CONSTRUCTION TENDER PRICE INDEX: MODELLING AND FORECASTING TRENDS

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To Bola

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ABSTRACT

The thesis considers the construction tender price index, an important area of construction economics, and models are developed to fit the trends in this index.

Between 1980 and 1987, the UK Building Cost Index produced by the Building Cost Information Service increased at an annual rate of 6.3% compared with Tender Price Index 3.3% and Retail Price Index at 6.7% per annum. This significant disparity between Tender Price and Building Cost Index is unexpected in view of the attributed importance of input prices in the tender price formation. This suggests that other factors apart from input prices may be responsible for the trends in building prices generally. The thesis reviews the pricing strategies of construction contractors leading to the conclusion that macroeconomic factors are equally important.

A univariate analysis of 24 potential indicators of tender price trends identified some variables of importance. An analysis is described of these variables using the OLS system of regression analysis. Single structural equation model of construction tender price level is developed which offer structural explanation of the movements in the index. Indicators of construction price (in real terms) produced by the structural equation were found to be unemployment level, real interest rate, manufacturing profitability, number of registered construction firms, oil crisis, building cost index, construction productivity and construction work stoppages.

A Reduced-form model of construction price is developed that utilises simultaneous equation models comprising construction demand, supply and equilibrium models - the reduced-form models being generally regarded as having better predictive power than structural equations. The model is validated by comparing its accuracy with forecasts produced by two leading organisations in U.K. The out-of-sample forecast errors of the reduced-form model are 2.78, 3.58, 4.28 and 5.59 RMSE percent over 0, 1, 2 and 3 quarter forecast horizons respectively, which are better than the Building Cost Information Service (3.32, 5.29, 7.57 and 9.96 RMSE percent) and Davis, Langdon and Everest (3.21, 5.01, 7.16 and 10.41 RMSE percent).

CHAPTER 1

General Introduction

GENERAL INTRODUCTION

1.1 Introduction to subject matter

Unlike many other industries, research into pricing in the construction industry has not made much progress in providing theoretical and empirical explanations of price level and intuitive cost modelling. Far more attention has been paid to predicting bid levels than in developing appropriate and concise explanation(s) underlying price movements. This is now being gradually redressed with studies such as Fleming (1986), Taylor and Bowen (1987) and Fellows (1988) all identifying the usefulness of construction price indices. Construction price indices are used in estimating, updating cost data, deflation of economic time series data into real terms, escalation management and in calculation of replacement cost of building.

Many establishments in the UK are involved in the production of periodic Tender Price Indices (TPI). The most popular of these are those produced by the Department of Environment (DoE) Public Sector, Building Cost Information Service (BCIS), DoE Road Construction, DoE Price Index of Public Sector House Building and Davis Langdon and Everest. These indices are predominantly based on cost information extrapolated from bids accepted for work either in public sector (DoE indices), both public and private sectors (BCIS index), or bids from new work in the outer London area that are handled by the quantity surveying practice of Davis, Langdon & Everest (DL&E index).

While it is established that tender price is highly fluctuating there has been wide disparity between annual rate of tender price and building cost. For example between 1980 and 1987 Tender Price Index (TPI) increased at an annual rate of 3.3 per cent compared with corresponding Building Cost Index (BCI) annual increase of 6.3 per cent and Retail Price Index Non-Food Items (RPI - a measure of inflationary rate) at 6.7 per cent per annum. This significant disparity between TPI and BCI is unexpected in view of the importance of input prices in the tender price formation, irrespective of the different base weighting of the two. What really accounts for this disparity?

Probably this disparity accounts for the high degree of forecast errors of TPI. Fellows (1991), for instance, found the forecast error of TPI produced by BCIS to be about 7 to 17% for forecasts made more than 4 quarters ahead.

Recent studies in TPI forecasting have however been based on time series analysis. Taylor and Bowen (1987) used a group of techniques of varying sophisticated time series for predicting the Bureau for Economic Reaearch (BER) building cost index (TPI). Fellows (1989) used a form of multivariate time series analysis in his proposals for a construction price escalation management system. Fellow's work aroused interest in that, despite the ability of multivariate time series analysis to consider other potential price influencing factors, the distributed lag pattern of previous price levels always seems to dominate the model.

What is clear is that these types of model are not intended to help very much with the understanding of construction price movements, although such an understanding is certainly needed for the proper use of the index.

The need to understand construction price movements is believed to be one of the paradigm shifts advocated by Beeston (1983) for the development of cost models that are more explanatory and logically transparent. Bowen and Edwards (1985) also saw a need for future approaches to cost modelling and price forecasting for construction projects to accept a continuing need for historically derived data in exploring cost trends and relationships amongst other needs. Thus, the importance of being able to explain and predict tender price level with tolerable accuracy is readily apparent.

1.2 Objectives

In view of the discussion above, the research described herein evolved around developing econometric equations that are capable of explaining, monitoring and forecasting tender price movements. The research therefore had the following objectives to:

a. analyze the movements in UK tender price index;
b. identify and examine the factors responsible for TPI movements;
c. develop models that are capable of explaining and tracking the historical movements in tender prices; and
d. evaluate the accuracy of these models.

1.3 Hypothesis

This tests the proposition that:

> "The tender price trend is more influenced by the market conditions than the level of construction input costs." This suggests that the construction industry lends itself more to market-oriented factors than cost factors in pricing decisions.

Market-oriented factors within this content relate to factors that influence demand (customer-oriented) and competition (Grabor, 1977). A measure of intensity of competition in the construction industry is the number of companies in the industry which apparently have influence on construction supply (Skitmore, 1986).

1.4 Methodology

The method employed in modelling tender price index is best described as one of hypothesis searching. Dhymes *et al* (1972) call this approach "Sherlock Holmes inference". The basic approach of hypothesis searching involves data analysis in which econometricians weave together all the bits of evidence into a plausible story. Regarding this research work, economic theory was used as a guide in the course of considerable experimentation with the data coupled with the experience of the construction industry which play a key role in the model building process. The results are models that creditably explain and forecast construction tender price movements.

The overall methodology used in this research contained three phases:

Phase I: Preliminary work
Phase II: Development of the Construction Price Model
Phase III: Validation of Model

Figure 1.1 shows the interrelationships between these 3 main phases.

Phase I: Preliminary work

This included all activities that were required to prepare the proposal that described the overall research objectives. The major activities of this phase were:

1. Literature review about the subject matter. This included review of books and journal; and extensive interview of experts and professionals in the research area.
2. Examining movements in construction price and cost in relation to construction profitability (Akintoye and Skitmore, 1991). The aim of this was to establish the level of relationship, if any between construction price and cost.
3. Developing a data collection strategy for the research work.
4. Developing an initial version of the model (Akintoye and Skitmore, 1990).

Phase II: Development of the Model

This phase focused on establishing the specific research strategy for this work and developing the models. The main activities of Phase II were:

1. Review of additional literature to identify the economic theory of price changes and appropriate methods for statistical analysis.
2. Producing potential list of construction price determinants based on interviews with professionals and experts.

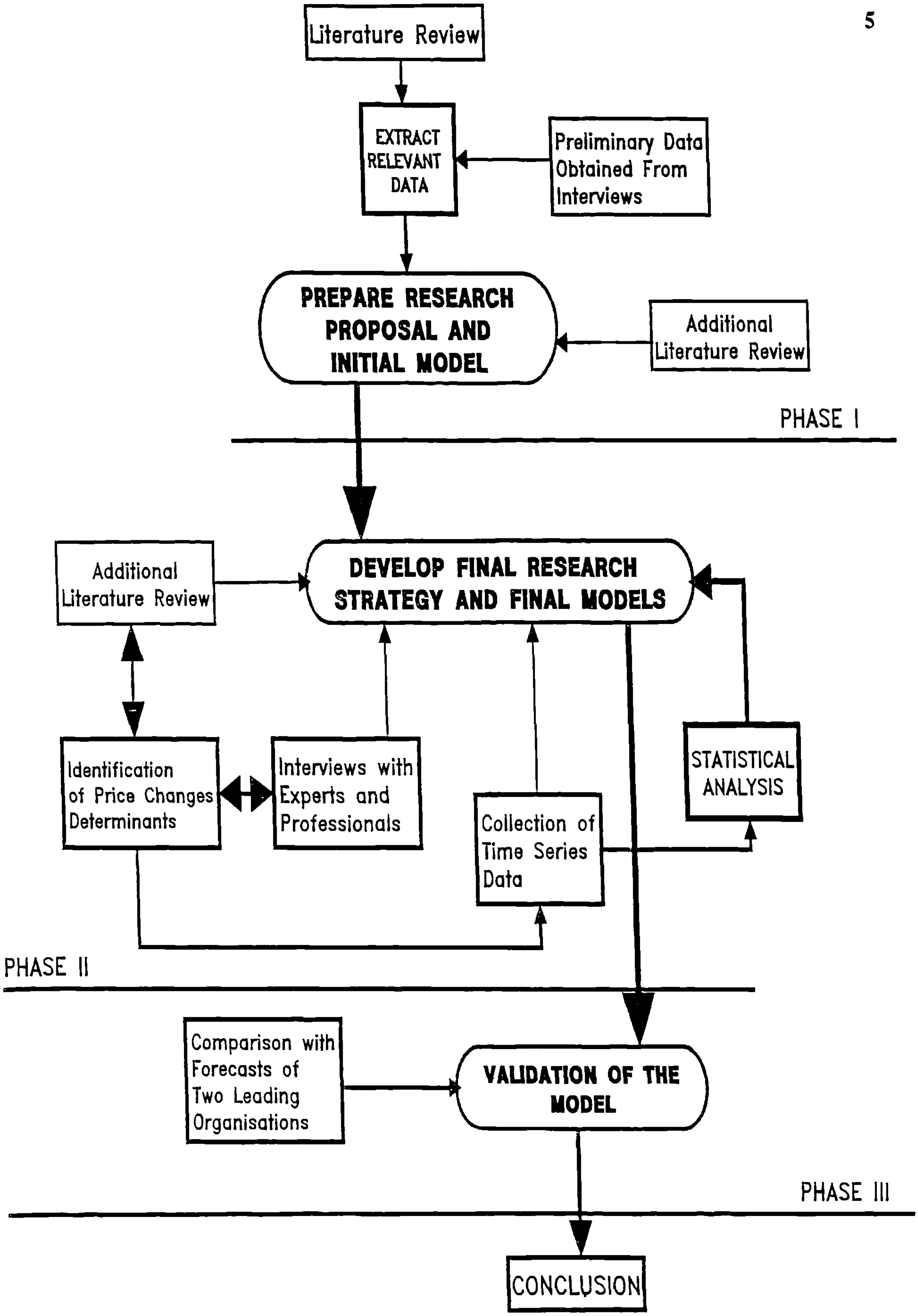

Figure 1.1 Principal Phases of the Research

3. Collecting time series data. These data were used to advance the model of construction price to final form.

Phase III Validation and Conclusion

This phase tests the forecasting accuracy of the model in comparison with forecasts published by two leading organisations in UK.

1.5 Organisation of the Thesis

The rest of this thesis comprises of ten chapters. The work is arranged in a form that each chapter contains literature review to start with. This method has been adopted because of the lack of a body of theory or comparable study that brings all the issues involved in this work together. The chapters are divided into four parts, apart from the introduction and conclusion chapters (Chapters 1 and 10 respectively).

Part one contains Chapter 2. This chapter looks into the theory and practice surrounding the formation of tender price at project level (micro-level). The conversion of projects' tender price to tender price index (macro-level) is also established.

Part two comprises of Chapters 3 to 5. These chapters evaluated existing construction price indexes. Potential factors responsible for the movements of TPI are identified and reports experiments undertaken to identify specific factors that influence annualized growth rate of the tender price index.

The third part of the research, described in Chapters 6 to 8, concentrate on the development of models of construction price movements. Chapter 6 examines the demand side of the construction price and Chapter 7 examines the supply side. Chapter 8 presents the single structural model and the reduced-form model of construction price trends. These chapters also explore the theoretical rationale underlying the specification of the equations and present the estimated equations and summary statistics.

The fourth part of the research is Chapter 9. This chapter discusses the forecasting behaviour of the reduced-form model of construction price compared with TPI forecasting accuracy of two leading organisations in UK.

Chapter 10 concludes the findings in this thesis. The principal results are summarized and recommendations for further research on the subject are offered.

CHAPTER 2

Pricing in the Construction Industry

PRICING IN THE CONSTRUCTION INDUSTRY

2.1 Introduction

Pricing construction contracts is not simple. The construction industry is extremely fragmented and highly competitive. Contractors have to competitively bid for most of their work while dealing with risks and uncertainties connected with bid submission. The high levels of price competition and low capital intensity, which characterize the industry, often result in low profit margins. A great deal of current information is needed for forecasts of demand, cost, competition, etc., to enable bids to be set and adjusted to desired profit levels.

