458	1.92	0.097	11.984	15.399
	2.71	0.76	0.21	1.08	2.12	0.98	2.59	0.52	3.61	0.75						
ME	-43765	12491	-7221	6649	1243	224	30	-11	0.25	0.18	0.974	3862	1.74	0.778	2.691	13.661
	-2.72	1.35	-1.54	0.99	6.01	0.15	3.13	-0.20	2.94	1.28						
EE	18245	-1666	-8193	2027	97	-2993	22	-2.54	0.60	0.19	0.966	2660	2.48	4.523	8.856	15.977
	1.04	-0.28	-2.36	0.47	2.08	-1.54	3.37	-0.11	3.66	1.06						
VE	44599	22123	9941	5109	542	11676	37	-86	0.02	0.19	0.858	13124	2.09	1.306	9.390	18.679
	1.88	0.73	0.73	0.21	1.77	1.48	1.14	-1.16	0.11	0.96						
FT	62286	-1791	-35982	-52718	334	5102	24	-45	0.55	0.89	0.961	3962	1.69	6.413	21.517	24.296
	0.92	-0.08	-1.68	-2.02	2.23	1.89	2.89	-1.30	2.82	10.91						
LE	2065	678	-4	789	4	141	1	-1	0.32	-0.08	0.922	319	2.01	0.846	5.568	11.120
	1.56	0.87	-0.01	1.51	1.53	0.83	1.82	-0.46	1.61	-0.43						
CF	2984	-1222	-1413	885	-30	1231	11	-10	0.47	-0.17	0.948	991	2.68	8.952	9.375	13.560
	0.61	-0.55	-1.22	0.57	-0.62	2.82	4.40	-1.61	3.55	-0.88						
TF	4796	3919	-483	3051	41	-411	3	-7	0.41	0.40	0.953	791	1.94	0.443	10.684	18.039
	1.37	2.15	-0.49	2.15	1.91	-1.03	1.40	-1.47	3.06	2.57						
CM	61259	-4774	-29972	-11863	131	-6233	70	-47	0.58	0.41	0.963	6423	2.51	5.340	11.864	24.424
	1.72	-0.30	-3.11	-1.08	0.84	-2.06	4.30	-1.32	4.62	3.56						
MM	-183804	-8509	-7544	18224	754	41112	60	-14	0.68	0.13	0.935	16939	2.50	4.002	8.447	14.614
	-2.67	-0.20	-0.42	0.59	1.85	3.85	1.28	-0.09	4.20	0.74						
IE	38249	3955	-2571	1803	78	-3387	15	7	0.39	0.07	0.936	2700	2.30	3.484	10.687	12.746
	2.72	0.65	-0.87	0.40	2.06	-2.70	2.28	0.18	2.95	0.38						
GC	34079	4464	-1086	2402	559	-800	15	-66	0.33	-0.11	0.838	4940	1.95	0.183	9.200	22.241
	1.11	0.39	-0.23	0.29	2.65	-0.33	1.19	-2.34	1.78	-0.62						
MM	-105472	-4105	2644	1570	500	53761	64	-496	0.35	0.08	0.960	13297	2.03	0.180	6.752	13.765
	-1.99	-0.13	0.21	0.07	1.58	6.66	1.87	-4.04	2.44	0.53						

MBKC4

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR4	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	35525	-1125	-3660	-634	-77	-2804	11	-31	0.46	0.01	0.929	1966	2.29	5.178	9.538	24.770
	2.15	-0.25	-1.63	-0.20	-0.70	-1.94	2.28	-1.33	2.37	0.06						
GC	79538	-1450	-194	-1190	575	-13476	19	-23	0.26	-0.10	0.831	5037	1.92	0.073	12.865	13.135
	2.24	-0.13	-0.04	-0.14	2.13	-2.96	1.53	-0.38	1.21	-0.47						
CH	-2958	-21032	-15686	-24386	130	14168	40	-95	0.48	0.21	0.887	7834	2.53	7.904	7.226	10.677
	-0.07	-1.17	-2.03	-1.91	0.38	3.78	2.10	-1.08	3.79	1.11						
TX	33320	4893	548	6912	106	4022	25	-13	0.42	0.17	0.938	3705	1.98	0.254	16.899	22.125
	2.51	0.58	0.14	1.09	0.80	1.28	2.77	-0.40	3.22	0.91						
ME	-1885	15970	-2986	9898	928	-6690	33	16	0.27	0.39	0.963	4603	1.90	0.674	2.896	22.243
	-0.12	1.49	-0.50	1.27	4.71	-2.09	3.04	0.23	2.61	2.72						
EE	10323	526	-7037	2291	224	-3430	20.71	28.22	0.53	0.34	0.970	2470	2.34	3.589	10.753	14.065
	0.67	0.09	-2.05	0.57	3.02	-1.92	3.57	1.21	3.51	1.90						
VE	-88459	32969	16994	14169	2090	11791	31	-105	-0.10	0.05	0.874	12343	2.03	0.156	0.602	15.230
	-1.83	1.18	1.31	0.67	2.48	1.82	1.01	-1.40	-0.51	0.25						
FT	40478	347	-37739	-50577	370	3667	25	-16	0.63	0.89	0.954	4295	1.73	6.837	21.854	27.329
	0.55	0.01	-1.48	-1.69	0.63	1.06	2.58	-0.43	2.87	8.68						
LE	-799	569	-321	889	20	176	2	1	0.48	0.05	0.922	320	2.13	0.776	6.207	12.537
	-0.78	0.72	-0.76	1.70	1.36	1.07	1.88	0.69	3.08	0.30						
CF	-1383	560	-119	1166	53	1179	9	-2	0.30	-0.16	0.950	977	2.52	8.321	9.420	11.197
	-0.62	0.22	-0.08	0.76	1.07	2.94	3.39	-0.29	1.62	-0.85						
TF	10621	4117	615	2875	65	-1731	2	-13	0.21	0.12	0.953	790	1.84	0.550	15.727	27.328
	3.13	2.31	0.59	2.07	1.94	-2.45	1.27	-2.78	1.13	0.65						
OM	70557	-1899	-27934	-9520	169	-8707	67	-53	0.57	0.42	0.963	6424	2.46	3.686	9.712	23.138
	2.12	-0.12	-2.81	-0.89	0.82	-2.04	4.11	-1.60	4.33	3.60						
MM	-156760	-15012	3269	-7111	2048	29028	81	57	0.10	0.27	0.957	13694	2.08	1.681	5.428	15.762
	-5.01	-0.43	0.22	-0.29	4.21	3.36	2.22	0.48	0.76	1.35						
IE	13961	2052	-3961	-438	185	-285	19	33	0.40	0.24	0.937	2685	2.13	2.022	6.709	16.180
	0.68	0.33	-1.23	-0.09	2.18	-0.17	2.97	0.70	2.72	1.43						
GC	68704	-2628	-1090	-2081	646	-13852	20	4	0.29	-0.07	0.830	5052	1.92	0.068	12.718	14.599
	2.37	-0.21	-0.22	-0.22	2.34	-2.90	1.45	0.12	1.40	-0.33						
MM	-90470	-6148	8400	-6360	1205	41214	73	-316	0.09	0.15	0.963	12764	1.91	0.623	6.620	14.446
	-2.57	-0.21	0.67	-0.29	2.17	4.38	2.28	-2.09	0.75	0.78						

MKD1

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	35525	-1125	-3660	-634	-77	-2804	11	-31	0.46	0.01	0.929	1966	2.29	5.178	9.538	24.770
	2.15	-0.25	-1.63	-0.20	-0.70	-1.94	2.28	-1.33	2.37	0.06						
GC	83065	-2424	-2414	-1839	564	-13495	20	-25	0.25	-0.13	0.834	4996	1.84	0.161	12.351	12.878
	2.33	-0.22	-0.50	-0.22	2.24	-3.13	1.63	-0.43	1.15	-0.60						
CH	-6605	-21964	-16558	-24852	165	14102	40	-88	0.48	0.21	0.887	7821	2.52	8.012	7.369	10.683
	-0.16	-1.21	-2.08	-1.95	0.48	3.76	2.09	-0.98	3.81	1.11						
TX	36176	4119	212	5348	154	2860	25	-5	0.40	0.13	0.940	3648	1.91	0.079	14.214	19.554
	2.73	0.50	0.06	0.84	1.23	0.93	2.75	-0.15	3.16	0.70						
ME	2824	9794	-7311	5418	922	-6770	34	15	0.26	0.35	0.967	4356	1.90	0.546	4.685	22.782
	0.20	0.95	-1.30	0.72	5.14	-2.30	3.21	0.23	2.72	2.54						
EE	13504	-2726	-7377	936	219	-3738	20	28	0.53	0.26	0.971	2444	2.34	3.157	9.274	14.339
	0.86	-0.49	-2.26	0.23	3.09	-2.08	3.49	1.20	3.45	1.40						
VE	-50780	29245	10465	1268	1597	14576	24	-120	-0.05	0.03	0.873	12411	2.09	0.226	0.794	13.170
	-1.52	1.05	0.85	0.06	2.68	2.60	0.80	-1.57	-0.25	0.14						
FT	36075	-3983	-41315	-58767	520	3292	26	-14	0.60	0.90	0.955	4245	1.73	7.246	22.038	27.766
	0.47	-0.15	-1.39	-1.55	0.90	0.97	2.70	-0.39	2.75	8.56						
LE	-698	445	-298	780	18	189	2	1	0.49	0.05	0.922	320	2.13	0.715	6.401	13.451
	-0.72	0.57	-0.70	1.48	1.33	1.18	1.91	0.65	3.11	0.27						
CF	-1099	95	-149	834	47	1215	9	-3	0.31	-0.16	0.950	978	2.52	7.910	9.309	11.119
	-0.52	0.04	-0.10	0.55	1.04	3.12	3.54	-0.40	1.74	-0.83						
TF	11925	3292	412	1844	79	-2067	3	-14	0.14	0.01	0.954	777	1.73	0.969	15.841	25.366
	3.56	1.88	0.46	1.25	2.45	-3.03	1.51	-2.84	0.78	0.05						
OM	69704	-3463	-28966	-11108	189	-8958	68	-51	0.57	0.41	0.963	6402	2.46	3.602	9.654	22.709
	2.10	-0.22	-3.00	-1.03	0.93	-2.13	4.17	-1.52	4.42	3.55						
MM	-132056	-44870	-17863	-27896	2027	28056	78	42	0.11	0.22	0.960	13306	2.07	1.176	5.123	17.201
	-5.12	-1.31	-1.23	-1.13	4.44	3.37	2.16	0.36	0.85	1.09						
IE	13437	-292	-4517	-1163	183	-346	19	35	0.43	0.20	0.939	2643	2.11	1.648	6.082	15.234
	0.69	-0.05	-1.45	-0.25	2.35	-0.22	2.90	0.76	2.99	1.15						
GC	72868	-2767	-3227	-2034	613	-13592	20	-1	0.28	-0.10	0.833	5015	1.85	0.205	12.649	14.843
	2.49	-0.22	-0.63	-0.22	2.44	-3.04	1.48	-0.04	1.38	-0.48						
MM	-80502	-26244	-5530	-20510	1297	39522	73	-305	0.08	0.11	0.965	12335	1.86	0.694	7.059	15.530
	-2.89	-0.91	-0.45	-0.96	2.58	4.38	2.31	-2.14	0.74	0.58						

MRC14

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	13222	-1003	-4357	-685	115	-2425	11	-10	0.51	-0.15	0.20	0.935	1919	1.79	0.743	12.215	13.201
	0.93	-0.22	-1.74	-0.21	1.44	-1.70	2.31	-0.61	2.26	-0.64	1.03						
GC	55605	-2492	-550	-2371	434	-2499	22	-109	0.31	-0.06	-0.20	0.834	5092	2.04	0.708	12.149	19.445
	1.23	-0.22	-0.11	-0.28	2.17	-0.87	1.74	-2.05	1.10	-0.23	-1.03						
CH	-16486	-21360	-17837	-23947	241	9471	39	-68	0.62	-0.52	0.15	0.917	6826	2.11	1.752	4.951	6.301
	-0.96	-1.32	-2.04	-1.88	1.44	4.00	2.25	-1.42	7.65	-2.99	0.88						
TX	27201	6110	596	8532	176	2336	24	13	0.45	-0.12	0.14	0.945	3575	1.82	0.270	13.516	16.902
	2.04	0.72	0.14	1.31	1.71	0.89	2.60	0.40	3.05	-0.42	0.59						
ME	-56765	25568	5927	10981	1537	1548	26	24	0.05	0.36	0.24	0.974	3950	1.77	1.879	3.261	11.242
	-2.58	3.00	1.04	1.86	6.42	0.51	2.93	0.34	0.43	2.01	1.83						
EE	7593	-322	-10282	3867	71	-2010	21	-6	0.75	-0.41	0.12	0.970	2519	1.99	0.331	7.042	18.676
	0.52	-0.06	-3.02	0.89	2.09	-1.32	3.45	-0.32	5.25	-2.28	0.70						
VE	34730	22134	8585	11371	471	11282	39	-79	0.11	-0.08	0.21	0.854	13557	2.11	1.542	8.797	20.274
	1.08	0.69	0.50	0.40	1.17	1.26	1.12	-1.07	0.26	-0.19	1.00						
FT	58093	-4966	-25643	-41530	328	5179	24	-44	0.55	0.04	0.86	0.961	4049	1.72	6.493	20.836	20.555
	0.79	-0.27	-1.44	-2.48	2.08	1.83	2.80	-1.19	2.54	0.45	10.22						
LE	697	559	-331	970	2	201	2	-1	0.54	-0.21	0.03	0.922	326	1.97	0.073	6.739	12.941
	0.43	0.70	-0.63	1.60	0.55	1.33	1.80	-0.60	1.97	-0.72	0.16						
CF	1492	-1974	-2230	1216	-33	852	11	-9	0.63	-0.50	-0.12	0.959	899	2.33	3.280	7.739	12.973
	0.40	-0.97	-2.31	0.80	-0.89	2.89	5.01	-2.06	6.66	-2.82	-0.72						
TF	3501	4252	-799	3865	32	-415	2	-7	0.54	-0.20	0.30	0.952	809	1.84	0.835	11.402	15.533
	0.98	2.25	-0.72	2.60	1.56	-1.37	1.09	-1.53	3.40	-0.88	1.72						
OM	30145	-13826	-40217	-14935	136	-4961	79	-31	0.71	-0.32	0.27	0.968	6081	2.15	2.825	9.631	25.276
	1.00	-0.92	-4.19	-1.35	1.16	-2.24	4.86	-0.93	6.92	-2.28	2.42						
MM	-171536	-13912	-10270	25250	719	22081	71	-13	0.91	-0.55	-0.06	0.948	15478	1.87	1.671	3.769	9.293
	-3.22	-0.36	-0.60	0.85	2.35	3.34	1.66	-0.10	6.65	-3.20	-0.32						
IE	22886	1924	-5882	1620	55	-2460	19	7	0.58	-0.44	-0.05	0.944	2584	1.90	0.511	8.478	8.909
	2.17	0.33	-2.10	0.36	1.90	-2.70	2.85	0.22	5.58	-2.35	-0.29						
GC	34249	6155	1378	3076	584	-526	13	-66	0.30	0.07	-0.06	0.835	5081	2.02	0.065	8.763	21.307
	0.76	0.53	0.26	0.35	2.33	-0.18	1.03	-1.89	0.93	0.23	-0.31						
MM	-115010	14313	13178	9406	540	61007	54	-544	0.26	0.18	0.08	0.960	13572	2.12	0.666	5.703	13.262
	-1.79	0.47	1.07	0.41	1.51	6.20	1.64	-4.26	1.72	0.89	0.52						

APPENDIX V

LINEAR MODEL

MPKC14

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	13222	-1003	-4357	-685	115	-2425	11	-10	0.51	-0.15	0.20	0.935	1919	1.79	0.743	12.215	13.201
	0.93	-0.22	-1.74	-0.21	1.44	-1.70	2.31	-0.61	2.26	-0.64	1.03						
GC	57658	-3541	-2141	-3072	436	-2645	23	-110	0.29	-0.06	-0.21	0.835	5072	2.01	0.630	12.477	18.866
	1.29	-0.31	-0.42	-0.36	2.27	-0.93	1.83	-2.11	1.10	-0.24	-1.12						
CH	-15989	-22682	-19002	-24694	246	9474	39	-68	0.62	-0.52	0.14	0.917	6816	2.11	1.736	4.755	6.109
	-0.96	-1.40	-2.19	-1.95	1.46	4.01	2.24	-1.42	7.64	-2.97	0.85						
TX	30139	5323	212	6402	198	2176	23	17	0.42	-0.06	0.13	0.946	3524	1.87	0.159	12.164	15.557
	2.13	0.65	0.05	1.02	1.97	0.82	2.57	0.52	2.72	-0.20	0.56						
ME	-42775	14967	-3411	5583	1327	1274	28	0	0.15	0.22	0.18	0.975	3870	1.79	1.215	3.953	13.167
	-2.29	1.64	-0.57	0.87	6.31	0.55	3.02	-0.01	1.14	1.07	1.31						
EE	8100	-1269	-10281	3498	71	-2019	21	-6	0.74	-0.41	0.10	0.970	2514	1.99	0.342	7.027	15.541
	0.55	-0.23	-3.07	0.81	2.11	-1.32	3.42	-0.30	5.19	-2.22	0.59						
VE	54212	24647	14438	2226	619	13171	35	-80	-0.11	0.15	0.21	0.859	13352	2.14	1.928	10.499	18.334
	1.58	0.81	0.82	0.09	1.67	1.36	1.12	-0.99	-0.30	0.39	1.08						
FT	53727	-6989	-27702	-45126	339	5116	24	-43	0.56	0.03	0.86	0.961	4039	1.73	6.513	20.987	20.639
	0.77	-0.38	-1.52	-2.65	2.17	1.81	2.86	-1.14	2.58	0.39	10.04						
LE	1832	649	-61	814	4	150	2	-1	0.36	-0.04	-0.06	0.922	326	2.00	0.606	5.716	11.288
	0.80	0.80	-0.09	1.30	0.93	0.89	1.80	-0.47	0.92	-0.08	-0.31						
CF	1565	-1769	-2295	1431	-35	836	11	-9	0.63	-0.51	-0.12	0.960	895	2.34	3.424	7.732	13.393
	0.46	-0.91	-2.37	0.97	-1.02	2.89	5.10	-2.19	6.77	-2.86	-0.74						
TF	4108	3958	-767	3357	37	-432	2	-7	0.48	-0.10	0.35	0.953	807	1.88	0.552	11.310	16.838
	1.10	2.10	-0.67	2.23	1.69	-1.28	1.23	-1.46	2.78	-0.45	1.99						
OM	28870	-15261	-41210	-16402	146	-4904	79	-29	0.72	-0.32	0.27	0.968	6060	2.15	2.783	9.590	25.788
	0.96	-1.01	-4.31	-1.46	1.24	-2.22	4.91	-0.87	7.01	-2.31	2.42						
MM	-164139	-24087	-16871	18282	710	21740	72	-8	0.91	-0.55	-0.06	0.948	15490	1.86	1.558	3.265	8.156
	-3.25	-0.62	-0.96	0.63	2.34	3.27	1.67	-0.06	6.64	-3.15	-0.33						
IE	23174	1251	-5911	1359	58	-2467	18	9	0.58	-0.42	-0.05	0.944	2571	1.92	0.535	8.471	8.413
	2.19	0.21	-2.14	0.30	1.97	-2.71	2.80	0.28	5.55	-2.24	-0.31						
GC	37311	5164	-603	2480	588	-786	15	-68	0.28	0.07	-0.09	0.838	5031	1.98	0.094	8.584	21.712
	0.83	0.45	-0.11	0.29	2.58	-0.27	1.13	-2.00	0.95	0.23	-0.47						
MM	-109788	7244	8333	4723	538	60597	53	-542	0.27	0.17	0.08	0.960	13519	2.11	0.629	5.325	13.254
	-1.88	0.25	0.66	0.21	1.58	6.21	1.64	-4.26	1.74	0.88	0.51						

MBKC14

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	24445	-2695	-5634	-1018	-113	-1315	12	-25	0.69	-0.40	-0.06	0.938	1879	1.94	2.672	14.681	31.522
	1.63	-0.63	-2.50	-0.33	-1.43	-1.05	2.66	-1.26	3.63	-2.01	-0.35						
GC	78717	-1457	-241	-1172	574	-13409	19	-22	0.27	0.00	-0.10	0.831	5137	1.92	0.064	12.812	13.095
	1.66	-0.13	-0.05	-0.13	1.92	-2.33	1.48	-0.36	0.84	0.00	-0.43						
CH	-10115	-20533	-17685	-23409	135	9790	39	-81	0.65	-0.51	0.13	0.911	7063	2.06	0.858	4.589	7.683
	-0.34	-1.22	-2.04	-1.81	0.56	3.97	2.13	-1.21	7.43	-2.89	0.74						
TX	28521	3163	-911	6741	68	4038	27	-15	0.48	-0.13	0.13	0.939	3763	1.86	0.219	16.140	21.339
	1.82	0.36	-0.21	0.98	0.52	1.30	2.82	-0.48	2.77	-0.46	0.55						
ME	-27973	21219	9167	5304	1471	-369	30	61	-0.08	0.60	0.26	0.977	3700	2.16	1.962	5.707	13.399
	-1.20	2.93	2.00	1.04	7.18	-0.09	3.92	0.88	-0.74	5.26	2.41						
EE	5108	632	-9121	3871	166	-2862	20	23	0.67	-0.35	0.18	0.973	2412	1.95	0.259	5.666	13.248
	0.36	0.12	-2.64	0.93	2.67	-1.87	3.33	1.07	4.68	-1.86	1.07						
VE	-88445	33105	17137	14159	2093	11842	30	-105	-0.10	0.01	0.05	0.874	12588	2.04	0.163	0.611	15.225
	-1.72	1.14	1.08	0.65	2.43	1.33	0.98	-1.36	-0.35	0.02	0.24						
FT	-56477	-19539	-40034	-46854	757	1088	31	42	0.91	-0.22	0.60	0.952	4475	1.77	1.767	18.245	17.266
	-1.05	-1.72	-2.41	-2.86	1.06	0.30	2.85	1.34	4.90	-1.59	4.40						
LE	-794	661	-402	1086	14	161	1	1	0.59	-0.23	0.07	0.924	321	1.99	0.116	6.336	15.051
	-0.87	0.83	-0.94	1.86	0.96	1.10	1.61	0.40	3.18	-0.85	0.41						
CF	-1978	-920	-1647	1543	14	945	10	-5	0.56	-0.48	-0.09	0.958	911	2.30	3.680	7.610	8.521
	-1.24	-0.41	-1.27	1.01	0.35	3.28	4.24	-0.93	3.44	-2.46	-0.53						
TF	8118	4217	25	3427	51	-1363	2	-11	0.36	-0.20	0.12	0.953	802	1.71	1.293	17.287	27.375
	2.18	2.26	0.02	2.32	1.58	-1.95	1.08	-2.58	1.69	-0.73	0.60						
CM	47491	-9171	-37163	-12153	166	-8053	73	-44	0.68	-0.29	0.29	0.968	6117	2.10	1.858	8.802	22.225
	1.69	-0.60	-3.67	-1.09	0.99	-2.25	4.44	-1.44	6.01	-2.10	2.58						
MM	-113137	-41670	-9902	-12251	1270	18558	105	16	0.41	-0.50	0.04	0.960	13581	1.98	1.976	6.228	15.646
	-5.10	-1.22	-0.63	-0.48	3.60	3.19	2.83	0.15	3.97	-2.63	0.20						
IE	2666	210	-7490	559	123	-346	21	32	0.65	-0.41	0.02	0.943	2610	1.87	0.473	4.757	14.124
	0.15	0.03	-2.53	0.12	1.78	-0.28	3.13	0.75	5.69	-2.19	0.12						
GC	68366	-2648	-1116	-2077	645	-13821	20	4	0.29	0.00	-0.07	0.830	5152	1.92	0.066	12.709	14.585
	1.52	-0.21	-0.21	-0.21	2.25	-2.49	1.42	0.11	0.96	-0.01	-0.31						
MM	-152209	29258	26965	3042	2375	49692	40	-260	-0.27	0.58	0.12	0.969	11829	1.88	1.607	8.537	16.638
	-2.19	1.34	2.94	0.19	2.84	4.45	1.68	-1.68	-2.06	3.23	0.78						