This chapter reviews pricing policies in the services industry in comparison with the construction industry. The processes of arriving at tender price by construction contractors and its relationship with construction tender price index are discussed.

2.2 Pricing in the Service Industry Generally

In comparison to the construction industry, a lot of research has taken place in the service industry into the processes and stages involved in pricing decisions. Tellis (1986) defines a pricing strategy as a reasoned choice from a set of alternative prices (or price schedule) that could aim at profit maximization within a planning period in response to a given scenario. Morris and Calantone (1990) classified pricing decisions into four categories: pricing objectives, pricing strategy, pricing structure and pricing levels/tactics. This classification is recognised as 'the pricing program' shown in Figure 2.1.

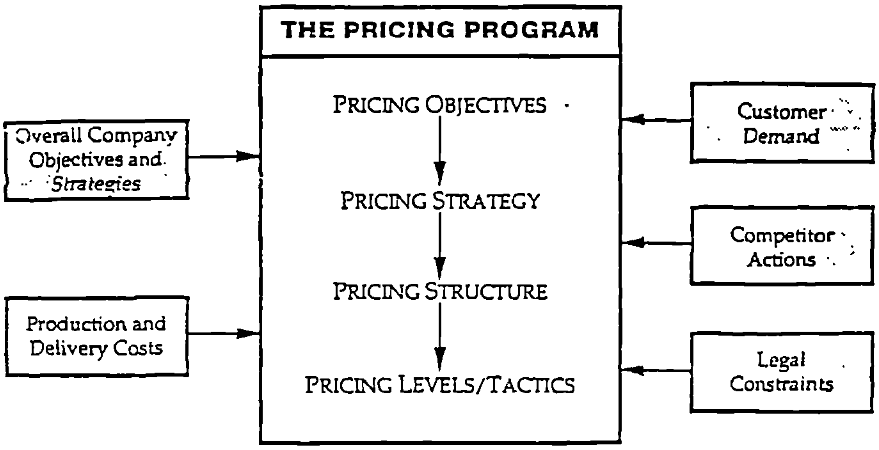

Figure 2.1 Company pricing program and its determinants

Source: Morris, M.H. and Calantone, R.J., 1990, Four components of effective pricing, *Industrial Marketing Management*, Vol.19, pp.323.

2.2.1 Pricing Objectives

Literature relating to marketing activities continues to report pricing objectives as the logical starting place for price determination. Goetz (1985) notes how a firm's overall objectives determine its pricing objectives which, in turn, establish the parameters of pricing policies. Shipley's (1981) investigation of objectives of firms showed the importance of the objectives of firms in their pricing policy and method, while Davis (1978) earlier reported that price should be chosen to achieve a company's objective. Within this field numerous pricing objectives have been identified. For example Oxenfeldt (1973) specified a list of twenty pricing objectives. However empirical work by Lanzillotti (1958), Hague (1971) and Pass (1971) have specified that the types of pricing objectives usually specified by businessmen or corporations are limited to seven.

Assael (1985) identified three major types of pricing objectives to be:

1. Cost-oriented objectives
   - to pursue a target return on investment
   - to recoup costs over particular period of time.
2. Competition-oriented objectives
   - to retain market share
   - to discourage competition
   - to provide a barrier to entry by other firms
3. Demand-oriented objectives
   - to meet the expectation of clients and the industry.

Govindarajan (1983), on the other hand, claimed that firms' pricing objectives are related to expected profit levels, usually concerned with either profit maximization or profit satisficing.

Abratt and Leyland's (1985) empirical study found a correlation between the pricing objectives of construction firms and their pricing strategies, the objectives being restricted to target returns on investment and market share. They also realised that most firms with a target return on investment operated a cost based pricing strategy.

2.2.2 Pricing Strategies

Ideas for different pricing strategies have evolved overtime. Economists have advocated the marginal analysis of all cost and revenue conditions as a pricing strategy for profit maximization of quantity and price of products. Market theorists, pioneered by Oxenfeldt (1960), continue to prescribe an integrative multi-stage approach to price determination. This technique involves the use of a checklist of relevant facets of setting price to ensure adequate consideration is given to objectives, demand, costs, rivals, distributors, complimentary goods and legal requirements.

Garbor (1977) has classified pricing strategies into two basic approaches - cost-based pricing and market-oriented pricing. Cost-based pricing encompasses profit oriented and government-controlled prices, while the market-oriented pricing includes customer-oriented and competition-oriented pricing. Morris and Calantone (1990) have classified the market-based strategies into nine different sub-strategies.

Empirical work by Skinner (1970) shows that most service firms adopt the cost-plus approach to pricing. This corroborated works by Kaplan *et al* (1958) and Barback (1964).

The most common benefit of cost-plus pricing is that it favours good customer relations as customers are more likely to accept cost increases than other causes as a justification for a price rise (Shipley, 1986). Other advantages include its simplicity to implement and manage compared to alternatives and its standardized operating procedure.

However, Shipley (1986) has strongly criticised the use of cost-plus pricing policy as it pays insufficient regard to other changes in the business environment. Nonetheless, 92 per cent of firms that responded to his questionnaire claimed to use this pricing approach. Another criticism of cost-plus policy is that apart from ignoring competitors' prices, it uses the estimates of both cost and sales volume to determine price, whereas price itself affects the levels of both costs and volume (Root, 1975; Lazer and Culley, 1983).

Advocates of competition-oriented and demand-oriented pricing strategies have further criticised the use of cost-plus pricing policy as a reflection of general level of *naivete* among managers responsible for pricing decisions. Morris and Calantone (1990) for example, have indicated that price should reflect value and customer's willingness to pay. In other words, value and customer's willingness to pay are market-oriented considerations. The price set based on cost-plus pricing policy is regarded as often too high or low given current market conditions.

2.3 Pricing in the Construction Industry

Skitmore (1989) described construction contract pricing as a flow process in which events need to be considered over a continuous time period. This is unlike a static situation in product pricing in which pricing activities are assumed to occur in simultaneous fashion. Flanagan and Norman (1989) recognised a variety of pricing systems in use in the industry which, is mainly determined by the contractual relationship between client and contractor. Schill (1985) examined the issues in contract pricing and concluded that the distribution of risk between contracting parties is the most important key.

The study of a sample of the 12 UK's largest building contractors reflected the increasing level of sub-contracting by large building contractors (Betts, 1990). Sometimes, contractors sub-contract some work to offset some of the financial risk. This increasing development has been recognised as playing a prominent role in construction pricing. Fessler (1990) for example, reported that the large general contractors can only be competitive by using prices submitted by local sub-contractors. On the other hand some firms have seen this development as an avenue to reduce or minimise uncertainty. In many cases contractors have reduced the function of their estimating department to evaluation of bids received from their sub-contractors which form the basis for tender price formation (Topping, 1990). Flanagan (1986) reported an extremely high variation in sub-contractors' bids of up to 600% and greater than that in general contractors' bids. The implication is that the choice of wrong sub-contractors in terms of bid and integrity for good performance could jeopardize a general contractors bidding success and performance on site respectively.

These features, amongst others, make construction pricing policy a complex marketing activity. However, it is worthwhile to identify factors that are considered by contractors while tendering for construction works.

2.3.1 Factors influencing construction pricing decisions

These are various factors that are considered when making a bid price decision. To compile these factors is a difficult task in view of the variety of pricing systems in the industry. An extensive literature search of standard textbook materials, proceedings and transactions of conferences, and referred journals has been conducted to bring these factors together in this section. Four broad areas have been identified. These are environmental, profitability, cost estimating and procurement factors.

2.3.2.1 Environmental factors

Decision makers often assess a various set of economic factors during project development. These include important macroeconomic variables encompassing the economic, political, social and technological circumstances of a project.

These factors determine largely the market situation in the construction industry. Southwell (1970) indicated how general economic conditions could determine the climate for tendering and market price level. In addition, Koehn and Navvabi (1989) have used the relationship between economic and social factors to develop their construction cost index, whilst Hutcheson (1990) identified some of these factors for forecasting changes in the building market.

The economic, social or political situation can dictate the level of demand for construction work, the number of construction firms registered and the degree of competition for construction works. Environmental factors found in literature are summarised to include the combination of the following:

Geographical location of construction demand
Competitive market conditions
General state of inflation or deflation
Local tendering customs
Governmental policies

Capacity and facilities available in the industry
Level of taxation
Economic well being of a nation

These factors are not mutually exclusive. In essence, there is some degree of interdependence of one another.

2.3.1.2 Profitability

Profitability in the construction industry is generally rather low compared with other industries (Akintoye and Skitmore, 1991). At the project level, profitability could be described as the trade off between winning a tender and making a reasonable profit. The expected profitability on a project often bears a close relationship with the mark-up value. Runeson and Bennett (1982) have emphasised the importance of mark-up in tendering strategies. Flanagan (1980), Beeston (1987) and Raftery (1987) have all identified factors involved in the construction contractors' mark-up.
Profitability factor specifics found in literature are mainly:

Level of risk and uncertainty in a project
Human error
Desirability of a project
Escalations
Strategic manoeuvring

2.3.1.3 Cost estimating

The first purpose of a cost estimate is to provide knowledge of likely cost of construction work. In the construction industry, a bid price is traditionally formulated by combining this cost estimate with a mark up value.

Queries have persistently being raised about the reliability of this process. For example Shaw (1973) notes that estimators cannot really estimate costs because they have no reliable means of knowing what their actual costs are. Skoyles (1977) also points out that few builders know the accuracy of their cost estimate. This is due to the lack of reliable feedback created by a combination of the competitive tendering system and variable site performance levels. However, empirical work by Azzaro et al (1988) suggests that cost estimates continue to provide the basis for most contractors' tender pricing.

Cost estimate factor specifics consist mainly of design and construction variables. These determine the level of complexity of project, the use of plant, specification and buildability of construction work. The factor specifics found in literature are summarised as follows:

Design variables

Plan shape
Size of project
Storey height of project
Number of storeys
Specification standard
General project arrangement including layout
Degree of repetition within building
Site conditions
Environmental needs - need for natural daylight
- need to meet some regulations
Extent of services and external works

Construction variables

Construction form
Degree of repetition with building
Complexity of task
Level of interdependence of construction operations
System of construction
Extent of experience on the type of construction
Contractor's work programme

Weather / ground conditions
Time overlap of design and construction

2.3.1.4 Procurement

Procurement systems are concerned with the execution of construction contracts and the factors involved in this. The factor specifics found in literature are summarised as follows:

Tendering procedure
Contractual arrangement
Intensity of competition
Contract duration
Financial consideration of client
Contractor's cash flow manipulation
Quality of project information
The designers involved
Quarter of the year that the bid is submitted
Drastic contract provisions
Level of use of subcontractors
Quantity of expected variation on a project
Method of cost estimating
Level of adequacy of cost data
Type of client
Contract value
Remoteness of project and distance from contractor base

2.3.2 Pricing policy

To meet specific objectives, and within the content of factors that influence pricing decision, firms have to adopt some type of pricing strategy. For example, a construction firm that is targeting a particular construction market could do this by tendering for such jobs at a low price level. Fellows and Langford (1980) suggest that firms may adopt low profit level pricing in times of economic recession to maintain market share or to penetrate a new market. Skitmore's (1987) investigation of market oriented pricing strategies of construction firms argued that the structure of the construction industry and the nature of the bidding process lends itself more to market-oriented pricing than cost-oriented pricing.

However, Clough (1975), Farid and Boyer (1987) claimed contractors embrace the conventional pricing practices of negotiated and competitive bid contracts. These are mainly cost-based oriented. Empirical work by Abratt and Pitt (1985) show that the most important factors influencing pricing of construction contractors are cost and competitors' prices. Insofar as the construction industry remains susceptible to changes in the business cycle, economic climate will continue to be an important factor in pricing. It is reasonable, therefore, to say that the industry has tendencies toward market-based pricing policy. In times of economic uncertainty firms may switch from cost based to market oriented pricing strategies. In boom conditions it is possible that construction firms settle for cost based pricing and therefore make target returns on investments.

Experience and observation of the construction industry indicate that six pricing strategies are identifiable in respect of construction bid pricing.

2.3.2.1 Cost-based pricing strategy

Two approaches here are relevant: cost estimate plus variable mark-up and cost estimate plus flexible mark-up. Construction literature emphasises the importance of market conditions on mark-up values. Mark-up is the allowance for profit and general overhead. It reflects the desirability of a project to the contactor. Tavakoli and Utomo (1989) and Ahmad and Minkarah (1988) identified numerous factors to be considered in determining a mark-up figure in contract bidding.

2.3.2.2 Market-based pricing policy

This relates to a construction firm's perception of 'going price' of a project considering the general level of competition, workload in the industry, clients bid price consciousness, etc. Attention is based on competitive conditions to ensure that the firm's price is not too far removed from those of competitors.