LINEAR MODEL

MHC14

	C	S1	S2	S4	Output	Price	Temp	Capacity	LDep	AR1	AR4	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PP	24445	-2695	-5634	-1018	-113	-1315	12	-25	0.69	-0.40	-0.06	0.938	1879	1.94	2.672	14.681	31.522
	1.63	-0.63	-2.50	-0.33	-1.43	-1.05	2.66	-1.26	3.63	-2.01	-0.35						
GC	84872	-2424	-2338	-1959	574	-13728	20	-25	0.23	0.03	-0.12	0.834	5093	1.87	0.118	12.306	12.941
	1.79	-0.21	-0.47	-0.22	2.15	-2.66	1.59	-0.41	0.77	0.11	-0.54						
CR	-11032	-21348	-18424	-23837	146	9743	39	-78	0.65	-0.51	0.12	0.911	7058	2.06	0.869	4.294	7.327
	-0.37	-1.26	-2.11	-1.84	0.59	3.95	2.12	-1.13	7.42	-2.88	0.71						
TX	35046	3840	-51	5429	145	2902	25	-5	0.41	-0.02	0.13	0.940	3720	1.90	0.093	14.251	19.534
	1.87	0.45	-0.01	0.77	1.03	0.90	2.70	-0.17	1.98	-0.07	0.59						
ME	-5654	14196	3768	-277	1222	446	29	32	-0.08	0.60	0.21	0.977	3734	2.17	3.269	7.708	18.489
	-0.25	1.86	0.80	-0.05	7.20	0.11	3.82	0.48	-0.70	4.71	1.79						
EE	6304	-1722	-9293	2879	166	-2898	19	24	0.67	-0.34	0.15	0.973	2391	1.97	0.226	5.332	13.759
	0.44	-0.32	-2.79	0.70	2.73	-1.88	3.30	1.09	4.64	-1.79	0.89						
VE	-52440	27656	8560	1967	1567	13649	26	-117	9.935D-0	-0.07	0.02	0.873	12645	2.04	0.133	0.654	13.270
	-1.47	0.96	0.60	0.08	2.57	1.79	0.81	-1.55	3.643D-0	-0.21	0.10						
FT	-65971	-24606	-42320	-55654	929	673	33	43	0.89	-0.25	0.57	0.953	4408	1.77	1.662	17.307	18.522
	-1.31	-2.02	-2.65	-3.30	1.39	0.19	2.99	1.41	5.10	-1.64	4.02						
LE	-699	555	-388	995	13	173	1	1	0.59	-0.23	0.06	0.924	322	1.99	0.103	6.444	15.705
	-0.80	0.71	-0.90	1.67	0.91	1.21	1.65	0.35	3.17	-0.82	0.38						
CF	-1883	-1077	-1687	1454	12	957	10	-5	0.56	-0.48	-0.09	0.958	911	2.30	3.512	7.535	8.489
	-1.25	-0.51	-1.31	0.95	0.31	3.41	4.36	-1.04	3.65	-2.50	-0.54						
TF	15806	3039	1170	839	102	-2660	3	-15	-0.09	0.29	-0.03	0.955	786	1.81	1.725	14.341	21.922
	3.99	1.86	1.21	0.60	2.88	-3.65	1.82	-2.91	-0.46	1.12	-0.15						
OM	47571	-10431	-38012	-13618	181	-8262	73	-42	0.68	-0.29	0.30	0.968	6095	2.11	1.688	8.760	21.517
	1.69	-0.69	-3.87	-1.24	1.08	-2.33	4.51	-1.38	6.09	-2.09	2.61						
MM	-187574	-22688	-6485	-30378	2788	49463	45	96	-0.26	0.62	0.12	0.968	12134	1.90	2.817	9.948	18.705
	-3.48	-0.92	-0.58	-1.69	5.06	4.00	1.89	0.82	-2.16	4.27	0.78						
IE	2770	-1148	-7570	99	125	-304	20	33	0.65	-0.39	0.00	0.943	2592	1.90	0.462	4.316	13.545
	0.16	-0.19	-2.60	0.02	1.89	-0.25	3.05	0.79	5.70	-2.02	0.02						
GC	75656	-2611	-3042	-2062	621	-13834	20	-2	0.26	0.04	-0.09	0.833	5112	1.88	0.146	12.655	15.046
	1.58	-0.20	-0.53	-0.22	2.42	-2.73	1.43	-0.06	0.85	0.12	-0.43						
MM	-116974	-8477	2376	-22436	2081	51310	44	-280	-0.23	0.56	0.09	0.972	11385	1.95	2.101	10.409	19.537
	-2.43	-0.36	0.22	-1.26	3.43	5.06	1.91	-2.01	-2.00	3.34	0.57						

Logarithmic Moddels(RELative prices)

S2KLS

	C	Price	Temp	Output	LDep	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	1.44957	-0.25358	0.12150	0.53518	0.47148	0.839	0.07585	2.06160	0.18428	20.71328	27.07536
	1.89	-2.05	7.16	2.43	4.53						
GCS	4.21536	-0.20774	0.06909	0.15100	0.48126	0.801	0.04050	2.29287	1.39392	7.47756	14.30844
	4.12	-3.38	7.56	1.80	4.56						
CRS	1.77118	0.17626	0.01855	0.53949	0.68588	0.696	0.08426	2.79740	13.31168	18.04496	21.09468
	1.32	1.24	0.88	2.10	6.45						
MES	5.68704	-0.08617	0.15942	0.93172	0.04231	0.875	0.05962	2.69514	7.90392	25.93432	28.83056
	5.62	-1.01	10.56	4.98	0.62						
EES	3.95461	-0.17538	0.12718	0.46918	0.31941	0.862	0.07229	1.39837	5.94232	22.09084	31.15348
	4.71	-1.47	7.11	4.41	3.86						
VES	7.48091	-0.06180	0.15340	0.40202	0.12856	0.793	0.08290	2.51057	4.51700	5.93160	15.84196
	5.86	-0.49	8.02	5.15	1.41						
FTS	2.45064	-0.11903	-0.00474	0.10548	0.72122	0.699	0.06502	3.06821	22.42148	32.22624	33.50804
	2.01	-1.04	-0.31	0.53	5.22						
LES	6.81167	0.04577	0.18103	1.179D-05	0.11631	0.870	0.06234	1.49564	2.76692	4.96176	19.42356
	8.06	0.49	12.91	5.77	1.58						
CFS	5.99044	-0.06592	0.23188	-0.18004	0.30939	0.826	0.07990	1.39039	7.11668	20.96600	25.28936
	3.99	-0.40	10.84	-0.53	4.11						
TTS	3.99698	-0.52772	0.21979	-0.12511	0.30320	0.827	0.08415	2.18549	0.65440	23.69584	26.39936
	3.66	-4.04	10.58	-0.58	4.05						
OMS	5.00155	-0.27407	0.14421	0.10261	0.39120	0.738	0.08776	2.42522	4.29056	30.66184	33.59284
	4.82	-1.69	6.82	0.52	4.04						
MMS	3.05906	-0.01550	0.13919	-0.15088	0.73297	0.829	0.09837	2.09112	0.21872	8.29272	13.20432
	1.50	-0.11	6.03	-1.12	6.70						
IES	2.90270	-0.30365	0.14219	0.01280	0.55321	0.820	0.07041	2.34423	3.40328	25.87352	29.51652
	3.25	-2.78	8.14	0.14	7.34						

S2KC1

	C	Price	Temp	Output	LDep	AR1	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	1.34941	-0.24966	0.12350	0.46426	0.51170	-0.08675	0.829	0.07768	1.94	0.10752	21.93953	26.84152
	1.61	-2.07	5.83	1.98	4.24	-0.37						
GCS	3.85762	-0.19977	0.07158	0.15856	0.51011	-0.19245	0.805	0.04057	1.94	0.36309	8.14527	14.57933
	3.74	-3.51	7.54	2.04	4.80	-1.02						
CHS	0.00726	0.08260	0.04063	0.35655	0.86475	-0.60601	0.790	0.07189	2.06	1.58321	3.44171	17.10684
	0.01	0.91	2.46	2.15	13.42	-4.18						
MES	4.72204	-0.11870	0.17080	1.02213	0.07321	-0.48252	0.903	0.05413	1.65	1.39725	15.35216	23.76851
	6.71	-2.09	13.19	7.58	1.30	-3.07						
EES	7.08471	0.03549	0.10719	0.65120	0.04612	0.67283	0.896	0.06356	2.48	6.97035	13.55496	24.08683
	5.65	0.23	7.55	4.85	0.57	4.93						
VES	6.41279	-0.08217	0.16520	0.39188	0.20864	-0.36166	0.823	0.07913	1.95	0.08518	1.72649	14.17627
	5.89	-0.86	9.15	6.41	2.49	-2.12						
FTS	0.49444	-0.02791	0.00544	0.14403	0.89312	-0.82176	0.862	0.04322	1.76	0.73394	11.43659	23.87533
	1.01	-0.57	0.69	1.73	15.25	-7.23						
LES	7.03145	0.01146	0.17893	1.172D-05	0.07716	0.22063	0.890	0.05773	2.21	0.80800	3.58894	17.11133
	7.77	0.11	14.17	5.19	1.03	1.28						
CFS	7.02565	0.04960	0.20954	0.09997	0.13339	0.56612	0.864	0.07204	2.56	6.95323	13.95420	21.87260
	4.11	0.25	11.56	0.28	1.77	3.75						
TFS	3.66405	-0.52860	0.22435	-0.12897	0.33613	-0.15645	0.829	0.08552	1.79	1.13315	22.66719	30.22118
	3.25	-4.21	10.27	-0.64	4.14	-0.77						
OMS	4.92508	-0.25750	0.15694	0.08670	0.40245	-0.30627	0.748	0.08116	1.77	1.00136	29.80680	32.57475
	5.13	-2.05	7.68	0.59	4.59	-1.65						
MMS	2.88223	-0.03474	0.13880	-0.15716	0.74368	-0.07848	0.829	0.10042	1.99	0.29656	7.70894	12.89753
	1.30	-0.25	5.40	-1.13	6.10	-0.37						
IES	2.62908	-0.30286	0.15858	-0.04911	0.59551	-0.36258	0.834	0.06587	1.92	3.04297	21.98364	29.76987
	3.70	-3.57	8.67	-0.73	9.67	-1.92						

Logarithmic Moddels(RELative prices)

S2KD4

	C	Price	Temp	Output	LDep	AR4	R̄²	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	5.86964	-0.11918	0.13529	0.31840	0.20188	0.84581	0.918	0.04859	1.95	1.19992	9.21575	12.92605
	3.98	-1.08	2.66	2.06	1.45	7.98						
GCS	5.31992	-0.17910	0.06834	0.20517	0.37695	0.16218	0.803	0.03839	2.23	0.84780	10.40249	17.73688
	4.10	-2.81	6.22	2.02	2.78	0.97						
CHS	2.93104	0.07748	0.04816	0.38994	0.59755	0.56879	0.767	0.07768	2.47	4.97808	6.29633	18.69008
	1.82	0.51	1.16	1.96	4.44	3.37						
MES	4.29513	-0.08304	0.16224	0.89930	0.17353	0.71804	0.946	0.04114	2.29	2.25421	2.14812	6.53771
	4.20	-1.22	5.36	6.18	1.81	5.95						
EES	5.37287	-0.13454	0.14774	0.07713	0.36933	0.88147	0.951	0.04262	2.28	2.78644	9.29509	17.16613
	3.05	-1.84	3.03	1.04	2.59	10.12						
VES	8.50896	0.01018	0.14900	0.44498	0.05255	0.23009	0.800	0.08505	2.44	3.85556	7.68852	16.50618
	5.34	0.07	5.62	4.19	0.42	1.22						
FTS	8.38550	-0.18205	0.04961	0.20143	0.16002	0.90338	0.928	0.02910	1.95	6.30803	12.75512	21.94636
	4.27	-2.73	1.33	2.01	0.92	14.20						
LES	6.78301	-0.01798	0.18354	1.140D-05	0.08903	-0.05748	0.886	0.05885	1.86	0.20509	4.60948	16.92529
	8.41	-0.19	13.92	5.74	1.29	-0.32						
CFS	4.82338	-0.13946	0.25010	0.14068	0.23334	0.69552	0.906	0.06121	2.34	1.98619	8.89567	15.28870
	3.78	-1.16	5.71	0.63	1.95	5.00						
TFS	5.05932	-0.17256	0.14688	0.28250	0.19376	0.74074	0.933	0.05022	1.98	0.96102	3.46572	10.17058
	4.33	-1.68	3.58	2.53	1.50	8.36						
OHS	6.38998	-0.10895	0.17805	-0.00082	0.35531	0.78093	0.911	0.04680	2.08	3.85441	10.19380	11.71156
	3.88	-1.10	3.83	-0.01	2.75	7.04						
MMS	1.46851	0.00363	0.14382	0.10118	0.77157	0.63602	0.869	0.08992	2.19	0.85435	3.57397	6.05563
	0.67	0.02	2.64	0.72	5.16	3.72						
IES	7.12696	-0.16008	0.11818	0.07896	0.21333	0.55020	0.906	0.04123	2.32	1.54987	7.27898	16.79062
	5.58	-2.07	5.51	1.36	1.85	7.19						

SHKLS

	C	Price	Temp	Output	LDEP	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	3.74733	-0.46546	0.12533	-0.45526	0.60268	0.831	0.07780	2.26487	1.93828	19.91296	24.44708
	2.75	-3.87	7.18	-1.97	7.43						
GCS	4.95578	-0.22248	0.06631	-0.11685	0.51841	0.797	0.04097	2.33974	1.69708	4.77068	9.04780
	3.89	-3.55	7.17	-1.54	5.20						
CHS	1.62437	0.12164	0.03594	0.24667	0.78541	0.665	0.08845	2.79945	12.37680	19.42472	24.61076
	1.01	0.68	1.80	0.88	7.84						
MES	7.09190	-0.13144	0.19273	0.35453	0.11050	0.860	0.06313	2.30715	1.79768	21.08708	26.80576
	7.31	-1.43	13.64	4.28	1.62						
EES	2.32030	-0.10695	0.15677	0.60156	0.41695	0.802	0.08664	1.52563	4.61664	30.45916	34.67580
	2.46	-0.45	8.03	1.71	4.06						
VES	2.52500	-0.22336	0.17575	1.59419	0.02365	0.823	0.07675	2.74515	8.04592	10.14932	18.12852
	1.77	-1.80	10.23	6.07	0.26						
FTS	-0.97466	-0.02682	-0.00030	1.80575	0.38133	0.770	0.05689	2.37327	6.33620	27.10248	29.53300
	-0.65	-0.26	-0.02	3.33	2.47						
LES	4.35858	0.32212	0.17957	0.86147	0.05434	0.867	0.06305	1.60311	2.02340	3.93700	21.00868
	5.29	3.14	12.64	5.63	0.68						
CFS	4.57467	0.21689	0.21556	0.83876	0.09533	0.917	0.05537	2.41022	2.23492	5.64620	9.13944
	6.35	2.45	17.11	6.20	1.52						
TFS	4.84363	-0.53418	0.21773	-0.27367	0.28583	0.843	0.08018	2.41210	2.88744	21.75996	21.84600
	4.86	-4.76	12.08	-1.98	3.98						
OMS	6.55001	-0.38225	0.15200	-0.28994	0.37570	0.763	0.08356	2.64945	9.15032	30.04008	32.31848
	5.15	-3.19	8.09	-1.98	4.48						
MMS	4.62724	0.19001	0.12077	1.22353	0.16299	0.943	0.05663	1.71182	1.30140	4.91768	11.98616
	5.97	2.27	9.48	8.63	1.87						
IES	2.83665	-0.24124	0.14233	0.11373	0.53860	0.821	0.07021	2.29791	2.91420	25.98120	29.30392
	3.30	-1.36	8.99	0.47	6.77						

SHKC1

	C	Price	Temp	Output	LDep	AR(1)	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	3.44666	-0.41807	0.13212	-0.46303	0.64780	-0.23697	0.836	0.07617	1.98	0.76534	17.39166	23.89916
	2.82	-3.94	6.36	-2.44	8.43	-1.10						
GCS	4.40920	-0.21816	0.06823	-0.11151	0.56317	-0.21352	0.798	0.04131	1.91	0.32581	5.26133	10.89309
	3.40	-3.71	7.15	-1.66	5.48	-1.11						
CHS	-0.11767	0.02745	0.05320	0.13803	0.93604	-0.59298	0.765	0.07613	1.92	1.51979	4.93342	19.05485
	-0.13	0.24	3.35	0.77	16.09	-4.08						
MES	6.48687	-0.14747	0.20046	0.34870	0.15522	-0.24130	0.870	0.06271	1.79	0.64085	20.29334	26.64472
	7.26	-1.89	13.33	4.97	2.27	-1.28						
EES	7.56463	0.41071	0.13893	1.03327	-0.04473	0.78549	0.860	0.07373	2.91	20.05782	25.75595	31.49348
	3.83	1.78	10.75	2.49	-0.45	6.54						
VES	1.14499	-0.29916	0.18697	1.65557	0.08529	-0.47511	0.860	0.07038	1.99	0.20354	4.59545	17.75432
	1.16	-3.42	12.62	8.23	1.10	-3.03						
FTS	0.06216	-0.00223	0.00692	0.27692	0.88520	-0.78627	0.852	0.04467	1.56	3.67961	15.97924	21.21850
	0.08	-0.04	0.84	0.82	9.58	-6.35						
LES	4.65660	0.28184	0.17751	0.82989	0.02051	0.20127	0.880	0.06033	2.16	0.58598	3.69291	19.72203
	5.03	2.42	13.13	4.72	0.24	1.09						
CFS	4.47923	0.21167	0.21891	0.84329	0.09861	-0.23715	0.922	0.05476	1.94	1.25323	2.67563	5.03502
	7.10	2.80	17.30	7.35	1.60	-1.33						
TFS	4.27761	-0.54863	0.22788	-0.28115	0.33560	-0.31693	0.855	0.07896	1.63	2.33563	19.36767	27.01721
	4.98	-5.82	12.30	-2.67	4.92	-1.69						
OMS	6.47013	-0.37818	0.17088	-0.30790	0.38096	-0.45891	0.810	0.07050	1.78	1.12866	26.07123	27.85673
	7.06	-4.80	10.88	-3.49	5.94	-2.96						
HMS	6.16133	0.27883	0.11487	1.46731	-0.02221	0.42795	0.946	0.05619	1.97	0.86880	3.20303	13.42914
	5.96	2.40	9.80	8.40	-0.23	2.35						
IES	2.52645	-0.23657	0.15176	0.06079	0.58485	-0.29432	0.832	0.06626	1.97	3.53898	22.89000	29.79538
	3.43	-1.57	8.49	0.31	8.25	-1.46						

SHKO4

	C	Price	Temp	Output	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	6.14687	-0.05969	0.14094	0.52045	0.12042	0.88284	0.916	0.04918	1.80	2.93339	12.59424	17.45989
	4.17	-0.39	2.47	1.64	0.80	9.21						
GCS	4.53641	-0.18931	0.06396	-0.04285	0.53716	0.19535	0.778	0.04075	2.08	0.25150	4.97038	12.55514
	3.17	-2.56	5.32	-0.47	4.61	1.03						
CHS	2.40962	0.13223	0.07723	0.56341	0.57186	0.66407	0.775	0.07623	2.45	6.10276	7.49232	19.02726
	1.39	0.76	1.51	2.26	4.07	4.36						
MES	4.63274	0.06528	0.18115	0.87757	0.19693	0.82186	0.941	0.04330	1.82	0.97535	2.27552	10.83758
	4.33	0.73	4.33	5.29	1.97	9.90						
EES	5.61205	0.00724	0.15514	0.32754	0.29017	0.88608	0.956	0.04029	2.29	3.43836	8.71279	15.99700
	3.48	0.08	3.32	2.11	2.11	11.49						
VES	3.04567	-0.17422	0.17317	1.63712	-0.01868	0.11219	0.820	0.08081	2.67	6.25788	7.85743	16.24007
	1.88	-1.25	8.05	5.17	-0.16	0.59						
FTS	7.10245	-0.12808	0.06831	0.65440	0.10770	0.93667	0.932	0.02816	1.80	7.71851	13.08254	17.73670
	3.57	-1.95	1.68	2.22	0.62	13.96						
LES	4.24642	0.19988	0.18177	0.71145	0.09066	0.26092	0.883	0.05939	1.71	1.74391	2.39990	14.87693
	4.61	1.77	9.65	4.01	0.94	1.50						
CFS	4.69238	0.15633	0.22387	0.77542	0.08415	0.14660	0.929	0.05318	2.54	3.14118	5.43611	7.19410
	6.13	1.52	15.03	5.12	1.19	0.81						
TFS	5.60746	-0.09865	0.09186	0.49687	0.11593	0.87253	0.936	0.04925	1.98	1.25654	3.37975	18.78592
	4.47	-0.82	1.61	2.76	0.77	13.04						
OMS	6.15688	-0.02859	0.19160	0.14597	0.34025	0.83383	0.913	0.04617	2.00	3.80974	9.98226	13.91652
	3.79	-0.23	3.42	0.89	2.67	7.65						
HMS	4.80069	0.22761	0.12715	1.22862	0.15545	0.19619	0.943	0.05932	1.72	1.07863	4.01778	14.03075
	5.31	2.28	7.25	7.08	1.49	1.01						
IES	7.17623	-0.15032	0.12588	0.09794	0.20065	0.52016	0.901	0.04229	2.40	2.12796	7.88159	20.75116
	5.50	-1.31	6.28	0.59	1.74	6.21						

F2KLS

	C	Price	Temp	Output	LDep	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	7.25460	-0.50069	0.11595	0.56933	0.06484	0.910	0.05664	2.02866	0.12240	12.22704	22.30196
	6.57	-5.94	9.13	3.80	0.64						
GCS	6.20104	-0.14936	0.06483	0.04353	0.43957	0.782	0.04245	1.77321	0.73036	8.55512	10.00356
	4.21	-2.70	6.61	0.45	3.62						
CHS	4.44069	0.33624	0.02473	0.46653	0.39087	0.761	0.07473	2.73792	14.91908	17.73752	21.27784
	3.01	3.38	1.37	2.44	2.91						
MES	6.09652	-0.02528	0.15736	0.97605	0.02210	0.872	0.06037	2.51843	5.27584	25.61136	29.51016
	6.21	-0.36	9.26	3.83	0.32						
EES	9.67123	-0.54110	0.13882	0.19994	0.03499	0.926	0.05286	1.82256	0.35444	9.77000	21.56932
	9.21	-5.87	10.61	2.25	0.47						
VES	7.80654	-0.05091	0.15054	0.43894	0.11422	0.793	0.08307	2.47720	4.02844	5.71612	15.71568
	7.82	-0.31	6.91	2.66	1.30						
FTS	10.64397	-0.43793	-0.00094	-0.07626	0.19180	0.804	0.05252	2.03150	0.70608	17.91036	24.02864
	5.00	-4.51	-0.08	-0.46	1.18						
LES	6.24996	0.21449	0.18572	6.020D-06	0.12122	0.890	0.05739	1.83946	0.53200	4.75416	18.19872
	10.66	2.56	14.25	2.04	1.90						
CFS	4.41998	0.34580	0.21529	0.35484	0.20918	0.921	0.05397	2.42087	2.14404	5.50300	11.14436
	4.32	6.49	16.16	2.03	4.03						
TFS	6.03490	-0.38441	0.19406	0.32004	0.15751	0.858	0.07636	1.93161	0.06168	21.38516	23.05160
	5.56	-5.22	10.41	1.85	2.05						
OMS	8.49206	-0.31430	0.13819	0.15939	0.20571	0.795	0.07773	2.35112	5.14896	27.86928	29.16892
	6.82	-3.64	7.60	1.14	2.14						
MMS	5.79318	0.52492	0.13749	-0.07306	0.43327	0.906	0.07318	1.74524	1.11784	13.34520	15.68528
	4.14	5.32	8.01	-0.73	4.52						
IES	5.89436	-0.33453	0.11798	0.22085	0.35331	0.869	0.06023	1.78631	1.03012	17.26268	22.69904
	5.99	-4.84	7.81	3.00	4.30						

APPENDIX V

Logarithmic Models(CAPital cost)