2.3.2.3 Standard rate table based pricing strategy

This is based on extracts from standard construction price books like Spon's, Laxtons, Wessex database, etc. This pricing strategy is most likely to be adopted by small firms or firms that are commencing trading for the first time. Medium and big size firms could consider this strategy for comparison with their tender figures.

2.3.2.4 Historical price based pricing strategy

In this case previous bid prices are adjusted for effects of time, location, current economic conditions, variations in design and construction, etc. This is more relevant to serial tendering where a firm is bidding for a similar project executed for the same client in the past, at the same or different site location(s).

2.3.2.5 Subcontractors' bids based pricing strategy

If a contractor can guarantee the quality and integrity of his subcontractors, and the ability to adhere to schedule and stay within estimates, subcontractor bids may constitute a huge proportion of the prime contractors bid price. In this case, the contractor may treat these bids as a cost to him and upon which to base his mark-up. Hillebrandt (1985) has emphasised that the more work a contractor subcontracts to others the lower, will be his risk and thus the lower the potential mark-up on the total value of the contract.

2.3.2.6 Cover price

Many reasons prompt a contractor to quote a cover price in competitive tendering. Lack of desirability for a job and lack of time to prepare detailed cost estimating or market studies are some of important reasons.

2.4 Construction pricing model

Individual firms' pricing objectives and perception of the factors influencing the pricing decision will largely determine or dictate the pricing policy to adopt on bid pricing.

Figure 2.2 models the general framework for contractors' pricing strategy. This suggests that the pricing objectives of firms can be broadly categorised into profit maximization and profit satisficing. A firm which adopts "target return on investment" as a pricing objective could be regarded as having satisficing profit rather than maximizing profit (Simon, 1959). Such firms set prices by adding a standard mark-up to costs and are therefore not profit maximizers (Hall and Hitch, 1951). On the other hand, a firm whose pricing objective is sensitive to competition, workload and price consciousness of clients could be regarded as profit maximizer and generally, adopts market oriented pricing policy.

Factors influencing pricing are factors that determine cost estimating and allocations of risk and uncertainty. Largely the profitability of a project, depends on the expected risk and uncertainty involved. A firm that intends to spread risk and uncertainty may settle for sub-contractors' bids based pricing policy. In essence, the sub-contractor's pricing process will be central to the overall pricing process (Flanagan and Norman, 1989).

The procurement system determines the contractual relationship between the client and contractor. The level of confidence a contractor has in this system will determine whether to settle for flexible mark-up or fixed mark-up in relation to cost based

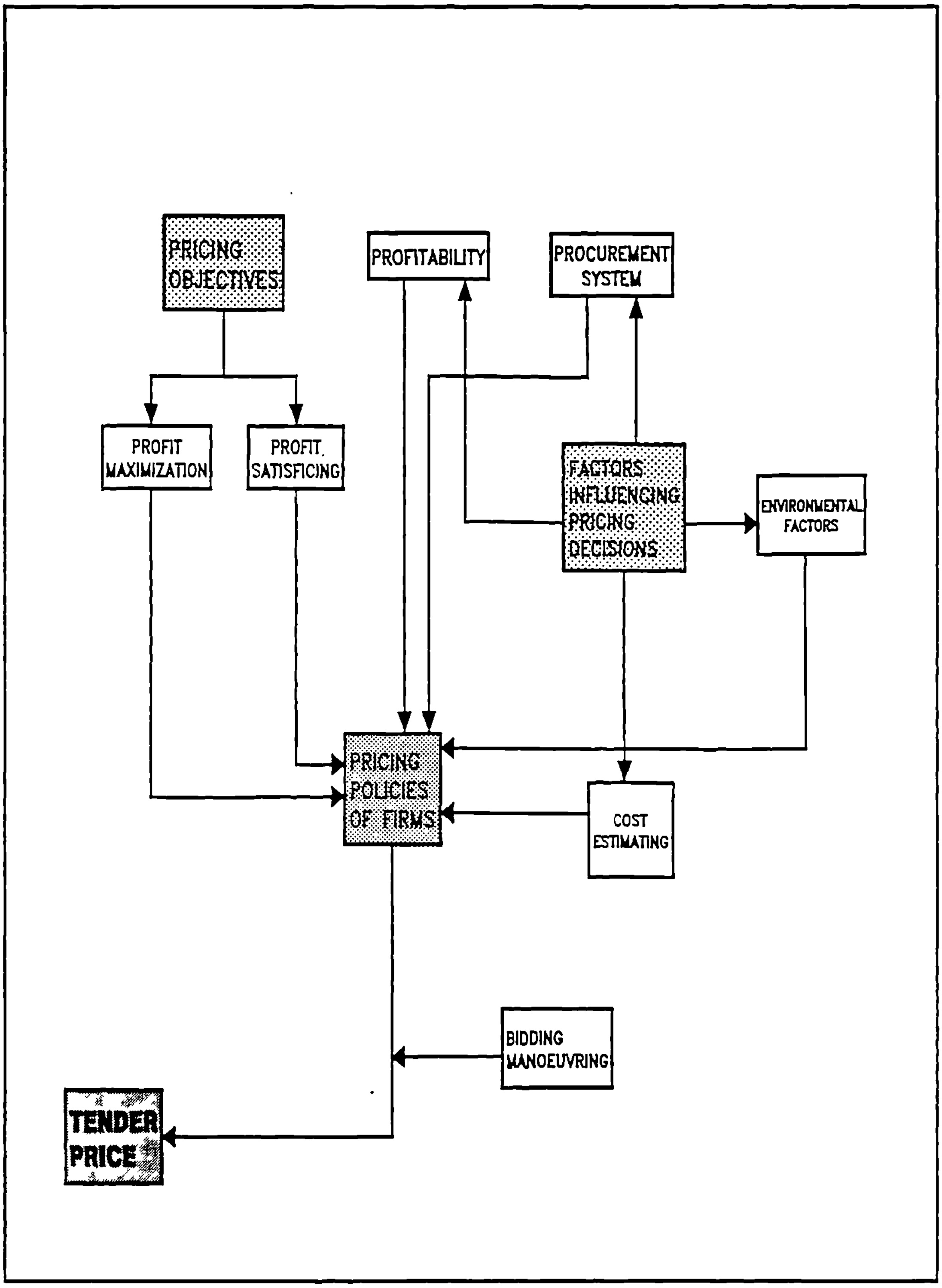

Figure 2.2 General framework for construction pricing strategy

pricing policy. A firm that has least confidence in a contract procurement system may bid based on cover price.

Environmental factors determine the workload of the industry. Turbulent environmental conditions characterised by sluggish construction demand, intense competition, fluctuating interest rate, high corporation tax, harsh government regulation etc, lead to quick changes in firms' pricing policies. In essence, pricing policies are fine tuned to prevailing economic condition, such that a firm can change cost based pricing to market oriented pricing (i.e., that pays more attention to environmental dynamics) in time of economic uncertainty, and when there is a need to break-even or penetrate into a new construction market.

A firm's pricing objective is central to its pricing strategy. The strategy is expected to be flexible and change with the circumstances of a construction project.

2.5 Building price and relationship with tender price

The price at which contracts are awarded in the construction industry is determined based on negotiation or competitive bidding at the extreme. These two extremes according to Flanagan and Norman (1989) include:

1. Contestable monopoly - negotiated tender price with single contractor;
2. Auction with rebid - negotiated competitive tender: two-stage tender; and
3. Sealed bid auction: competitive tender and lump sum bid. The sealed bidding means that all the competitors supply the customer with their terms and conditions in sealed envelopes, which are opened on a fixed date.

In the negotiated contract the client has the option of negotiating the contract price with a contractor. On the other hand, competitive tendering involves more than one contractor bidding for the same contact. The competitive tendering includes open and selective tendering at extremes.

There are always criteria for selecting a contractor to carry out a contract. The most commonly used criteria is price, whether as an acceptable offer or a preliminary offer (McCanlis, 1979). Other criteria are time and concepts related to contractor's reputation such as quality of his work, experience on the type of work, his resources, and so on. The concept of contractors reputation is very important in open tendering, though this is mostly judged subjectively. In selective tendering it is common to award contract to the lowest priced bid as the reputation of the contractors are ascertained during the process of inviting them to bid.

Figure 2.3 shows the concepts of building price on cost-based pricing strategy. Two concepts of building price are exhibited: accepted tender price and final account sum. This figure shows *n* number of contractors competing to win a contract. Only one tenderer is expected to win the contract anyway. It also shows negotiation with one contactor. The accepted tender price, therefore, is determined based on competitive bidding or negotiation. The accepted tender price could, therefore, be regarded as the market price for the contract. Final sum represents the total price of construction to the client on completion of contract. This involves the adjustment of the accepted tender price for variations, escalations, claims and so on. Since the adjustments are priced on the commercial basis, the final account figure cannot be regarded as market price, rather it is a commercial price of construction.

Within the context of this work therefore, building price is the accepted tender price by construction client.

2.6 Relationship between accepted tender price and tender price index

Tender price index reflects the trend in the accepted tender price. The basis for the preparation of the tender price index was reported by Bowley and Corlett (1970). They measured the reliability of the indices using various levels of sampling of the items in Bills of Quantities. The Bowley and Corlett report was initiated in 1963 due to a general concern about the reliability of available building price index series caused partly by the lack of consistency between various published index series and

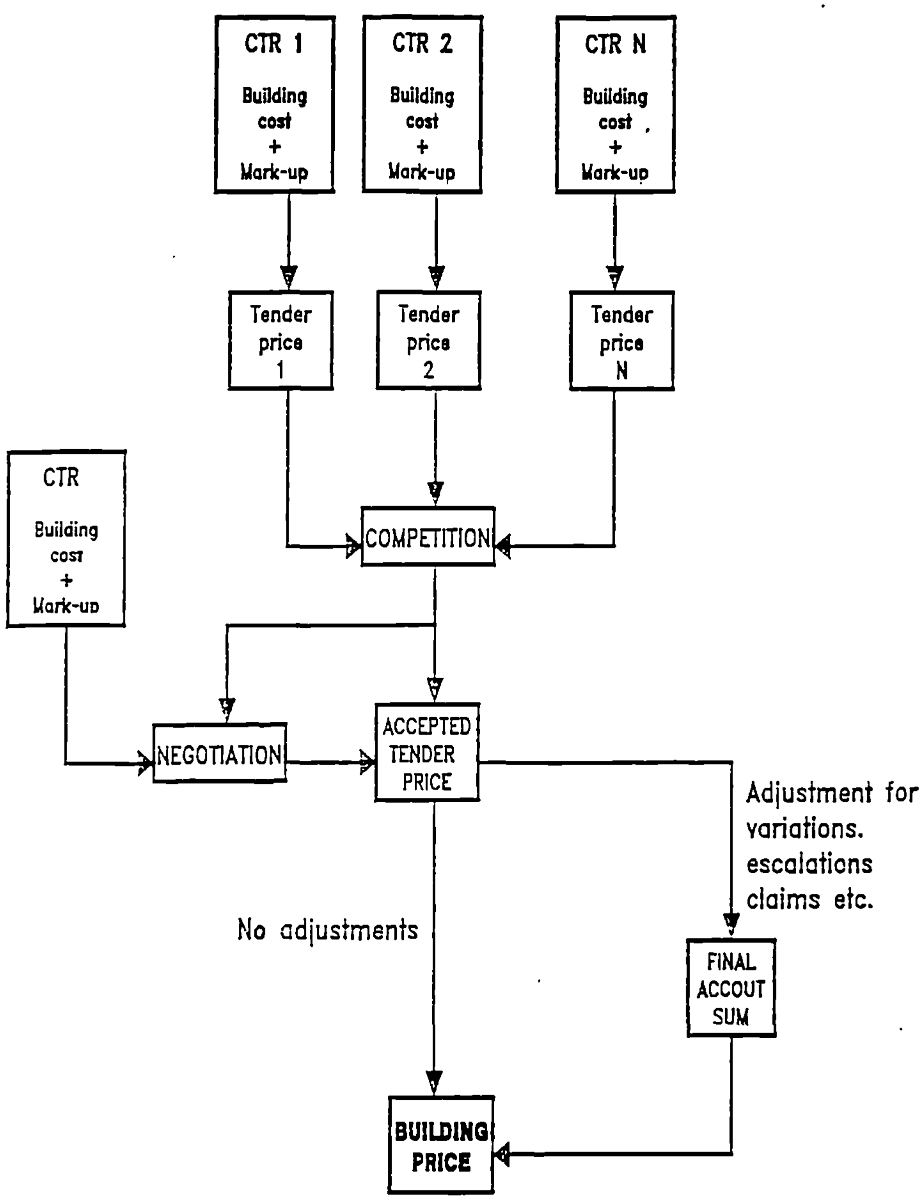

Figure 2.3 Building price determination process

partly by their failure to represent numerically the movement in building prices that members of construction felt through their general experience to have taken place (Jupp, 1971).

The methodology for extraction of tender price index from accepted tender price, which takes after Bowley and Corlett (1970), is currently being used by Building Cost Information Service (BCIS) and Directorate of Building and Quantity Surveying Services of Property Services Agency (PSA). Mitchell (1971) described the basic methodology, which has been summarised by BCIS (BCIS, 1983).

Essentially the BCIS methodology of preparation of tender price index is based on examination and analysis of priced bill of quantities for accepted tenders. Project index is prepared on selected sample of priced bill of quantities by repricing using a base schedule of rates and the 'base' tender figure compared with the actual figure. This is allocated to a quarter by either date of tender as indicated by the bill of quantities or base month of the scheme. The project index is produced by repricing significant items (by selecting items in each trade that represent 25% of the value of work in that trade). The published TPI is an average of several individual project index figures calculated in the manner described above. A sample of 80 bills are needed (that is 80 project indexes) to produce a reliable index.

2.7 Conclusion

In this chapter we have examined the issues involved in pricing policies in the construction industry. A review of pricing policies in the field of commerce was undertaken as a basis for comparison. Aggregating the various factors influencing pricing policies we have been able to produce a diagrammatic model representing the general framework for pricing in the construction industry.

The links between tender prices, accepted tender price and tender price index have also been examined.

The following chapter examines the various tender price indices produced in UK.

AN EVALUATION OF EXISTING CONSTRUCTION TENDER PRICE INDICES

3.1 Introduction

In the last chapter we have examined the link between tender price, accepted tender price and the tender price index. In this chapter we discuss existing construction tender price indices in the UK construction industry. There are a number of published tender price indices, and probably hundreds of unpublished ones. In fact, most quantity surveying consultancy firms find it desirable to prepare their own tender price indices. These at times are related to specific schemes in terms of types of construction, geographical location, method of construction and contractual arrangement.

In this chapter, eight organisations involved in calculation and publishing tender price index are evaluated based on a questionnaire survey and oral interviews. Eight organisations are identified.

3.2 Index Number

Bowley (1926) described index number as a means of measuring some quantity, which cannot be observed directly, but are known to have a definite influence on many other quantities, which can be observed. This influence is known to be concealed by the action of many causes affecting the separate quantities in various ways. The concept of index number, as known today, dates back to 1798. Tysoe (1982) has produced a report on the history of index numbers right from the time of Sir George Schuckburgh Evelyn in 1798 to the current work on the subject.

3.2.1 Use of Index Number

Index numbers show how the average price or the average quantity of a group of items is changing over time. They express the current price or quantity level as a percentage of the level at some reference point in the past taken as 100. If the index number at any other time is 125, this indicates a 25% increase on the base year. In essence, index number provides a measure of trends. When an index number is produced at firm level (such as the trend in individual firm output) it provides some advantages: provides a common means for firms to compare their output levels; provides a basis for a firm to compare its output level with the output level of the industry it belongs; provides baseline to make future projects; etc.

These benefits make index number a useful tool for comparisons and projections which may be necessary for decision making at company and industry level.

The usefulness of index numbers is not limited to measuring changes in price and quantity as expressed above, they are widely used also to express complex economic phenomena such as cost of living, total industrial production and business cycle (Freund and Williams, 1958). This involves a process of combining many prices or quantities in such a way that a single number can be used to indicate over-all changes.

3.2.2 Construction of Index

In constructing an index decisions may have to be made on the following six factors (Freund and Williams, 1969; Tysoe, 1982):

<u>Purpose of the Index</u>

This establishes the used for which the index is intended. This needs to be specified before any attempt is made to construct an index as this statement of the purpose influences other factors involved in construction of index.

Availability of data

The problem of availability of data could create a serious problem years after an index number series has been started. Hence, it is always important to ensure right from the onset that the data will continue to be available in the right format otherwise this may distort future usefulness and reliability of such index number series.

Selection of items to include

In constructing a general purpose index like consumer price index, it is practicable impossible to include all consumer goods. The only feasible alternative is to take samples in such a way that it may reasonably be presumed that the items which are included adequately reflect or indicate the overall picture.

Choice of the base period

In general, the year or period which one wants to compare is called 'given year' or 'given period' while the year or period relative to which comparison is made is called 'base year' or 'base period'. The index number at the base year is always taken as 100. Ideally, in the choice of a base year it is generally desirable to base comparisons on a period of relative economic stability (a period of average steady inflation without any unusual occurrence) as well as a period not too distant in the past. Index based on period of abnormal economic conditions tends to give wrong impression of the phenomenon being observed. When base period is too remote data related to such period could very difficult to collect.

Choice of the Weights

This accounts for significance of individual items in the overall phenomenon that an index is supposed to describe. Choice of the weights, therefore, becomes very important when items being considered in are index are not of equal importance. The weights assigned to the various items must therefore be measures of their relative importance and should be carefully chosen to avoid biased and misleading results.

Methods of Construction

This relates to choice of a number of formulas that described relative changes. These formulas provides index numbers and the choice of particular formula should be based on practical considerations.

The selection of the items and the choice of weights in respect of the construction industry price and cost indices were reported by Bowley and Corlett (1970). The study by Bowley and Corlett recognised that construction price index number based on short-lists of items in Bill of Quantities reflect the trend in prices shown by full-repricing of Bills of Quantities. Though this study did not make any experiment with alternative ways of selecting the number of items to be included in the short-list, however, it recognised that the choice of the same number of items from each trade is clearly not efficient. This study led to construction project price index being produced by repricing selected items in each trade that represent 25% of the value of work in that trade.

3.2.3 Category of Index

Indices can be classified into two: weighted and unweighted index. Under each classification are several methods of computation (see Blackwell, 1979).

Unweighted index numbers

Unweighted index numbers are sometimes called simple aggregative index and are computed using the following formula:

$$I = \frac{\Sigma P_n}{\Sigma P_0}$$

where

P_n = the sum of the given year prices
P_0 = the sum of base year prices
I = the index of given year

A weakness of a simple aggregated index is that it can produce vastly divergent results if the various items and their prices are quoted in different units.

Weighted Index Number

In weighted index the prices in simple aggregate index are assigned with weight which are usually quantities. Two examples of weighted index are Laspeyres and Paasche indices. Neither of these two are affected by changes in the units to which the prices refer as it is the case with simple aggregative index. These are two common systems in use and both assume that the quantities being purchased do not alter with changing prices.

Laspeyres index assumes that people are still buying now the quantities they bought in the base year. Hence, this is commonly called base-weighted price index. This is represented as follows:

$$\text{Base weighted price index} = \frac{\text{Total cost of base-year quantities at current prices}}{\text{Total cost of base-year quantities at base-year prices}}$$

That is:

$$\text{Base-weighted price index} = \frac{\Sigma q_0 p_n}{\Sigma q_0 p_0}$$

Paasche index assumes that people were buying in the base year the same quantities as they are buying now. Hence, this is commonly called current weighted price index. This is represented as follows:

$$\text{Current weighted price index} = \frac{\text{Total cost of current-year quantities at current prices}}{\text{Total cost of current-year quantities at base-year prices}}$$

That is:

$$\text{Current-weighted price index} = \frac{\Sigma q_n p_n}{\Sigma q_n p_0}$$

Where

q_0 = the quantity for the base year
q_n = the quantity for a given year

<u>Ideal and Drobisch Indexes</u>

Developments from Laspeyres and Paasche indices are Ideal Index and Drobisch Index. The development of these indexes is as result of drastic changes between the 'base year' and 'given year' which could provide a wide difference between Laspeyres Index and Paasche Index. This wide difference could make a choice of any of these two indexes unsatisfactory. To solve this problem Ideal Index and Drobisch Index are developed.

Drobisch Index is the arithmetical mean of Laspeyres and Paasche Indexes as follows:

$$\text{Drobisch Index} = \frac{\dfrac{\Sigma q_0 p_n}{\Sigma q_0 p_0} + \dfrac{\Sigma q_n p_n}{\Sigma q_n p_0}}{2} * 100$$

Ideal Index developed by Irving Fisher is the geometric mean of Laspeyres and Paasche Indexes as follows:

$$\text{Ideal Index} = \sqrt{\frac{\Sigma q_0 p_n}{\Sigma q_0 p_0} * \frac{\Sigma q_n p_n}{\Sigma q_n p_0}} * 100$$

Ideal Index is generally preferred because it satisfies mathematical criteria of the time reversal and the factor reversal tests. Although the Ideal Index is theoretically an excellent index, the requirement to up date quantity weight q_n makes it difficult to use for a general purpose index.

3.2.4 Comparison of Laspeyres and Paasche Index

The major advantage of current weighted index over the base weighted is that each item is weighted in accordance with its current importance, and there is therefore no danger of producing a misleading index number through the use of outmoded weights (Carter, 1980). However, base-weighting is sometimes preferred to current weighting for some reasons.

1. There is a close association between price and quantity. A large increase in price is usually associated with a decrease quantity sold, which reduces the effect of price changes in current-weighting. This relationship masks the effect of changes in current weighting. Laspeyres Index, therefore, can generally be expected to overestimate or to have upward bias, while Paasche Index will generally do the exact opposite.

2. Current-weighting is time-consuming and expensive as the index is calculated every time unlike base-weighted index for which calculation is carried out once.

3. Base-weighting makes year to year comparison of index possible. For current-weighting, comparison can only be made with the base year.

3.3 Indices of construction costs and prices

These have been classified into three groups (Fleming, 1986) as follows:

1. Output price indices
2. Tender price indices
3. Cost indices

Output price indices measure the trend in the prices of construction output. These are published on quarterly basis in *Housing and Construction Statistics* by Department of the Environment. They are base-weighted indices.

Cost indices measure the trend in construction input prices. They reflect changes in cost to the construction contractor rather than costs to the construction client. These are published as General Building Cost Index by the Building Cost Information Service and Spon's cost indices on quarterly basis. They are base-weighted indices.

Tender price indices measure the trends in the cost of construction to construction clients. These are published in some technical journals or in-house bulletins. The indices of tender price are generally based on the accepted tender prices. It has been reported by Bowley and Corlett (1970) that a minimum of 80 Bills of Quantities are required quarterly for a reliable tender price index to be prepared on a quarterly basis. This suggests that only few organisations are in a position to meet this requirement. Building Cost Information Service and Directorate of Building and Quantity Surveying of the Property Services Agency (PSA) are two big organisations that manage to meet this requirement. It has been difficult meeting this requirement in recent years because of reduced demand for construction. The tender price indices produced by these two organisations are current weighted.

3.4 Tender price index: Monitoring and forecasting organisations

There are eight organisations responsible for publication of tender price index trends and forecasts. These are arranged alphabetically as follows:

1. Building Cost Information Service (BCIS)
2. Beard Dove Limited
3. Davis Langdon & Everest
4. Gardiner & Theobald
5. Gleeds
6. E. C. Harris
7. Monk Dunstone Associates
8. Directorate of Building and Quantity Surveying Services (PSA)

All these organisations were approached with a structured questionnaire and a request for oral interview. The essence of the oral interview was to confirm the responses to the questionnaires. All these organisations responded to the questionnaire. Four agreed to face-to-face interview and four to telephone interview. The questionnaires were filled (See Appendix 3.1) and oral interviews were carried out with the official responsible for producing information on tender price trends within these organisations.

Except for BCIS and PSA, other organisations are firms of chartered quantity surveyors and construction cost management consultancies. Their headquarters are all in London.

The Building Cost Information Service is a self financing non-profit making organisation, an arm of Royal Institution of Chartered Surveyors - quantity surveying division. Its office is in Surrey.

Directorate of Building and Quantity Surveying Services (PSA) is a public institution responsible for public sector tender prices index. It is an arm of Department of the Environment. It is a unit of Property Service Agency (PSA) Services that is currently under consideration for privatisation. Its office is in Croydon.

3.4.1 Tender price monitoring by these organisations

Table 3.1 provides summary information on these organisations in terms of:

Names of Tender Price index monitoring and forecasting organisations
Starting date of TPI series publication
Frequency of release of tender price index information
Publication references
Bases for the series and other remarks

From the table it is obvious that the oldest TPI producing organisation is the Department of Environment, followed by Building Cost Information Services. This is not accidental. Tender Price Index (TPI) production requires a lot of resources, particularly, a large database which may not be available to private organisations. Being a division of the Department of Environment, the PSA is responsible for the greatest proportion of public sector projects. So also BCIS operates as a collaborative venture for the exchange of building cost information and is based upon the principle of reciprocity, that is, all BCIS subscribers have undertaken to provide data from their resources and, in return, receive the information made available by all. The mode of operation of these two organisations continued to guarantee them acceptable tender price information. The six firms of chartered quantity surveyors do not have this guarantee.