F2KC1

	C	Price	Temp	Output	LDep	AR1	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	6.98542	-0.48042	0.11789	0.55286	0.09370	-0.07981	0.904	0.05818	1.88	0.12617	13.07284	22.05341
	5.51	-5.20	8.24	3.57	0.79	-0.37						
GCS	8.53178	-0.18549	0.05969	0.09454	0.22906	0.33919	0.784	0.04275	2.12	0.96595	8.14336	12.52130
	3.69	-2.21	6.00	0.86	1.24	1.38						
CHS	1.91771	0.20437	0.04454	0.32840	0.66259	-0.65106	0.846	0.06150	2.05	0.31902	1.19157	11.77262
	2.24	3.60	3.42	3.03	8.19	-4.80						
MES	5.29646	-0.03107	0.16617	1.08420	0.04463	-0.39743	0.892	0.05700	1.63	1.43832	19.12950	27.94931
	6.71	-0.59	10.67	5.17	0.73	-2.34						
EES	9.77266	-0.53480	0.13511	0.22449	0.01706	0.12538	0.925	0.05409	2.08	0.16552	10.87121	22.94288
	8.52	-5.09	9.43	2.11	0.20	0.61						
VES	6.92498	-0.04256	0.16231	0.42187	0.18691	-0.33931	0.819	0.07986	1.94	0.09017	1.80605	14.60671
	7.52	-0.31	8.03	3.08	2.25	-1.95						
FTS	1.50377	-0.05079	0.00558	0.10739	0.83734	-0.81118	0.863	0.04302	1.68	1.47861	10.00678	24.74609
	1.01	-0.79	0.70	1.21	7.78	-6.75						
LES	6.52288	0.16702	0.18369	7.189D-06	0.09900	0.06327	0.898	0.05558	2.13	0.47385	3.89672	16.58455
	10.22	1.90	14.35	2.35	1.45	0.35						
CFS	4.26052	0.34430	0.21969	0.35723	0.22153	-0.23892	0.923	0.05410	1.89	0.53208	2.75722	8.73354
	4.73	7.47	16.23	2.39	4.27	-1.33						
TFS	6.16229	-0.38307	0.19278	0.31468	0.14768	0.04920	0.857	0.07840	2.02	0.47065	20.92444	28.22648
	4.82	-4.55	9.47	1.71	1.60	0.23						
OMS	8.25339	-0.27083	0.15252	0.15918	0.21354	-0.33647	0.825	0.06768	1.85	0.87953	24.71629	30.09080
	7.58	-4.43	9.31	1.66	2.53	-1.95						
MMS	7.14601	0.95632	0.10586	0.25939	0.17508	0.78104	0.928	0.06509	2.41	3.53106	8.65277	11.32474
	5.43	4.82	7.85	2.38	2.07	7.01						
IES	8.01992	-0.40035	0.09718	0.33329	0.13511	0.46398	0.883	0.05518	2.48	8.26480	15.49583	21.72066
	7.17	-4.16	7.33	3.42	1.50	2.82						

F2K04

	C	Price	Temp	Output	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	5.55558	0.02246	0.15761	0.40047	0.23191	0.89184	0.916	0.04930	2.05	3.10223	12.70994	18.73210
	3.80	0.17	2.78	3.09	1.69	9.62						
GCS	5.44171	-0.06769	0.06718	0.14600	0.45508	0.13213	0.757	0.04265	1.77	0.86720	7.99171	10.55894
	3.36	-0.92	5.52	1.09	3.12	0.74						
CRS	4.19610	0.33802	0.03877	0.37646	0.43961	0.40347	0.799	0.07208	2.68	6.98249	7.37089	19.32887
	2.67	2.52	1.36	2.26	3.14	2.43						
MES	4.47238	-0.02613	0.16577	0.94495	0.16924	0.72233	0.944	0.04209	2.07	0.44500	1.82365	7.34933
	4.31	-0.27	5.33	6.21	1.72	5.99						
EES	5.04188	0.02732	0.17585	0.08818	0.42756	0.90280	0.946	0.04485	2.29	3.22682	9.12082	14.47265
	2.57	0.23	3.36	1.14	2.79	10.38						
VES	8.70123	0.13078	0.15471	0.35190	0.05116	0.25513	0.803	0.08448	2.44	4.04399	8.00939	16.39948
	6.71	0.65	5.37	1.92	0.42	1.38						
FTS	4.33027	0.14545	0.09764	0.19731	0.52634	0.93421	0.920	0.03070	2.31	4.06958	13.77947	21.21833
	2.39	1.79	2.46	1.88	3.76	18.24						
LES	6.55929	0.14517	0.18681	7.329D-06	0.09569	0.03635	0.893	0.05698	1.97	0.01004	4.24674	16.20299
	10.18	1.39	13.17	2.11	1.40	0.19						
CFS	4.55200	0.34778	0.22391	0.34670	0.19404	0.12807	0.928	0.05364	2.42	2.16518	4.95360	8.71459
	4.31	5.29	14.41	1.97	3.29	0.71						
TFS	4.29895	0.12823	0.13608	0.32272	0.31733	0.81349	0.929	0.05171	2.02	1.45159	2.24320	10.37416
	3.53	0.89	2.70	3.01	2.38	9.55						
CMS	5.88757	-0.01204	0.20791	0.05736	0.39581	0.83494	0.908	0.04767	1.97	4.04233	11.97835	17.70426
	3.66	-0.09	3.79	0.56	3.28	8.37						
MMS	3.56103	0.67307	0.13380	0.14165	0.52283	0.28386	0.917	0.07138	1.75	2.18671	8.13600	11.05553
	2.12	4.63	5.60	1.15	4.68	1.65						
IES	7.54272	-0.13596	0.11461	0.15137	0.21637	0.43080	0.895	0.04347	2.07	0.24138	6.98587	15.37844
	5.73	-1.32	6.18	2.66	1.92	3.21						

F4KLS

	C	Price	Temp	Output	LDep	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	7.04308	-0.73609	0.11015	0.61307	0.09617	0.900	0.05983	1.73613	0.88160	9.56360	19.00772
	5.89	-7.04	8.13	3.05	0.90						
GCS	7.16628	-0.44622	0.06022	0.51627	0.20731	0.851	0.03502	1.94846	0.00684	8.57288	12.39664
	5.86	-5.49	7.50	4.09	1.81						
CHS	4.21537	0.39971	0.03876	0.39864	0.42084	0.753	0.07598	2.78040	15.11676	18.60100	21.25300
	2.72	3.61	2.27	2.15	3.13						
HES	6.35931	-0.45071	0.18311	0.95956	0.03445	0.884	0.05748	1.99160	0.19064	21.41532	25.79132
	7.43	-3.11	13.84	4.45	0.55						
EES	9.36517	-0.59275	0.15015	0.32086	0.01158	0.931	0.05129	2.20567	0.67184	11.83920	20.88404
	9.05	-8.09	13.04	2.75	0.16						
VES	4.57549	0.01501	0.17572	1.36600	0.00868	0.807	0.08021	2.28348	1.65056	5.77312	14.27844
	3.05	0.12	9.74	3.19	0.09						
FTS	6.95341	-0.39979	8.141D-05	1.66270	-0.17204	0.868	0.04308	1.74326	0.79696	12.83788	21.27920
	3.70	-5.12	0.01	4.16	-1.09						
LES	4.76767	0.27955	0.18735	0.26648	0.13503	0.886	0.05847	1.91899	0.31836	6.07904	20.03452
	6.15	4.14	14.19	1.65	2.11						
CFS	4.91268	0.20511	0.22200	0.40262	0.15030	0.927	0.05164	2.70337	5.88916	8.58956	12.29364
	7.29	3.48	18.91	2.78	2.96						
TFS	5.66602	-0.66436	0.19315	0.69526	0.05596	0.900	0.06406	2.23436	0.88352	11.75188	14.02372
	7.22	-7.44	13.08	4.43	0.81						
OMS	8.19333	-0.55590	0.13572	0.47023	0.13995	0.822	0.07245	2.25048	3.94464	24.05624	27.12704
	7.13	-5.01	8.20	2.61	1.50						
MMS	4.94605	0.29641	0.12543	0.85855	0.18240	0.954	0.05113	1.95249	0.04324	3.67192	11.97636
	7.62	3.77	10.88	6.15	2.47						
IES	5.33155	-0.21954	0.13736	0.18618	0.39628	0.842	0.06609	2.00722	0.69944	22.64524	28.84544
	4.07	-2.56	9.23	1.24	4.47						

F4KC1

	C	Price	Temp	Output	LDep	AR1	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	8.06714	-0.80674	0.10502	0.64798	-0.00390	0.24454	0.896	0.06049	2.14	0.85238	9.86392	20.78205
	4.96	-6.21	7.81	2.48	-0.03	1.17						
GCS	7.20342	-0.44796	0.06011	0.51769	0.20385	0.01351	0.846	0.03607	1.97	0.01654	8.50099	15.77039
	4.86	-5.02	7.12	3.91	1.50	0.07						
CHS	1.74932	0.25033	0.05460	0.28411	0.68287	-0.65406	0.841	0.06253	1.97	0.12975	0.85402	11.98564
	1.98	3.97	4.41	2.81	8.51	-4.85						
MES	6.15598	-0.43520	0.18442	0.95258	0.05220	-0.03870	0.889	0.05798	1.96	0.01708	21.44087	26.96316
	7.04	-2.93	12.54	4.23	0.74	-0.19						
EES	9.01174	-0.56853	0.15323	0.32093	0.03876	-0.14363	0.930	0.05222	1.88	0.16325	11.53218	22.32664
	8.48	-7.81	12.45	3.02	0.49	-0.75						
VES	4.24895	0.04358	0.18311	1.24940	0.07315	-0.22679	0.820	0.07972	1.90	0.25767	3.63523	15.02557
	2.86	0.36	9.99	2.93	0.72	-1.20						
FTS	11.96397	-0.57022	-0.00222	1.51655	-0.51335	0.49637	0.865	0.04270	1.94	0.75949	6.67087	10.96583
	3.88	-5.69	-0.26	2.98	-3.50	2.68						
LES	4.77441	0.25270	0.18645	0.29910	0.12141	0.01198	0.891	0.05730	2.08	0.38598	5.47576	18.89714
	6.14	3.69	13.87	1.82	1.72	0.06						
CFS	4.75575	0.19889	0.22804	0.42220	0.15393	-0.38651	0.937	0.04894	1.92	1.38665	1.23786	5.50676
	9.17	4.63	20.97	4.05	3.33	-2.34						
TFS	5.47427	-0.67800	0.19512	0.71583	0.06638	-0.14454	0.903	0.06450	1.82	0.50786	10.69891	20.96039
	7.14	-7.31	12.67	4.71	0.87	-0.77						
OMS	8.43735	-0.46784	0.14857	0.34009	0.15340	-0.27720	0.843	0.06406	1.92	0.26832	22.50366	30.34524
	7.88	-5.32	9.48	2.55	1.70	-1.55						
MMS	5.06041	0.31096	0.12513	0.86613	0.16896	0.04594	0.953	0.05244	2.02	0.01151	3.47818	11.71065
	6.84	3.62	10.42	5.39	1.89	0.22						
IES	5.19762	-0.18601	0.14030	0.20046	0.39698	-0.08120	0.849	0.06276	2.12	1.90847	21.11616	29.02669
	3.80	-2.36	7.78	1.49	3.92	-0.35						

F4KD4

	C	Price	Temp	Output	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPS	5.99935	0.06477	0.15099	0.59840	0.11947	0.90133	0.918	0.04870	1.84	3.29692	14.07906	18.84560
	4.14	0.50	2.65	3.16	0.80	14.92						
GCS	6.94547	-0.42990	0.06066	0.49709	0.23158	-0.06910	0.820	0.03668	1.99	0.06725	9.61150	13.68292
	5.17	-4.69	7.32	3.65	1.84	-0.36						
CHS	3.45224	0.31957	0.05258	0.40135	0.48570	0.44843	0.794	0.07309	2.62	7.19042	7.38288	18.40331
	2.01	2.27	1.71	2.03	3.52	2.65						
MES	4.85372	-0.14748	0.18173	0.85121	0.17602	0.73488	0.942	0.04281	1.94	0.37199	1.84730	15.01099
	4.48	-1.28	5.59	6.07	1.77	6.58						
EES	5.64106	-0.00237	0.15428	0.31943	0.28917	0.88620	0.956	0.04030	2.28	2.78582	7.34785	15.80526
	3.41	-0.02	3.39	2.89	2.03	11.02						
VES	5.69281	0.14552	0.17418	1.17732	-0.02533	0.16739	0.816	0.08172	2.33	1.55441	3.81154	14.89284
	3.21	0.87	7.53	2.36	-0.21	0.86						
FTS	4.70102	0.02005	0.10274	0.73710	0.30035	0.95137	0.924	0.02977	1.88	6.13026	13.59497	24.63408
	2.59	0.22	2.62	2.17	1.63	16.71						
LES	4.51195	0.21946	0.18711	0.32511	0.14153	0.26995	0.893	0.05691	1.84	0.42098	3.00510	14.06732
	5.00	2.45	10.19	1.86	1.72	1.49						
CFS	4.96310	0.18095	0.22911	0.43672	0.12785	0.12262	0.936	0.05061	2.76	6.11323	6.96452	8.95626
	6.89	2.45	16.63	2.79	2.22	0.69						
TFS	5.29991	0.11019	0.09405	0.53730	0.16236	0.89153	0.936	0.04907	2.09	1.35659	4.74134	18.72907
	4.27	0.79	1.63	3.51	1.08	15.76						
OMS	6.12645	-0.05448	0.19113	0.19274	0.33906	0.82974	0.914	0.04610	1.98	3.70084	9.07528	13.20077
	3.93	-0.43	3.67	1.54	2.70	8.54						
MMS	5.30642	0.39944	0.13149	0.82116	0.15380	0.14766	0.957	0.05134	2.03	0.09284	3.43591	10.00588
	7.21	4.08	9.21	5.45	1.82	0.83						
IES	6.48984	0.06414	0.12725	0.29526	0.22331	0.52635	0.897	0.04315	2.15	0.25682	7.71278	20.83446
	4.53	0.57	6.17	2.68	1.84	4.84						