Davis, Langdon and Everest (formerly Davis, Belfield and Everest) started publication of tender price index in 1975 limited to London area. The limitation to London area is not unconnected with the huge resource that is required to cover the whole country. All the other firms of chartered quantity surveyor commenced publication of TPI in late 1980s. This time coincided with the rise in construction activities in the UK. Most of them took the initiative to produce their tender price index as they were dissatisfied with the information produced by BCIS. Apart from this, the published TPI by these organisations are the outcomes of tender price trends that have been informally monitored by them over sometime. These were used to monitor movements in accepted tender price on work type and regional bases within these firms.

Currently three of the firms of chartered quantity surveyors are publishing their tender price index in their firms' 'In-House Bulletin'. These are released to the press on quarterly basis. Lack of availability of appropriate technical journal is responsible for the publication in-house.

The basis of these tender price indices are mainly the accepted tender price. Most of the firms of chartered quantity surveyors lack adequate number of Bills of Quantities. Hence they have to rely on other means of monitoring tender price movements. Gleeds rely on an average of 15 bills of quantities quarterly to produce tender price index. E.C. Harris relies on extrapolation of tender price index produced by PSA, BCIS and D.L.& E. Gardiner & Theobald relies on tender price information and the opinion provided by about 800 construction and specialist contractors that subscribe to the firm on a quarterly basis.

3.4.2 Tender price index forecasting by these organisations

Table 3.2 produces summary of forecasting information in respect of these organisations.

Except BCIS that commenced publication of tender price index forecasts in 1980, the starting dates of commencement of publication of TPI forecasts coincided with the dates that TPI are published for the first time. These forecasts are released four times a year. They are mainly forecasted over 8 quarters ahead. Exception to this are Gardiner & Theobald; Beard Dove Ltd, and PSA that forecast over 4, 5 and 12 quarters ahead respectively.

With the exception of BCIS and Gardiner & Theobald, tender price index is produced based on "Experts' Judgements". Expert judgement is mainly based on provision of specific indicators and survey of construction and specialist contractors. PSA tried both "mechanical" and "statistical" methods in the past that were found to take much time to compile and less accurate. The specific mechanical and statistical methods were not disclosed. BCIS used both the Linear Regression model and judgement. The nature of the model is not divulged though this model uses construction neworders, construction output and building cost index as variables. The firm finds it difficult quantifying in percentage terms the respective contributions of the model and judgement to the published tender price index. Gardiner & Theobald uses Cost Models, which are prepared for different types of construction and different components of building. The specific nature of the models were not disclosed.

Table 3.1 Summary information on Tender price Index producing organisations

	Start Date of publication	Frequency of release	Publication reference	Bases of index and remark
BCIS	1974	Quarterly	BCIS Quarterly Review of Building Prices	Based on accepted tender prices in both public and private sector.
Beard Dove Ltd	1990	Quarterly	New Builder (under the caption "Economic Report")	This has been produced informally for many years; based on accepted tender of contractors. Another index published is civil engineering sector tender index.
D L & E	1975	Quarterly	Architects Journal until July 1989 Currently in Building (under the caption "Cost Forecast")	Based on accepted tender for new work in the London area handled by the firm
Gardiner & Theobald	1988	Quarterly	In House Bulletin. Quarterly Press Release	Based on tender information produced about 800 contractors and specialist contractors that subscribe to this firm
Gleeds	1987	Quarterly	In House Bulletin. Quarterly Press Release	Based on accepted tender for new work handled by the firm in UK. Average of 15 bills are analyzed every quarter
E.C. Harris	1990	Monthly	In house Bulletin. Monthly Press Release	Extrapolation of BCIS, PSA and D.L.& E. quarterly tender price indices
Monk Dunstone Associates	1989	Quarterly	Architects Journal	Has been produced in-house since early 1980s.
PSA	1950	Quarterly	Housing and Construction Statistics	Based on accepted tender price for works in the public sector

3.4.3 Judgemental predictions of Tender Price Index

It is obvious from Table 3.2 that the predictions of tender price indices are predominantly produced based on the judgemental assessment of 'experts' within the respective organisations. These experts do not rely only on their intuition but mainly on perception of other time series information, usual and unusual occurrences in the economy. This information and occurrences may be classified into three major sections: financial variables, non-financial variables and prices. Opinions of the experts responsible for producing and predicting tender price index were sought on variables considered in their forecasts.

Table 3.3 shows the financial, non-financial and price variables considered by these experts in monitoring and forecasting tender price index on organisation basis. Responses of the organisations on factor basis have been summed up to determine factors considered by most of the experts.

The variables that are mostly considered by experts in prediction of tender price index are 'building cost movements' and 'general retail inflation' with scores of 7 points each. These are followed by 'interest rate' and 'construction neworder' with 6 points. 'Construction output', 'general public expenditure' and 'architects commission' scored 5 points each. These are followed by 'sterling exchange rate', 'unemployment level' and 'lagged TPI' with 4 points.

PSA factors are predominantly government and political climate related. This is not surprising as public investment in capital project are predominantly determined by these variables. The organisations that used 'lagged tender price index' are firms of chartered quantity surveyors. This is also not surprising since they rely on historic tender price index published by BCIS and PSA to prepare their forecasts. Some factors have been added to the list under non-financial factors by some organisations.

For example architects appointment advertisements by D.L.& E; merchant sales, housing starts, and contractors' state of trade enquiries by BCIS; views of contractors by Gardiner & Theobald.

Table 3.2 Summary information on Tender price Index forecasting by these organisations

	Date Forecast Issued Regularly	Frequency of release per Year	Typical Forecasting Horizon Quarters	Forecasting Technique)s)	Remarks and Basis for forecasting
BCIS	1980	4	8	Linear Regression Model and Judgement	Model based on research done in 1970s at Loughbourough University by McCaffer et al into computer aided tender price prediction for buildings
Beard Dove Ltd	1990	4	5	Judgement	Based on review of trends in cost information and future market condition. Based on current general economic data.
D L & E	1976	4	8	Judgement	Subjective assessment of in-house 'experts'
Gardiner & Theobald	1988	4	4	Cost Models	Developed standard cost models for different types of construction
Gleeds	1987	4	8	Judgement	Major contractors' prediction of workload based on telephone survey Also based on BCIS predictions
E.C. Harris	1990	4	8	Judgement	Based on review of BCIS predictions plus other organisations forecasts Also based on returns of regional questionnaires and review of macro economic factors.
Monk Dunstone Associates	1989	4	8	Judgement	Based on general economic information (National Westminster Bank Economic Forecast, Barclays Bank forecast, Cambridge Econometrics). - Firm's Regional Directors' survey of contractors workload perceptions. - Study of other Quantity Surveying firms' indices and BCIS historical tender price index
PSA	1950	4	12	Professional Judgement	Claimed to have used mechanical/ statistical methods in the past which were found to take too much time to compile and less accurate.

3.4.4 Importance of Building Cost Movements in TPI monitoring and forecasting

Table 3.3 shows that building cost movements is one of the two factors with 7 points. This shows that this factor is considered by experts in almost all the firms in judgemental prediction of tender price index. This does not indicate the strength of this factor in judgement by experts.

Table 3.4 shows the importance of building cost movements in tender price index forecast. Except Beard Dove Limited that claimed a very high importance, the importance of building cost in tender price index forecast is generally low among the firms. This suggests that factors responsible for construction market conditions play dominant role in the expert's opinion of construction price movements.

3.4.5 Factors responsible for construction market conditions

Opinion of the experts were sought on the factors responsible for the construction market condition. Table 3.5 indicates factors claimed by the experts in each organisation.

Almost all the firms claimed the construction workload (neworders) is responsible for the construction market condition. This can be interpreted that the current and the

expected construction workload have tremendous impact on the tender price movements.

Other factors claimed, which are related to each other are interest rate, state of economy and business confidence. Gleeds specifically claimed 'the industry capacity to respond to construction demand', which can be interpreted as the capacity for construction supply.

Table 3.3 Factors considered in 'Experts' judgement forecasting of Tender Price Index

	Tender price index forecasting organisations								
	1	2	3	4	5	6	7	8	Total
Financial Variables									
Interest rate	*	*	*		*	*	*		6
Money supply							*		1
Sterling exchange rate	*	*	*			*			4
Corporation tax									0
Non Financial Variables									
Construction new-order	*	*	*		*	*	*		6
Construction Output	*	*	*			*	*		5
Construction work stoppage (strike)									0
Architect commission	*	*	*			*	*		5
Unemployment level			*		*	*	*		4
Number of registered construction firms									0
Construction productivity			*					*	2
Gross National Product			*				*	*	3
General public expenditure	*	*	*				*	*	5
Industrial production			*				*		2
Others									
Architects appointment advertisement			*						1
Contractors' state of trade enquiries	*	*							2
Merchant sales	*								1
Housing starts	*								1
View of contractors				*					1
Political climate						*		*	2
Prices									
Lagged tender price index		*	*			*	*		4
All share index									0
Building cost index	*	*	*		*	*	*	*	7
Retail price index (inflation rate)	*	*	*		*	*	*	*	7
Producers price index			*			*			2

1. Building Cost Information Service (BCIS)
2. Beard Dove Limited
3. Davis Langdon & Everest
4. Gardiner & Theobald
5. Gleeds
6. E. C. Harris
7. Monk Dunstone Associates
8. Directorate of Building and Quantity Surveying Services (PSA)

Table 3.4 Importance of Building cost trend in TPI forecast

	Very High	High	Fairly High	Low	Very Low
BCIS				*	
Beard Dove	*				
D.L.& E.				*	
Gardiner & Theobald					*
Gleeds				*	
E.C. Harris			*		
Monk Dunstone				*	
PSA			*		
Total	1	0	2	4	1

Table 3.5 Major factors determining construction market trends

	Factors
BCIS	+ Construction demand
Beard Dove	+ Factors considered by the firm in judgemental forecast of TPI
D.L.& E	+ Interest rate + Construction demand + Business confidence + General retail inflation
Gardiner & Theobald	+ Market competitiveness + Contractors' tendencies to press for claims when bid too low
Gleeds	+ Construction demand + Industry's capacity to respond to construction demand
E.C. Harris	+ Perception of workload in the industry
Monk Dunstone	+ Contractors' workload (percentage of order book filled).
PSA	+ Inflation rate + Political climate + State of economy

3.4.6 Factors responsible for difficulties in monitoring TPI

Different factors responsible for difficulties in forecasting tender price index were suggested by the organisations. These are shown in Table 3.6.

It is difficult to summarize the factors in a concise form. However, it is obvious that the difficulties are mainly related to availability of database and sporadic fluctuation in construction market. The factors claimed in respect of the general economy are part of the factors responsible for unpredictable construction market condition. Also it has remained a difficult task for the industry to model the action and reaction of construction contractors when bidding for contracts to general economic condition.

Table 3.6 Factors identified as responsible for difficulties in forecasting TPI

	Factors
BCIS	+ Reactions of contractors to changes in construction demand + Unpredictable speed to changes in construction demand
Beard Dove	+ Delays in availability of up to date economic data and indices + Unpredictable speed at which changes in market conditions can change tender price levels
D.L.& E	+ Identification of timing of changes in direction of Tender Price Index + Difficulty in forecasting general retail inflation beyond 2 years
Gardiner & Theobald	+ Tendency of contractors to bid at prices below the level of profitability.
Gleeds	+ Lack of accurate historic data of forecast data
E.C. Harris	+ Difficulties in quantifying confidence in the economy, construction industry, pound sterling and government
Monk Dunstone	+ Shocks - global influences, ERM, + Unpredictable government budget causing fluctuating public spendings
PSA	+ Sporadic changes in the construction market condition.

3.5 Conclusions

This chapter examined the concept 'index number'. Two methods of weighted index number were identified as being used in respect of construction cost and price indices: base-weighted and current-weighted. However, tender price indices as produced by UK organisations are current-weighted.

The chapter also examined the various activities of eight organisations responsible for monitoring and forecasting tender price index based on questionnaire, face-to-face oral interview and telephone oral interview.

Having done this one would expect that the indices prepared by these organisations are compared. The difficulties in this are obvious. Five out of the eight organisations commenced publications of tender price movements and forecast within the past four years. The remaining three, BCIS, PSA, and D.L.& E cannot easily be compared because their indices relate to different construction market: BCIS tender price index monitors accepted tender price in both private and public sectors in UK; PSA index monitors accepted tender price for work in public sector; and D.L.& E index monitors accepted tender for new work in the London area handled by the firm.

From the analysis of the questionnaire and the oral interviews it has become clear that the construction industry lack adequate models for tender price forecasting. Forecasts of tender price movements are predominantly judgemental. Factors considered by the experts in their judgements are building cost trends, general retail inflation, construction neworder and output, general public expenditure, architects' commission, unemployment, sterling exchange rate and lagged tender price index.

Contrary to expectations from chapter two, the experts' opinion of the influence of building cost trends on tender price movements is low. Experts' opinion of factors responsible for tender price movements relate to those determining construction market trends. Difficulties encountered by experts in forecasting construction price movements were identified and was dominated by lack of appropriate database and sporadic fluctuation in the construction market conditions.

The Building Cost information Service tender price index, as earlier mentioned, is based on accepted tender prices in both public and private sectors of UK economy. This index represents the widest construction market condition of the UK construction market and it gives us more confidence on the competitive situation in the industry than any other tender price index. For these reasons the index will be further analyzed in this research work. The following chapter analyses the movements in this index.

CHAPTER 4

Movements in the Tender Price Index

MOVEMENTS IN THE TENDER PRICE INDEX

4.1 Introduction

This chapter analyses the general movements in the UK tender price index within the framework of tender price indices identified in chapter 4. In order to do this it is obvious that explanation of movements in this index would involve a look into its secular movement, cyclical behaviour, volatility and its general behaviour within the context of the trade cycle of the whole economy. This chapter, first reviews the relevant literature and offers explanations for movements in the UK tender price levels.

4.2 Time Trends

"Trends can be thought of as 'time vector' or even as time trajectories. What this means is that trends describe a dynamic, moving, energetic chain of events. A trend has momentum. And like a car rolling effortlessly down a hill, that momentum will take it only as far as circumstances permit. .... Determining trends therefore requires that we know a little about the trend history, its momentum, and the terrain within which it operates (Kurtzman, 1984)." This brief explanation of the term 'trend' by Kurtzman describes trends in both non-quantitative and non-qualitative terms. He also highlights issues involved in trend analysis and its implication for predicting the future based on historical trends.

The secular movement or trend of an economic time series is the long-run underlying movement of the series. The trend ignores the shorter cyclical run, seasonal, and irregular variations in a series in order to focus on its behaviour over the long run.

It is customary to characterise a time series Y_t as the sum of a non-stationary trend component and a stationary cycle component (Rappoport and Reichlin, 1989). The trend variable can be expressed in a monotonic form (i.e., may always increase or always decrease) or fluctuating (Christ, 1966). The simplest monotonic trend is a linear function of time, denoted by T, described as follows:

$$Y^T_t = \delta_{0t} + \delta_{1t} T \qquad \text{Eqn. 4.1}$$

This simply joins adjacent observations by straight line to form its graph.

Other forms of trends apart from the linear function of time includes the quadratic trends. A quadratic trend function could be described as shown in equation 4.2

$$Y^T_t = \delta_{0t} + \delta_{1t} T + \delta_{2t} T^2 \qquad \text{Eqn. 4.2}$$

The rate of change of the equation 4.2 with respect to T is represented by equation 4.3.

$$\frac{Dy}{Dt} = \delta_{1t} + 2\delta_{2t} T \qquad \text{Eqn 4.3}$$

Figure 4.1 shows the illustrative graphs of the linear and quadratic trends which, depend on the values of δ_{2t} in equation 4.3, that is $\delta_{2t} = 0$; $\delta_{2t} < 0$; and $\delta_{2t} > 0$, irrespective of the value of δ_{1t}.

4.2.1 Trends and Growth Rates in Tender Price Index

Figure 4.2 shows the seasonally adjusted TPI plotted against time, and quadratic and linear trends. A visual inspection of the quadratic trend and linear trend compared with the seasonally adjusted TPI show that the linear trend is a better fit. Hence, estimated trend values are obtained by regressing the natural logarithms of the seasonally adjusted actual TPI (actual values) on the fourth order polynomial in time.

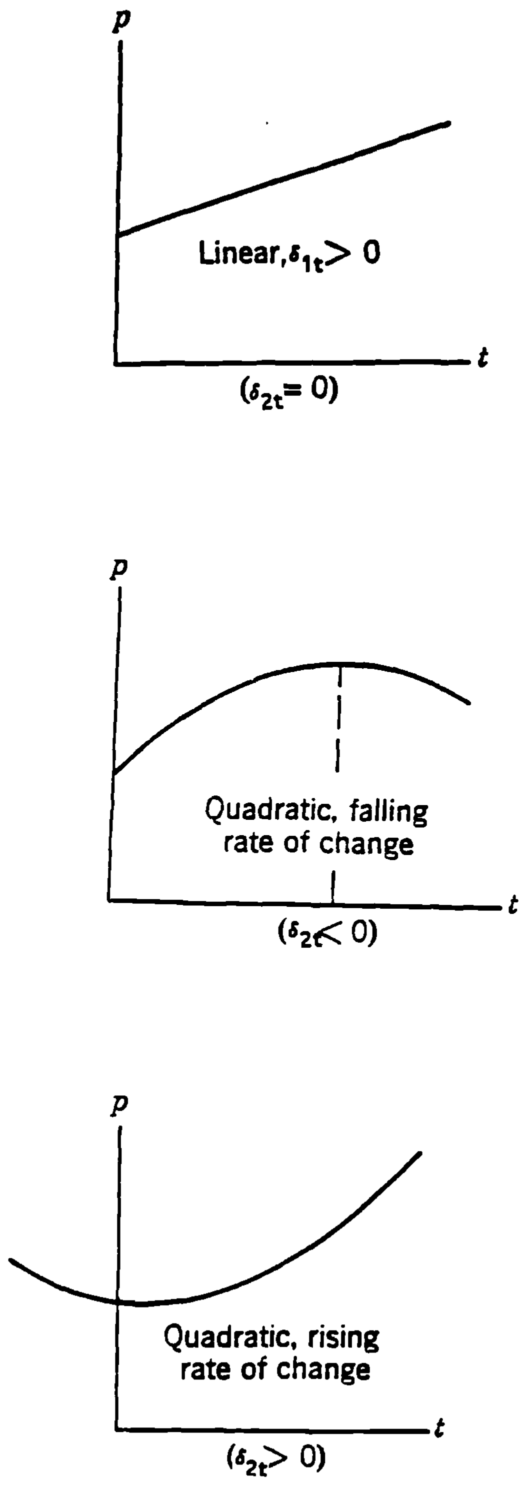

Figure 4.1 Linear and quadratic trends

Adapted from Christ, F.C., 1966, *Econometric Models and Methods*, London: John Wileys & Sons, pp. 171.

The order of each polynomial is set as four to allow for changes in trend due to the four trade cycles that occurred in UK from 1974 through 1990 (CSO, 1990b).

Equation 4.4 is the model of the regression and equation 4.5 the estimated equation using the least square regression analysis.

$$Ln\, Y^T_t = \delta_{0t} + \delta_{1t} T + U_i \qquad \text{Eqn. 4.4}$$

$$Ln\, Y^T_t = 4.652 + 0.073\, T + U_i \qquad \text{Eqn. 4.5}$$

Where

Y^T_t = Estimated Trend value
U_i = Residual

The growth rates are also calculated from the estimated trends. Each growth rate is calculated as the difference in estimated natural logarithms of the trend level.

$$\text{Trend Growth Rate} = \frac{Y^T_t - Y^T_{t-1}}{Y^T_{t-1}} \times 100 \text{ Per Cent} \qquad \text{Eqn. 4.6}$$

Figure 4.3 is the steady upward trend of the tender price index which, shows the actual levels and the estimated trend levels. Table 4.1 contains the calculated growth rate of the trend values of the tender price index. The period has been classified into three "sub-periods" in line with the beginning of the major trade cycle in UK, that is 1974-79, 1980-85 and 1986-90. The growth rate of TPI was high in 1974-79, only to decline in 1980-85, and pick-up again in 1986-90. The decline growth rate of 1980-85 could be explained by the sporadic high or overheated tender price indexes in second and third quarter of 1980 that was followed by a period declining TPI growth rate. The over all growth rate (1974-90) was 1.85 per cent.

Table 4.1 also compares the growth rate of the TPI with some variables. The overall trend growth rate of Building Cost Index (BCI=2.37) is higher than TPI without any

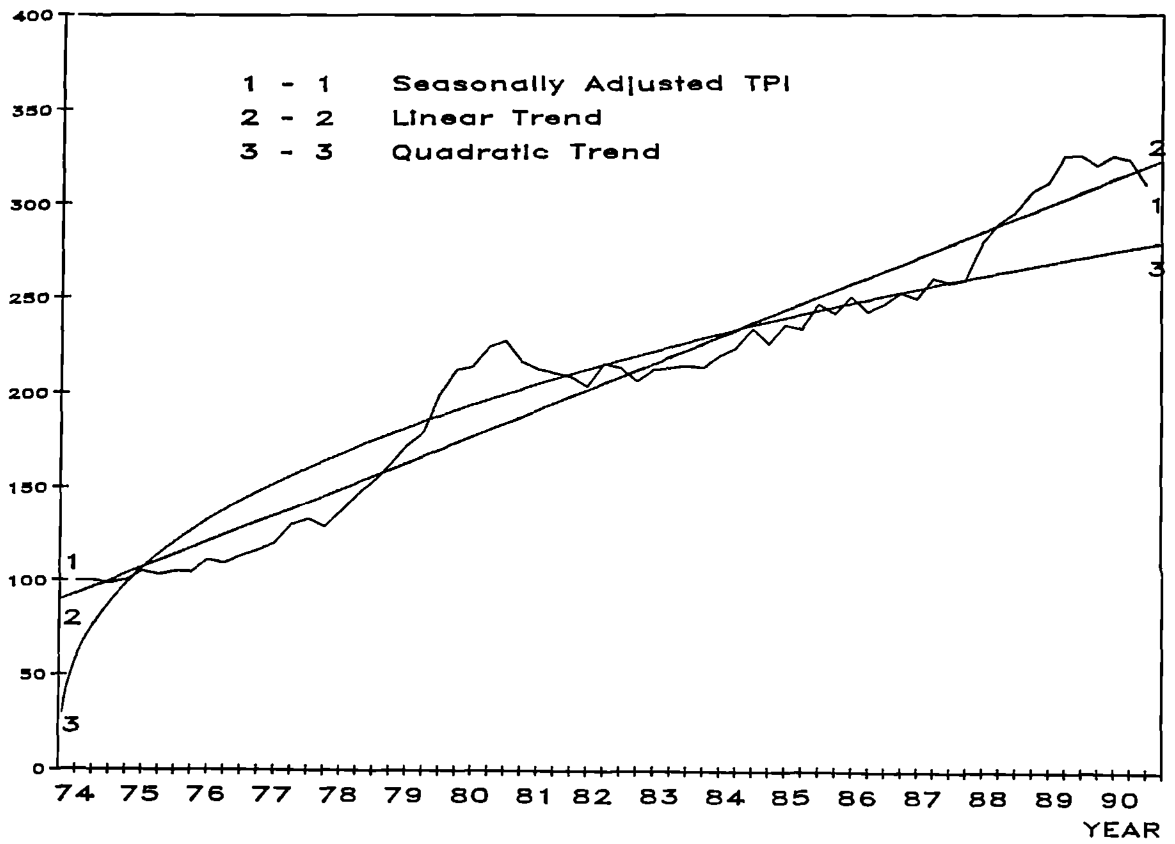

Figure 4.2 Comparison of linear and quadratic trends in TPI

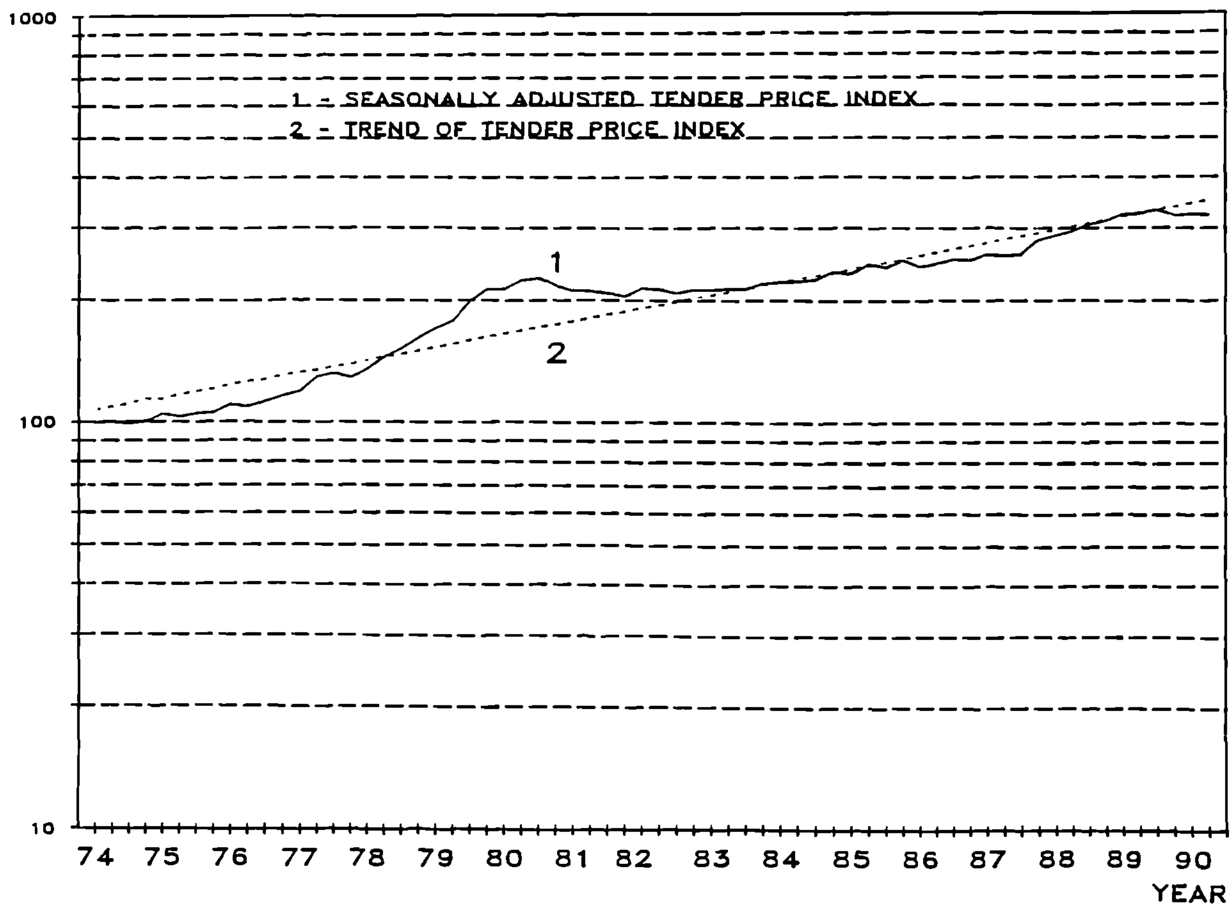

Figure 4.3 Actual and trend levels of the UK Tender Price Index

similar pattern across the three periods. The period 1980-85 produced a higher trend growth rate of BCI compared to TPI while the period 1986-90 produced higher trend growth rate of TPI than BCI. The Retail Price Index-Non Food (RPI) has a similar trend growth rate with BCI in all respect. The Construction Neworder (ORD) has a higher overall trend growth rate than TPI with unrelated movement except for the period 1986-90.