Variable Output Elasticity(RELative fuel prices)

L2KLS

	C	Price	Temp	Output	CapOut	LDep	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	8.65831	-0.56836	0.11501	0.39150	0.01172	0.00000	0.921	0.05373	2.32	2.16748	9.94460	21.30524
	11.37	-9.11	9.56	2.40	2.31	0.06						
GCX	10.94574	-0.24676	0.06161	0.18787	-0.00028	-0.00000	0.813	0.03981	1.56	5.81728	15.02820	22.08600
	22.76	-5.22	6.74	2.00	-4.48	-0.05						
CHX	8.97167	0.62267	0.03252	0.34737	0.01330	-0.00000	0.725	0.08137	1.88	15.77080	23.29908	25.91016
	8.37	7.91	1.54	1.27	1.41	-1.14						
MEX	6.63723	-0.03301	0.15777	0.88269	0.01027	-0.00000	0.883	0.05864	2.51	5.00780	22.78600	27.57020
	6.79	-0.48	9.86	3.57	1.47	-1.12						
EEX	10.17362	-0.56241	0.14096	0.16507	0.00394	-0.00000	0.927	0.05335	1.92	0.18208	9.20836	23.53916
	21.40	-7.51	10.39	1.66	0.73	-0.33						
VEX	9.07899	-0.00586	0.14544	0.43759	0.00547	-0.00000	0.795	0.08372	2.46	8.86216	9.41880	18.07368
	18.66	-0.03	6.62	2.65	1.13	-0.83						
FTX	12.40477	-0.54380	-0.00511	0.00070	0.02104	-0.00000	0.877	0.04218	2.01	1.33596	10.37528	19.59448
	19.63	-12.36	-0.52	0.01	4.46	-1.09						
CFX	7.90433	0.38105	0.21958	0.00582	0.00697	0.00000	0.889	0.06482	2.03	14.13768	22.07324	23.27804
	6.12	5.89	12.91	0.02	0.97	0.73						
TFX	8.73646	-0.43528	0.19259	0.01999	0.01735	0.00000	0.860	0.07689	1.56	3.73668	20.02076	23.69392
	9.37	-6.49	10.30	0.09	2.15	0.49						
OMX	11.82227	-0.39665	0.13727	-0.04659	0.01446	-0.00000	0.853	0.06672	2.27	6.44664	22.25468	32.09088
	18.14	-5.95	8.80	-0.32	2.21	-3.38						
MMX	11.80893	0.73970	0.15799	-0.33579	0.01146	-0.00000	0.878	0.08435	1.72	12.29316	23.36928	28.23568
	21.73	7.33	7.93	-3.24	2.78	-0.21						
IEX	9.60439	-0.48448	0.10170	0.37567	-0.01249	-0.00000	0.838	0.06788	1.20	13.40044	18.00896	25.51220
	22.11	-7.98	5.72	3.04	-1.23	-2.23						

APPENDIX V

Variable Output Elasticity(RELative fuel prices)

L2KC1

	C	Price	Temp	Output	CapOut	LDep	AR1	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	7.78201	-0.51174	0.12092	0.36309	0.01199	0.08413	-0.26555	0.920	0.05381	1.80	0.61402	8.89106	19.90365
	6.92	-6.65	9.71	2.55	2.71	0.83	-1.40						
GCX	7.84315	-0.17978	0.06434	0.13028	-0.00022	0.27528	0.00657	0.835	0.03793	1.93	0.06279	11.90877	17.65101
	4.54	-2.90	6.94	1.37	-3.35	1.99	0.03						
CHX	2.94779	0.26200	0.05472	0.12998	0.01020	0.62726	-0.69166	0.865	0.05862	2.09	0.33400	1.69478	9.27783
	3.13	4.37	4.22	0.95	2.10	8.13	-5.46						
MEX	5.76520	-0.03290	0.16985	0.91045	0.00768	0.06041	-0.38492	0.899	0.05619	1.68	1.12745	18.82729	25.40004
	6.73	-0.63	10.91	3.76	1.39	0.98	-2.22						
EEX	9.80643	-0.53934	0.13969	0.18038	0.00304	0.02594	0.03309	0.925	0.05486	2.00	0.04668	10.58320	24.34754
	8.43	-5.37	8.91	1.53	0.49	0.30	0.15						
VEX	6.96844	-0.01174	0.16100	0.36328	0.00716	0.19360	-0.41006	0.837	0.07713	1.99	0.12371	3.62220	15.17931
	8.17	-0.09	8.49	2.77	1.88	2.49	-2.45						
FTX	18.06545	-0.73036	-0.00644	-0.01975	0.02185	-0.44354	0.47122	0.880	0.04090	1.77	0.59171	3.19632	6.29870
	10.13	-8.85	-0.71	-0.12	3.58	-2.80	2.49						
CFX	4.83019	0.33601	0.22289	0.22308	0.00411	0.21813	-0.22826	0.925	0.05447	1.86	0.55949	5.05588	10.36788
	3.99	7.03	15.70	0.94	0.72	4.14	-1.20						
TFX	7.32103	-0.37702	0.19471	0.05080	0.01481	0.12590	0.03671	0.870	0.07580	1.85	2.17764	19.29619	26.13702
	5.31	-4.66	9.99	0.22	1.81	1.42	0.18						
CMX	8.71600	-0.28464	0.15107	-0.01188	0.01236	0.22561	-0.36123	0.850	0.06356	1.94	2.15693	23.23913	28.87427
	8.41	-4.99	9.67	-0.10	2.30	2.93	-2.03						
MMX	6.27851	0.47813	0.14817	-0.14479	0.00861	0.41220	-0.19537	0.915	0.07183	1.90	0.64841	12.59209	20.26136
	4.34	4.93	8.28	-1.48	2.50	4.10	-0.97						
IEX	7.95214	-0.39819	0.09582	0.36578	-0.00563	0.13569	0.43941	0.885	0.05576	2.46	7.21492	15.07510	21.37360
	6.99	-4.22	6.86	3.16	-0.58	1.47	2.51						

APPENDIX V

Variable Output Elasticity(RELative fuel prices)

L2KC4

	C	Price	Temp	Output	CapOut	LDep	AR4	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests <------> L1	L4	L8
PPX	6.88005	0.00166	0.15070	0.33326	0.00558	0.13420	0.88549	0.919	0.04913	1.91	2.83280	13.30834	17.66729
	3.69	0.01	2.70	2.29	1.11	0.83	9.97						
GCX	8.25857	-0.17024	0.06462	0.17963	-0.00024	0.22054	-0.25363	0.823	0.03707	2.05	2.09797	9.71748	14.88949
	6.23	-3.16	8.58	1.84	-3.74	1.96	-1.31						
CHX	5.63084	0.34180	0.04991	0.14268	0.01364	0.38414	0.52177	0.815	0.07032	2.68	9.35780	10.17648	18.79974
	3.19	2.41	1.48	0.71	1.72	2.75	3.19						
MEX	4.73201	-0.02450	0.16500	0.90481	0.00250	0.15962	0.70771	0.944	0.04269	2.11	3.68266	4.41601	9.82789
	3.98	-0.25	5.40	4.93	0.43	1.59	5.66						
EEX	4.97532	0.02713	0.17712	0.08980	-0.00045	0.43259	0.90227	0.946	0.04561	2.28	4.25444	9.18900	15.70392
	2.41	0.22	3.22	1.13	-0.11	2.68	10.20						
VEX	8.63564	0.12699	0.14990	0.33429	0.00541	0.05927	0.23660	0.811	0.08413	2.58	5.27630	9.29570	16.23989
	6.79	0.64	5.24	1.81	1.11	0.50	1.24						
FTX	8.89651	0.06203	0.05956	0.23029	0.01110	0.15066	0.92503	0.942	0.02664	1.87	7.84804	17.41658	24.59538
	4.19	0.83	1.72	2.51	3.38	0.90	19.61						
CFX	5.22899	0.33536	0.22814	0.18457	0.00527	0.19062	0.12359	0.929	0.05385	2.37	1.87150	8.18662	11.29421
	4.01	4.96	13.97	0.72	0.86	3.23	0.66						
TFX	4.35498	0.12155	0.13729	0.31835	0.00035	0.31260	0.80908	0.929	0.05261	2.00	1.83330	2.30605	12.22632
	3.16	0.80	2.70	2.35	0.08	2.27	9.10						
OMX	6.68805	-0.05486	0.20321	-0.09780	0.00948	0.38509	0.86931	0.933	0.04139	2.02	3.37723	10.79550	13.72486
	4.77	-0.47	3.96	-0.99	3.28	3.78	9.60						
MMX	4.81583	0.71078	0.13907	0.07847	0.00593	0.43244	0.24378	0.925	0.06909	2.05	0.22990	7.81546	15.27854
	2.82	4.99	6.24	0.63	1.72	3.77	1.40						
IEX	7.60016	-0.12984	0.11506	0.13988	0.00128	0.21347	0.43662	0.895	0.04418	2.07	0.23969	7.20025	15.67260
	5.45	-1.22	6.02	1.75	0.20	1.83	3.24						

Variable Output Elasticity(RELative fuel prices)

LHKLS

	C	Price	Temp	Output	CapOut	LDep	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	8.60324	-0.68257	0.11236	0.25328	0.01247	0.07792	0.910	0.05746	2.02	0.04308	8.32760	19.66104
	6.18	-6.56	8.60	0.96	1.99	0.76						
GCX	8.39758	-0.38477	0.06031	0.33516	-0.00012	0.16930	0.852	0.03551	1.82	0.22372	9.19756	14.01180
	6.32	-4.03	7.40	2.18	-1.71	1.33						
CHX	4.81015	0.41574	0.03177	0.32368	0.00424	0.39608	0.755	0.07680	2.79	17.80156	21.34748	22.44968
	2.51	3.62	1.59	1.14	0.42	2.81						
MEX	7.18097	-0.37428	0.15459	0.81897	0.00370	0.02134	0.879	0.05952	1.99	0.26088	22.48432	26.80140
	7.98	-2.33	8.43	2.85	0.46	0.31						
EEX	8.44799	-0.54032	0.11412	0.51633	-0.00712	0.03687	0.946	0.04593	1.63	1.73940	7.59752	18.16976
	8.35	-8.03	8.17	3.94	-1.28	0.55						
VEX	6.77707	0.22060	0.15307	0.41287	0.00645	0.16852	0.777	0.08733	2.51	5.81776	9.72684	15.47920
	4.61	1.91	6.04	1.38	1.31	1.90						
FTX	13.33205	-0.59790	-0.00584	0.01887	0.02116	-0.07834	0.872	0.04300	1.76	1.52788	8.71352	17.03952
	7.26	-6.85	-0.51	0.07	4.15	-0.48						
LEX	4.12581	0.24034	0.17354	0.38013	-0.00017	0.16443	0.897	0.05623	1.76	0.95384	4.00428	16.92896
	4.12	3.10	11.36	1.72	-0.04	2.73						
CFX	4.53478	0.18827	0.20772	0.42797	0.00042	0.18699	0.934	0.04985	2.63	5.07316	7.82120	10.95036
	5.92	2.84	15.78	2.43	0.08	3.95						
TFX	6.03103	-0.61718	0.16962	0.56947	0.00938	0.07053	0.907	0.06257	2.44	2.83988	16.38004	19.45432
	7.43	-6.77	10.32	3.32	1.69	1.07						
OMX	8.93202	-0.44473	0.12451	0.18493	0.01507	0.16025	0.838	0.06995	2.41	7.01740	26.03936	30.34580
	7.81	-3.96	6.82	0.94	2.43	1.80						
MMX	5.66018	0.32400	0.05780	0.86691	-0.00065	0.15353	0.947	0.05560	1.67	1.78164	5.29060	11.80304
	7.72	3.70	2.72	4.67	-0.21	1.76						
IEX	3.84006	-0.09049	0.10306	0.52335	-0.01387	0.41279	0.864	0.06224	1.66	2.86716	20.10788	27.73556
	2.80	-0.88	5.25	2.46	-1.28	4.92						

APPENDIX V

Variable Output Elasticity(RELative fuel prices)