The Table indicates that the movements of TPI during the "sub-periods" and the period 1974-90 were closely related to movements in Unemployment (EMP), Gross National Product (GNP) and Construction Output (PUT), all seasonally adjusted. Rising GNP generally results in more demand and the need to produce more output. In the short run, when the output cannot meet up with the demand the tendency is for the price to increase. Hence, this close relationship is not surprising.

Table 4.1 Trend Growth Rates in Selected variable (averages of quarterly percentage changes)

Variable	1974-79	1980-85	1986-90	1974-90
TPI	3.21	0.54	1.92	1.85
BCI	3.73	1.82	1.53	2.37
WKL	2.61	2.29	2.97	2.51
GNP	4.22	2.20	2.38	2.82
EMP	3.88	3.23	-4.73	1.85
PUT	3.21	1.32	3.56	2.45
RPI	3.63	1.78	1.60	2.32

4.3 The Cyclical behaviour of the Tender Price Index

4.3.1 Economic cycle

Economic cycle is an irregular path or fluctuations in economic trends. These short-term fluctuations are commonly known as trade cycles (in UK) or business cycles (in USA) (Lipsey, 1989). The general consensus among economists, despite that there is not a single cause governing trade cycle, is that the business fluctuation (cycle) is primarily attributable to aggregate demand shocks in GDP and secondarily to the aggregate supply shocks. The aggregate demand shock is a function of investment changes. A major shift in the determinants of investment is expected to bring about a fluctuation in business.

4.3.2 Cycle: Definition and Measurement

Cyclical movement of an economic time series is recurring variations related to fluctuations in general economic activity. Cyclical behaviour of a series excludes the trend movements in a series such that the shorter run variations can be identified. The cyclical component, therefore, consists of the fluctuation around the trend. The percentage deviations of the actual levels (seasonally adjusted values) from the estimated trend levels are used to represent the cyclical behaviour of economic time series. Specifically, the residuals obtained from each trend estimation procedure are assumed to constitute the cyclical movement of the variable.

Barro (1978), Sargent (1978), Taylor (1979), Hall (1980), and Kydland and Prescott (1980) regard residuals from fitted linear or quadratic time trends as the relevant data for cyclical analysis. However, current interest in this area is controversial. Granger and Engle (1987) have suggested the practice of treating time series as cyclical fluctuation around a deterministic trend is misrepresentative and that time series trend is stochasticly exemplified by the random walk. That is, though, it exhibits secular movement, it does not follow a deterministic path (Nelson and Plosser, (1982).

With the same view, Hylleberg and Mizon (1989) have classified the trend into two categories: deterministic (e.g., a polynomial in time) and stochastic (e.g., random walk).

This view tends to suggest that if the trends (secular movement) in economic time series comprise both the deterministic and stochastic element then the economic activity cycle cannot be purely deterministic. Accordingly, Nelson and Plosser (1982) concluded that, if the secular movement in macroeconomic time series is of a stochastic rather than deterministic nature, then models based on time trend residuals are not well specified. In essence, the cyclical movement in economic time series can also be said to contain an element of random walk.

The view on the random walk is based on the premises that random shock has a permanent effect on the economy apart from the effect of the deterministic trend. It is, however, worth mentioning that this body of theory is still at developmental stage.

4.3.3 Types of cycles in economic activities

Three major types of cycle are noticeable in relation to UK economic activities. These are identified as follows (Lipsey, 1989):

1. Nine-year cycle: This is usually identified as the trade cycle and has a duration of nine years from peak to peak.
2. 18 to 40 months cycle: This lasts anywhere between this period and is sometimes associated with variation in shocks
3. 50 year cycle: This is a very long cycle of about 50 years' duration and this is often associated with, among other things, major fluctuations of investment activity following from some fundamental innovation.

These types of cycle are relevant to a free market economy. However, over the years, the different cycle durations have varied tremendously due to economic shocks which, affected general demand. For example, the unexpected Arab Oil embargo of 1974 with the concurrent increase in the price of crude oil brought a premature recession in most industrialized countries. Appendix 4.1 presents glossary on cycle.

4.3.4 Tender Price Index cyclical movements

This work has adopted the deterministic structure in secular movements in TPI in the attempt to explain the cyclical movements in the UK TPI for two reasons. The view on co-integration of macroeconomic time series is an expanding field (Granger and Engle) and has not been accepted by most economists. On the other hand, the deterministic trend structure has consistently been adopted as an approach to cyclical indicators for the UK economy. Choosing the deterministic approach provides a common basis to compare the cyclical movement of TPI with the cyclical indicators for the UK economy.

Equation 4.7 indicates the basis for the estimation of the cyclical movements of TPI and other variables selected for this cyclical analysis.

$$\text{Cyclical movement} = (U_i \,/\, Y^T{}_t) \times 100 \text{ Per cent} \qquad \text{Eqn 4.7}$$

Where

U_i = Residuals based on Equation 4.4
$Y^T{}_t$ = Estimated Trend value

Figure 4.4 shows the estimated cyclical movements of TPI in comparison with BCI. The Figure shows that the cyclical movement of the TPI is lead by the general trade cycle. The cyclical peak of TPI generally occurred 4 to 5 quarters after the peak in business activity, i.e., just before the business activity trough. The Figure shows that the TPI cyclical trough occurred during the recovery period of business activity. The result of cyclical movement in BCI, apart from the fact that it peaks up with TPI

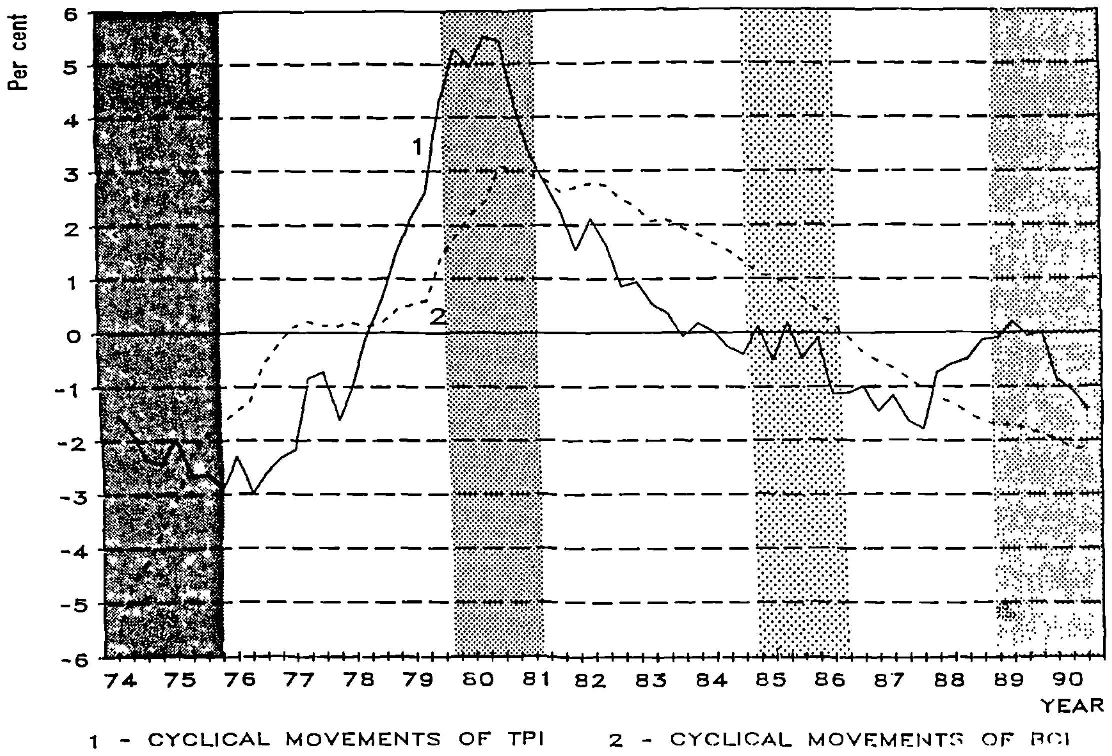

Figure 4.4 Estimated Cyclical Movements of the UK Tender Price Index

cyclical movement in 1979-81 recession is inconclusive in comparison with TPI or general trade cycle cyclical movements.

4.4 Volatility of Tender Price Index

Becketti and Sellon, Jr. (1989) have classified volatility into two categories: normal and jump volatility. The normal volatility refers to the ordinary variability, that is, the ordinary ups and downs in variables rate of change. Jump volatility, on the other hand, refers to occasional and sudden extreme changes in a variable. Some volatility in the tender price index could reflect a normal part of allocating construction resources among competing uses. Extreme or excessive volatility in the tender price may be detrimental, however, because such volatility may impair the investment in construction and adversely affect the performance of the industry. Extreme volatility in construction price may create uncertainty about the future profits of the industry.

Stiltner and Barton (1990) have measured the volatility of economic variables using normal mean and absolute value mean of the quarter-to-quarter per cent changes in the variables. On the other hand, Becketti and Sellon, Jr. (1989) prefer to use the standard deviation of the mean of quarter-to-quarter percentage changes. The analysis of the TPI volatility adopts these two approaches concurrently.

Table 4.2 contains the data analysis needed for the two approaches for measuring the volatility of TPI and some selected variables using quarterly data for the period 1974-1989. Figures 4.5 and 4.6 contain the trends in the volatility of TPI and BCI. From the Table all the selected variables have larger standard deviations than TPI which shows that they are more volatile than TPI except for GNP, BCI and MAN (manufacturing profitability). The Figures shows that TPI and BCI have differential volatility which, is more noticeable between 1978 and 1982. Visual inspection volatility in TPI (shown in Figure 4.5) between 1982 and 1987 which, shows up and down fluctuations could be regarded as normal volatility. However, periods 1978-1982 and 1987-1989 show wide volatility in TPI which, could be regarded as jump volatility. These two periods coincided with changes in UK trade cycle and period 1978-1982 is particularly coincided with the general oil crisis of 1979 which, could have affected the TPI movements.

Table 4.2 Volatility of TPI and other selected variables quarter-to-quarter per cent changes (1974-1989)

Variables	Minimum	Maximum	Mean Normal	Std. Dev	Mean Absolute	Std. Dev.
TPI	-4.85	11.17	2.00	3.38	3.19	2.29
BCI	0.25	8.56	2.69	1.89	2.69	1.89
ORD	-30.18	36.09	3.28	11.51	9.10	7.76
GNP	0.40	7.83	3.19	1.56	3.19	1.56
EMP	-9.18	22.45	2.41	7.74	6.28	5.13
PUT	-7.70	16.94	2.84	5.16	4.80	3.41
RPI	-10.33	25.68	2.64	3.93	3.00	3.66
MAN	-2.70	3.27	0.15	1.29	1.03	0.79

4.5 Behaviour of TPI-Inflation: 1974 to 1990

The evaluation of quarter-to-quarter volatility of Tender Price Index shows high variability which obscure some characteristics of tender price index inflation. On the other hand, measuring TPI yearly results in less variability in TPI inflation because it averages the quarterly growth rate for the four intervening quarters. Such averaging can also eliminate important characteristics and introduce spurious results For example, TPI was 212 in 1982:4 and 219 in 1983:4, however this index was 213 in 1983:1. Thus tender price levels increased by 0.47 per cent from 1982:4 to 1983:1, or at a compounded annual rate of 5.64 per cent. From 1982:4 to 1983:4, the tender price levels rose by 3.3 per cent. The compounded annual rate of 5.64 per cent is far greater than annual increase of 3.3 per cent.