LHKC1

	C	Price	Temp	Output	CapOut	LDep	AR1	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	8.54192	-0.66042	0.11358	0.21775	0.01260	0.09547	-0.03909	0.904	0.05909	1.97	0.24098	8.75304	19.98633
	5.70	-5.49	7.82	0.80	1.95	0.78	-0.18						
GCX	8.69375	-0.39479	0.05949	0.33975	-0.00012	0.14400	0.08302	0.847	0.03650	1.93	0.00741	9.04465	17.09198
	5.23	-3.89	6.89	2.19	-1.67	0.95	0.38						
CHX	3.30301	0.27664	0.06048	0.00180	0.01259	0.63924	-0.68708	0.858	0.06004	2.04	0.83749	1.24426	10.09476
	2.99	4.53	4.43	0.01	2.07	8.14	-5.42						
MEX	6.95484	-0.35733	0.15658	0.80529	0.00442	0.04225	-0.04617	0.885	0.05979	1.94	0.05074	22.17333	28.17578
	7.43	-2.20	7.78	2.77	0.55	0.55	-0.23						
EEX	8.27000	-0.52258	0.10265	0.64927	-0.01074	0.00705	0.31787	0.948	0.04577	2.16	0.58360	7.24796	14.66384
	7.93	-5.98	7.65	4.55	-1.82	0.11	1.70						
VEX	5.29007	0.17583	0.15891	0.56179	0.00677	0.23710	-0.40055	0.816	0.08190	1.90	0.24983	3.53344	11.11024
	3.93	1.77	7.12	1.90	1.68	3.01	-2.27						
FTX	18.09094	-0.72919	-0.00483	-0.08399	0.02172	-0.42196	0.47343	0.879	0.04104	1.76	0.97785	3.82968	5.74837
	10.19	-8.64	-0.48	-0.38	3.47	-2.60	2.50						
LEX	3.75362	0.17743	0.16619	0.53239	-0.00232	0.14467	0.13277	0.907	0.05395	2.12	0.40708	2.75820	16.89511
	3.72	2.11	10.95	2.27	-0.48	2.30	0.69						
CFX	4.39173	0.17675	0.21126	0.45423	-0.00127	0.19136	-0.35044	0.942	0.04793	2.00	1.95819	2.03432	5.22452
	7.08	3.31	17.33	3.20	-0.30	4.33	-2.05						
TFX	5.77644	-0.62086	0.17393	0.57941	0.01004	0.08843	-0.26339	0.915	0.06136	1.71	1.83924	14.93423	26.50791
	8.05	-7.56	10.75	4.00	2.04	1.32	-1.46						
OMX	8.47652	-0.39446	0.14193	0.18059	0.01044	0.19157	-0.39134	0.863	0.06077	1.95	0.89294	20.60947	29.50740
	9.13	-4.96	9.04	1.37	2.31	2.53	-2.33						
MMX	7.15518	0.44195	0.03301	1.03911	-0.00609	-0.02648	0.58093	0.953	0.05332	1.84	2.52080	5.51600	11.65983
	8.56	3.35	1.47	4.72	-1.88	-0.31	3.44						
IEX	5.09475	0.01801	0.06717	0.85987	-0.00460	0.15676	0.71150	0.907	0.04998	2.54	11.62305	13.85658	23.06881
	3.70	0.10	5.20	5.17	-0.49	2.10	6.30						

APPENDIX V

Variable Output Elasticity(RELative fuel prices)

L/HKCH

	C	Price	Temp	Output	CapOut	LDep	AR4	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests <------> L1	L4	L8
PPX	6.47827	0.04963	0.14793	0.52660	0.00234	0.10036	0.89173	0.917	0.04971	1.78	4.07408	14.36544	18.75550
	3.32	0.37	2.59	2.05	0.40	0.61	13.23						
GCX	9.01944	-0.39426	0.05967	0.30660	-0.00015	0.12984	-0.27535	0.827	0.03665	1.91	0.32198	9.99288	11.90160
	6.73	-4.15	8.47	2.03	-2.15	1.02	-1.36						
CHX	5.81142	0.31807	0.05527	0.06856	0.01534	0.39448	0.56449	0.810	0.07127	2.59	8.30632	9.30586	18.53539
	2.70	2.12	1.49	0.25	1.70	2.75	3.39						
MEX	4.65618	-0.13193	0.16749	0.92103	-0.00287	0.17665	0.76744	0.945	0.04225	1.97	0.26086	2.09390	11.33402
	3.36	-1.16	4.74	4.90	-0.41	1.68	6.92						
EEX	4.88980	-0.00814	0.15635	0.41452	-0.00649	0.32288	0.86876	0.960	0.03914	2.22	2.45077	7.59884	13.86371
	2.97	-0.08	3.49	3.34	-1.63	2.33	9.90						
VEX	7.33973	0.31243	0.14986	0.44453	0.00547	0.10346	0.23517	0.797	0.08722	2.52	3.80743	6.17962	14.60956
	4.24	1.93	4.65	1.18	1.10	0.88	1.27						
FTX	8.02743	0.00263	0.06054	0.38475	0.00758	0.17517	0.94151	0.931	0.02898	1.70	8.13514	19.72969	26.40096
	3.38	0.03	1.49	1.11	2.12	0.89	15.75						
LEX	3.91558	0.17989	0.17188	0.45036	-0.00105	0.16248	0.18189	0.904	0.05494	1.79	0.59314	1.96240	13.08449
	3.61	1.91	9.41	1.98	-0.23	2.27	0.98						
CFX	4.59998	0.17471	0.21395	0.45084	0.00012	0.16803	0.02033	0.942	0.04897	2.74	6.12756	6.93511	8.47480
	5.95	2.34	15.48	2.51	0.02	3.44	0.11						
TFX	5.52846	0.08096	0.09163	0.53876	0.00179	0.13817	0.88583	0.940	0.04841	2.01	1.36220	5.73689	17.14385
	4.36	0.56	1.63	3.32	0.51	0.93	14.32						
CMX	6.72321	-0.09819	0.18641	0.02177	0.00834	0.34899	0.84628	0.932	0.04159	2.02	2.61760	9.09580	16.48476
	4.66	-0.86	3.74	0.18	2.85	3.13	8.53						
HMX	6.01856	0.43529	0.07040	0.83612	0.00027	0.11772	0.20553	0.954	0.05410	1.83	0.89878	3.23845	10.48828
	7.00	3.86	3.00	4.01	0.09	1.20	1.10						
IEX	6.17728	0.04827	0.10360	0.38022	-0.00325	0.23463	0.45149	0.908	0.04148	1.93	0.34193	5.46815	17.67856
	4.24	0.46	5.38	2.74	-0.48	2.11	3.86						

Variable Output Elasticity(CAPital cost)

<u>C2KLS</u>

	C	Price	Temp	Output	CapOut	LDep	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	0.92338	-0.34954	0.12183	0.60226	-0.00924	0.47152	0.844	0.07567	2.17	0.87788	20.57932	30.14580
	1.02	-2.30	7.20	2.64	-1.08	4.54						
GCX	4.48188	-0.16939	0.06968	0.19501	-8.951D-05	0.45574	0.809	0.04029	2.17	0.65332	6.70452	13.82872
	4.30	-2.44	7.65	2.13	-1.17	4.25						
CHX	1.61606	0.15929	0.01749	0.56425	-0.00222	0.68746	0.696	0.08543	2.79	13.96252	20.62940	23.70688
	1.05	0.97	0.80	1.98	-0.22	6.36						
MEX	6.60048	-0.02416	0.16393	0.74792	0.00862	0.04223	0.879	0.05968	2.54	5.60128	24.23720	26.98080
	4.77	-0.23	10.37	2.81	0.97	0.61						
EEX	3.30702	-0.27398	0.12546	0.49429	-0.01030	0.34930	0.867	0.07201	1.40	6.05116	22.33408	30.16076
	3.26	-1.85	7.02	4.57	-1.13	4.03						
VEX	7.71023	-0.02771	0.14984	0.37605	0.00584	0.12453	0.802	0.08236	2.64	6.51516	8.26628	16.72740
	6.01	-0.22	7.80	4.67	1.21	1.38						
FTX	2.13981	-0.06880	-0.00641	0.13241	0.00579	0.74546	0.703	0.06555	3.02	21.82312	32.21484	33.13720
	1.63	-0.50	-0.41	0.64	0.66	5.17						
CFX	7.73758	-0.09432	0.24352	-0.62337	0.01403	0.29580	0.839	0.07801	1.42	6.33420	18.96608	26.20428
	4.28	-0.58	11.05	-1.46	1.65	4.00						
TFX	5.46527	-0.51598	0.22095	-0.42584	0.01715	0.26907	0.848	0.08013	2.28	1.14416	18.43380	24.74188
	4.39	-4.14	11.16	-1.72	2.14	3.69						
OMX	5.56809	-0.29139	0.14337	-0.11793	0.01570	0.40170	0.764	0.08449	2.36	3.53132	30.93012	34.08816
	5.35	-1.86	7.04	-0.53	1.94	4.31						
MMX	5.00863	0.10882	0.14921	-0.23974	0.00857	0.63332	0.839	0.09680	2.24	1.10540	8.45004	14.86124
	2.08	0.67	6.29	-1.65	1.46	4.97						
IEX	2.75966	-0.46373	0.12682	0.25392	-0.03196	0.46236	0.858	0.06364	2.80	11.39400	23.71640	32.84068
	3.42	-4.13	7.63	2.20	-2.97	6.19						

Variable Output Elasticity(CAPital cost)

C2KC1

	C	Price	Temp	Output	CapOut	LDep	AR1	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	0.49815	-0.37362	0.12678	0.48739	-0.01162	0.55313	-0.20332	0.839	0.07661	1.91	0.33372	21.62390	28.99467
	0.58	-2.65	6.13	2.25	-1.47	5.12	-0.91						
GCX	4.19149	-0.16856	0.07139	0.19626	-6.817D-05	0.47895	-0.14409	0.810	0.04071	1.96	0.28891	8.12561	14.87585
	3.83	-2.49	7.46	2.21	-0.92	4.29	-0.74						
CHX	0.22374	0.11165	0.04251	0.32007	0.00330	0.86453	-0.61261	0.792	0.07272	2.07	2.28134	7.61966	20.01819
	0.25	1.03	2.47	1.76	0.50	13.33	-4.16						
MEX	4.68251	-0.12140	0.17062	1.03065	-0.00034	0.07293	-0.48500	0.903	0.05496	1.65	1.72602	16.30847	24.22516
	4.26	-1.50	12.51	4.56	-0.05	1.27	-2.98						
EEX	6.63964	-0.02483	0.10416	0.70542	-0.01188	0.06170	0.71680	0.902	0.06252	2.47	6.74357	12.41156	24.88727
	4.83	-0.15	7.47	5.01	-1.47	0.77	5.48						
VEX	6.63429	-0.05042	0.16201	0.35945	0.00678	0.20557	-0.42253	0.838	0.07678	2.00	0.12679	3.30736	15.49181
	6.42	-0.55	9.44	6.01	1.78	2.60	-2.55						
FTX	0.33068	-0.00038	0.00439	0.16317	0.00273	0.90467	-0.82612	0.864	0.04358	1.75	2.33337	11.46627	25.61758
	0.60	-0.01	0.54	1.84	0.67	14.70	-7.10						
CFX	8.01966	0.00370	0.21862	-0.22876	0.01240	0.14058	0.56113	0.872	0.07100	2.57	8.37892	14.27743	26.42465
	4.40	0.02	11.61	-0.54	1.40	1.92	3.63						
TFX	5.22649	-0.54732	0.22715	-0.47746	0.01762	0.30114	-0.20571	0.851	0.08126	1.64	3.30630	17.36849	29.34543
	4.05	-4.70	11.30	-1.94	2.14	3.90	-1.05						
OMX	5.21184	-0.26702	0.15522	-0.05303	0.00996	0.41606	-0.29997	0.764	0.07981	1.81	1.53925	30.01900	33.89927
	5.39	-2.15	7.60	-0.30	1.46	4.81	-1.55						
MMX	4.43434	0.09111	0.14834	-0.23195	0.00935	0.67104	-0.20048	0.842	0.09802	1.96	0.84318	8.61198	14.41249
	1.87	0.63	5.81	-1.64	1.71	5.27	-0.97						
IEX	2.28921	-0.50671	0.14662	0.18711	-0.03234	0.50806	-0.58150	0.889	0.05467	1.91	2.23763	17.13933	26.33783
	4.59	-6.52	10.87	2.44	-4.27	10.08	-3.77						

Variable Output Elasticity(CAPital cost)

C2KO4

	C	Price	Temp	Output	CapOut	LDep	AR4	$\bar{R}^2$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	6.72184	-0.08377	0.13802	0.29383	0.00393	0.14060	0.86068	0.920	0.04889	1.86	2.34043	12.06968	17.04514
	3.63	-0.71	2.59	1.83	0.74	0.88	8.66						
GCX	5.64011	-0.14006	0.07030	0.26011	-8.880D-05	0.34221	0.11223	0.811	0.03823	2.27	1.21327	10.34870	17.62384
	4.34	-1.99	6.74	2.32	-1.12	2.52	0.64						
CHX	7.14000	-0.01848	0.15588	0.02183	0.02161	0.24185	0.91468	0.819	0.06968	2.35	11.32682	13.46299	25.37683
	3.86	-0.12	1.80	0.12	3.11	1.62	10.00						
MEX	3.81867	-0.11403	0.16148	0.94881	-0.00399	0.19020	0.73676	0.947	0.04166	2.33	3.82500	3.77834	8.00276
	2.80	-1.25	5.02	5.38	-0.53	1.87	6.14						
EEX	5.01170	-0.16049	0.15333	0.08393	-0.00367	0.39213	0.88219	0.952	0.04280	2.19	2.71519	9.83408	16.07994
	2.75	-2.01	3.09	1.12	-0.86	2.68	9.99						
VEX	8.72022	0.04376	0.14394	0.42461	0.00574	0.04867	0.22026	0.809	0.08458	2.56	4.82652	8.91648	16.68913
	5.46	0.30	5.44	3.98	1.15	0.40	1.15						
FTX	11.28309	-0.13954	0.03107	0.24530	0.01012	-0.08094	0.90880	0.949	0.02497	1.71	8.95446	13.45316	20.99135
	5.82	-2.38	0.97	2.81	3.28	-0.49	18.87						
CFX	5.61739	-0.14680	0.25680	-0.06187	0.00634	0.22944	0.67850	0.909	0.06111	2.37	2.20385	9.39298	19.13566
	3.80	-1.21	5.98	-0.21	1.06	1.96	4.70						
TTX	5.61552	-0.19833	0.14505	0.19148	0.00386	0.16391	0.73087	0.935	0.05046	1.93	1.18552	3.67888	17.40334
	4.23	-1.85	3.57	1.24	0.86	1.24	8.01						
OMX	7.46624	-0.11569	0.16562	-0.17507	0.00964	0.32623	0.80331	0.935	0.04055	2.18	3.59611	9.66197	11.01834
	5.08	-1.35	3.92	-1.60	3.30	2.93	8.23						
MMX	1.81839	0.02588	0.14351	0.08203	0.00118	0.75634	0.62641	0.869	0.09136	2.22	1.45220	3.98077	8.85089
	0.71	0.15	2.65	0.53	0.27	4.65	3.56						
IEX	6.55218	-0.21387	0.11759	0.11802	-0.00723	0.23999	0.56016	0.909	0.04121	2.44	2.48839	7.40581	16.08541
	4.67	-2.27	5.39	1.71	-1.02	2.01	6.69						

CHKLS

	C	Price	Temp	Output	CapOut	LDep	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	4.58902	-0.40944	0.12572	-0.57543	0.00639	0.58549	0.832	0.07850	2.23	1.58784	21.24792	25.32080
	2.37	-2.70	7.13	-1.89	0.62	6.77						
GCX	6.09153	-0.17261	0.06552	-0.19641	-0.00014	0.47252	0.811	0.04003	2.29	1.24160	3.53472	7.42112
	4.27	-2.52	7.24	-2.22	-1.63	4.66						
CHX	1.52132	0.11833	0.03561	0.26461	-0.00099	0.78754	0.665	0.08973	2.80	13.17412	20.96244	26.19120
	0.74	0.64	1.73	0.73	-0.08	7.51						
MEX	7.63611	-0.07695	0.19205	0.27461	0.00630	0.10545	0.861	0.06379	2.25	1.38504	20.55452	26.48456
	5.37	-0.55	13.40	1.59	0.53	1.52						
EEX	1.02375	-0.18184	0.15070	0.85180	-0.02028	0.43636	0.820	0.08377	1.58	3.60200	32.21052	34.47244
	0.89	-0.77	7.86	2.33	-1.85	4.37						
VEX	2.75911	-0.19902	0.17344	1.55116	0.00329	0.02524	0.826	0.07727	2.73	7.69512	10.29696	19.50464
	1.87	-1.54	9.87	5.72	0.73	0.28						
FTX	-0.97188	-0.06550	0.00044	1.94442	-0.00481	0.32213	0.772	0.05739	2.41	7.15628	27.06244	29.61080
	-0.65	-0.54	0.03	3.30	-0.63	1.77						
LEX	4.50333	0.33633	0.17955	0.83721	0.00131	0.05429	0.867	0.06392	1.60	2.11064	3.90060	21.51244
	4.39	2.82	12.46	4.54	0.24	0.67						
CFX	4.42253	0.19839	0.21558	0.88410	-0.00347	0.08847	0.918	0.05581	2.52	3.84108	7.02980	11.21808
	5.80	2.12	16.98	5.80	-0.66	1.38						
TFX	5.49336	-0.47951	0.21158	-0.35602	0.01303	0.26071	0.859	0.07726	2.44	2.84692	20.64536	22.36168
	5.39	-4.29	11.98	-2.55	1.92	3.70						
OMX	7.52168	-0.31533	0.14459	-0.40412	0.01713	0.33993	0.800	0.07786	2.69	10.85284	30.04620	32.73204
	6.03	-2.74	8.15	-2.81	2.51	4.28						
MMX	4.30595	0.15355	0.11745	1.28252	-0.00348	0.16043	0.945	0.05656	1.58	2.66392	6.43480	12.05668
	5.16	1.69	8.95	8.40	-1.04	1.84						
IEX	3.03996	-0.38111	0.13847	0.26353	-0.02560	0.44804	0.850	0.06526	2.76	10.70056	25.81776	30.90320
	3.79	-2.19	9.36	1.12	-2.55	5.46						

APPENDIX V

Variable Output Elasticity(CAPital cost)

CHCl

	C	Price	Temp	Output	CapOut	LDep	AR1	R^2	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	3.75432	-0.39990	0.13200	-0.50434	0.00217	0.63995	-0.22816	0.836	0.07730	1.98	0.90328	18.24237	24.19775
	2.08	-2.93	6.25	-1.91	0.23	7.62	-1.03						
GCX	5.58060	-0.17419	0.06675	-0.18853	-0.00012	0.51141	-0.18566	0.810	0.04066	1.93	0.21817	3.96053	10.51467
	3.62	-2.64	7.10	-2.16	-1.43	4.68	-0.95						
CHX	0.49990	0.04896	0.05612	0.02107	0.00604	0.92692	-0.60378	0.769	0.07667	1.93	1.23263	5.90425	16.74063
	0.40	0.41	3.41	0.09	0.73	15.59	-4.14						
MEX	6.91770	-0.10392	0.19921	0.29287	0.00455	0.14937	-0.21667	0.870	0.06355	1.82	0.68991	20.05279	26.59827
	5.03	-0.78	12.88	1.82	0.39	2.11	-1.12						
EEX	6.97361	0.35999	0.13672	1.11744	-0.01172	-0.02586	0.79919	0.867	0.07298	2.95	19.79585	25.81082	31.27492
	3.34	1.55	10.68	2.65	-1.29	-0.26	6.69						
VEX	1.30890	-0.28486	0.18560	1.62183	0.00174	0.08750	-0.47161	0.861	0.07119	1.99	0.39628	4.78132	17.87686
	1.25	-3.06	12.19	7.56	0.50	1.11	-2.95						
FTX	0.06204	-0.02358	0.00737	0.35338	-0.00211	0.85191	-0.78208	0.853	0.04517	1.66	4.13232	16.46588	25.63439
	0.08	-0.35	0.88	0.93	-0.51	7.38	-6.11						
LEX	4.76628	0.29174	0.17748	0.81216	0.00098	0.01979	0.20583	0.880	0.06123	2.16	0.59623	3.62876	20.52629
	4.31	2.23	12.96	4.03	0.18	0.23	1.10						
CFX	4.16465	0.17192	0.22046	0.92935	-0.00649	0.08529	-0.32347	0.926	0.05392	2.00	1.83507	1.99645	5.87321
	6.64	2.27	18.08	7.69	-1.49	1.43	-1.86						
TFX	4.82910	-0.50926	0.22227	-0.34760	0.01062	0.31085	-0.32404	0.868	0.07644	1.56	4.23064	18.74317	29.00914
	5.47	-5.45	12.28	-3.22	1.79	4.62	-1.73						
OMX	6.97421	-0.32906	0.16584	-0.37720	0.01146	0.36771	-0.50664	0.842	0.06537	1.83	1.81104	23.76274	28.99498
	8.23	-4.45	11.34	-4.50	2.54	6.37	-3.31						
MMX	5.57403	0.18111	0.10769	1.58988	-0.00747	-0.04031	0.55286	0.952	0.05389	1.79	1.27234	5.48028	13.52750
	4.68	1.32	9.86	8.92	-2.03	-0.47	3.35						
IEX	2.52510	-0.52097	0.15519	0.07434	-0.02771	0.51873	-0.58679	0.884	0.05580	1.82	4.18965	18.92444	24.59570
	5.14	-4.28	12.92	0.53	-4.25	9.73	-3.84						

APPENDIX V

Variable Output Elasticity(CAPital cost)

CHCH

	C	Price	Temp	Output	CapOut	LDep	AR4	$\bar{R}$	S.E.R.	Durbin Watson	Lagrange Multiplier Tests L1	L4	L8
PPX	6.62088	-0.05417	0.14041	0.46795	0.00216	0.09705	0.88059	0.916	0.04994	1.75	3.37572	13.14864	17.44387
	3.36	-0.35	2.43	1.26	0.37	0.59	8.90						
GCX	5.46247	-0.17156	0.06442	-0.14371	-9.447D-05	0.50544	0.05018	0.783	0.04099	2.20	0.60070	3.93343	11.93432
	3.36	-2.37	6.27	-1.31	-0.95	4.39	0.24						
CHX	6.86111	-0.00578	0.15590	0.06409	0.02070	0.25484	0.90770	0.818	0.06973	2.36	11.49595	13.42091	24.54923
	3.28	-0.03	1.82	0.25	2.72	1.65	9.64						
MEX	4.16397	0.05094	0.18251	0.94140	-0.00381	0.21294	0.83594	0.941	0.04380	1.81	0.92891	2.29136	11.33748
	2.79	0.52	4.12	4.41	-0.47	1.96	9.51						
EEX	4.74954	-0.00929	0.16733	0.42009	-0.00695	0.32508	0.88309	0.961	0.03900	2.19	3.32816	8.39930	13.86569
	2.91	-0.10	3.66	2.62	-1.73	2.42	11.38						
VEX	3.40232	-0.14229	0.16898	1.58804	0.00420	-0.02274	0.14376	0.825	0.08111	2.61	5.23091	7.36229	15.50066
	2.01	-0.98	7.39	4.85	0.89	-0.19	0.75						
FTX	9.20092	-0.11125	0.04309	0.41734	0.00569	0.03677	0.92871	0.937	0.02759	1.61	8.53906	14.88838	17.76834
	3.91	-1.68	1.07	1.31	1.62	0.21	14.34						
LEX	4.23859	0.19915	0.18177	0.71255	-6.157D-05	0.09078	0.26100	0.883	0.06041	1.71	1.74614	2.58329	16.29202
	3.79	1.56	9.48	3.55	-0.01	0.92	1.48						
CFX	4.55164	0.14454	0.22358	0.82540	-0.00311	0.07612	0.14023	0.930	0.05374	2.65	4.82562	6.51722	7.18420
	5.69	1.40	14.98	4.79	-0.60	1.05	0.77						
TFX	6.04593	-0.13726	0.09562	0.37550	0.00393	0.09937	0.85191	0.938	0.04925	1.92	1.44324	5.73862	23.26910
	4.60	-1.10	1.73	1.74	1.07	0.67	11.17						
OMX	7.05665	-0.08586	0.17158	-0.07984	0.00829	0.33053	0.81500	0.932	0.04169	2.11	2.92874	10.48950	15.76724
	4.62	-0.81	3.70	-0.48	2.77	2.85	7.34						
MMX	4.45161	0.18241	0.12449	1.27924	-0.00318	0.15495	0.19195	0.945	0.05943	1.60	2.16922	5.10354	14.20798
	4.50	1.65	7.03	7.04	-0.93	1.48	0.95						
IEX	6.82230	-0.18495	0.12632	0.12821	-0.00495	0.21429	0.52345	0.902	0.04270	2.46	2.90178	8.05075	20.46852
	4.74	-1.48	6.20	0.73	-0.65	1.81	5.88						

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