A measure of growth in variable that strikes a balance between these two approaches is provided by Moore and Kaish (1983) Niemira (1984), Moore (1986). This is described by equation 4.8 below:

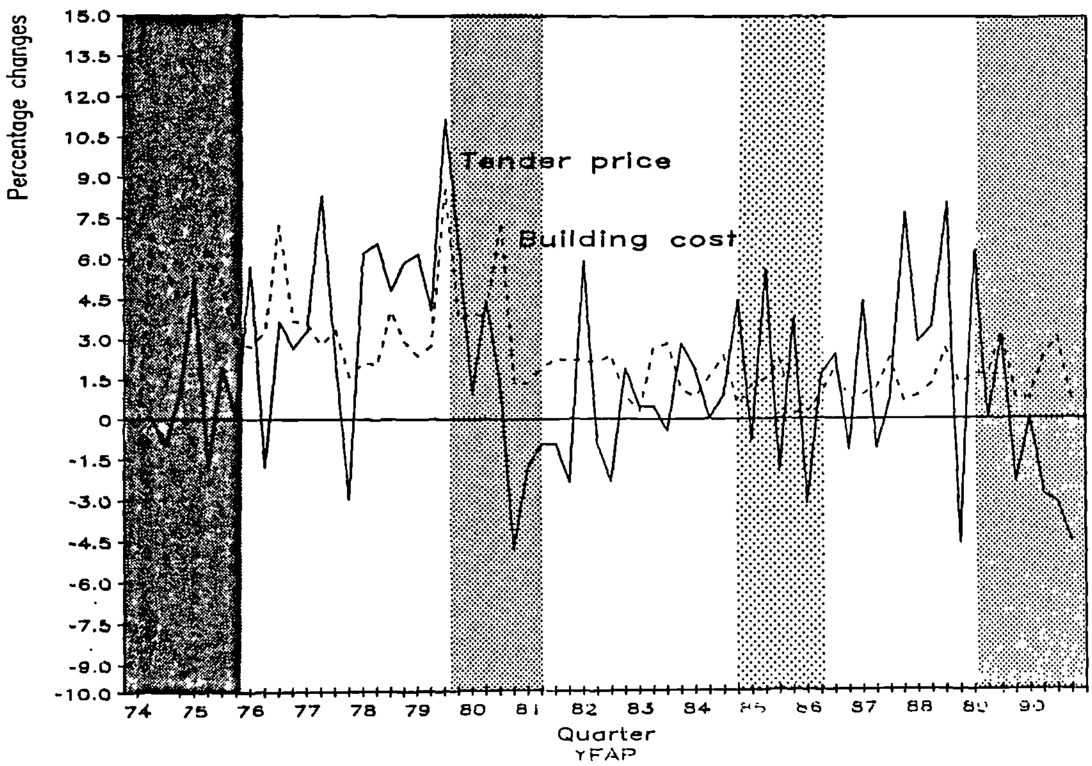

Figure 4.5 Quarter-to-quarter percentage changes (volatility) of TPI and BCI

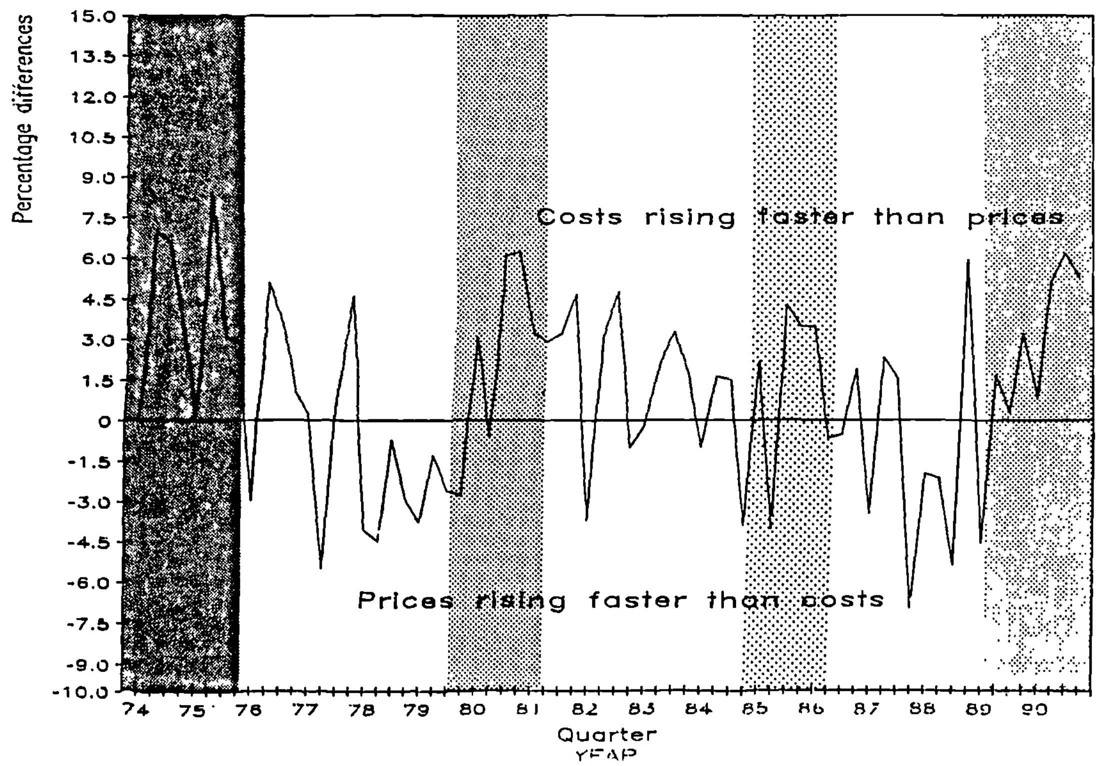

Figure 4.6 Difference in quarter-to-quarter volatility between TPI and BCI

$$TPI\text{-}INF_t = [(TPI_t / [\sum_{i=1}^{4} TPI_{t-i} / 4])^{(4/2)} - 1.0] \times 100 \qquad \text{Eqn. 4.8}$$

Where

$TPI\text{-}INF_t$ = Tender price inflation or growth at time t (in per cent)
TPI = Tender price index at time t
i = quarters

Equation 4.8 measures growth of TPI for a given quarter from its average value in the preceding 4 quarters. This measure is less variable than the quarter to quarter and yet does not alter characteristics of variable of interest (Moore, 1986). This equation is adopted in measuring the growth rate of BCI for comparison with TPI growth rate.

Figure 4.7 is the TPI inflation from 1974 to 1990. The TPI inflation scenario described six month smoothed annualized changes in Tender Price Index, similar in meaning to general inflationary rate derived from the Consumer Price Index. Tender prices rose over most of this period, with an average annual rate of 10.01 per cent (standard deviation=11.44) compared with BCI inflation with an average annual rate of 14.39 per cent (standard deviation=8.3). The rate of TPI inflation varied considerably, ranging from 42.8 per cent in 1979:3 to -8.7 per cent in 1981:2. This fall in TPI between 1980:2 to 1981:4 (1980:2=-2.9; 1981:1=-7.4; 1981:2=-8.7; 1981:3=-7.5; 1981:4=-7.9) could be explained by the overheating in TPI between 1978:4 to 1980:1 (1978:4=31.5; 1979:1=32.4, 1979:2=27.9; 1979:3=42.8; 1979:4=41.9; 1980:1=26.2). The rate of BCI inflation varied from 32.3 per cent in 1974:2 to 3.7 per cent in 1986:2. The period 1974:1 to 1976:4 was associated with high BCI inflation (average=26.6 per cent) compared with low TPI inflation (average=7.55 per cent). Apart from the two periods, 1974:1-1977:1 and 1980:3-1983:4, the TPI inflation was generally ahead of BCI inflation.

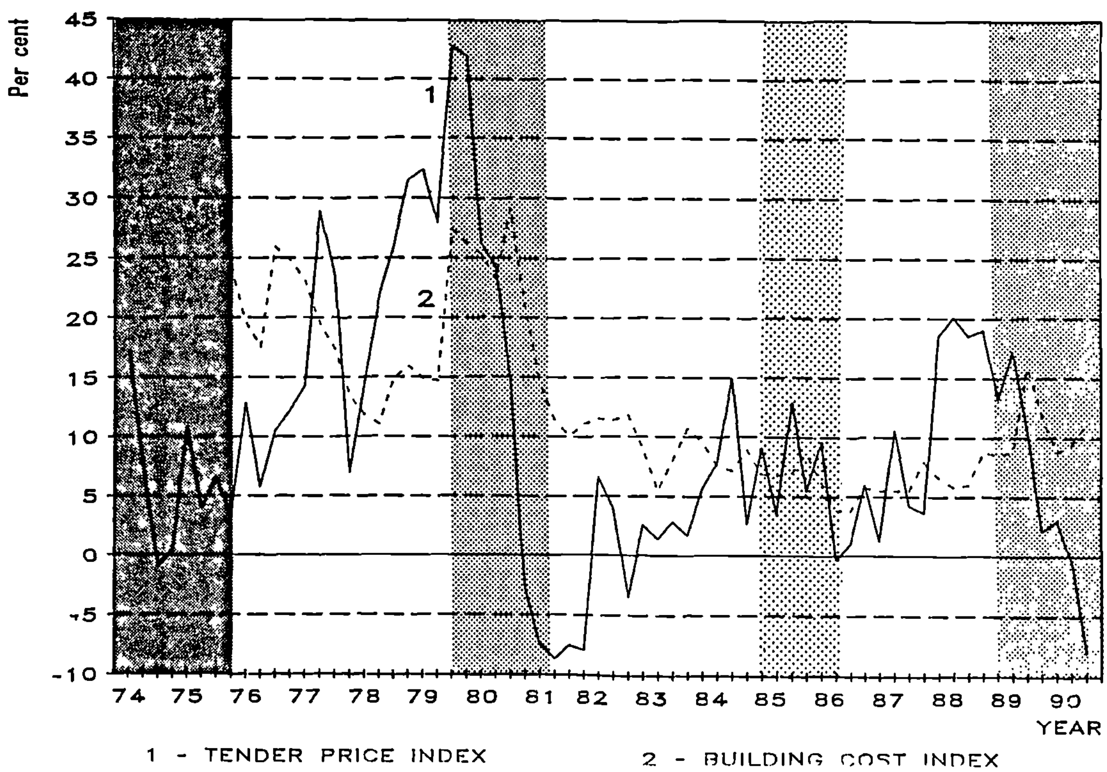

Figure 4.7 Growth rate of TPI and BCI (six-month smoothed rate, annualized)

The figure tends to suggest that recession slows down tender price inflation. During 3 out of the 4 recessions (recessions are temporary depression in economic activity and these periods are represented by shaded areas on Figure 4.7), TPI inflation was lower at the end of the recessions than at the beginning. Not only was TPI inflation lower at the end of the recessions, the rate of TPI inflation picked up immediately after business had started to recover. The only exception to this was May 1973-August 1975 recession which, showed that the TPI-inflation picked up during the recession.

A contrary trend was shown with respect to BCI inflation which, failed to decline until almost the end of the recessions. In all the cases, the rate of BCI-inflation continued to fall even into the recovery period. The fall in BCI-inflation which started in the recession of May 1979- November 1980 continued into another recession of January

1985-August 1986.

The figure also tends to suggest that expansions (trough to peak or recovery period) fuel TPI-inflation as this was higher at the end (peak) of expansion that at the beginning (trough). This is inconclusive with respect to BCI-inflation as this was higher at the beginning than at the end in 2 out of the 3 expansions.

Tables 4.3 and 4.4 show the TPI-inflation and BCI-inflation peaks and troughs marked in Figure 4.7 respectively. Table 4.3 shows that the expansionary phases of TPI-inflation lasted 10.75 quarters (two to three years), on average, during which the TPI-inflation rate rose an average of 27.5 percentage points. Contractionary phases (during recession) of TPI-inflation were shorter, lasting 6.33 quarters with the rate of TPI-inflation declining 29.7 percentage points. In contrast, as shown in Table 4.4 BCI-inflation has almost equal expansionary phases lasting 11 quarters, on average, but with TPI-inflation the rate rose to a smaller percentage points (15.2 percentage points on average). However the contractionary phases of BCI-inflation were longer (lasting 20 months, on average), though the rate of BCI-inflation was less (declined 23.35 percentage points, on average).

In all respects, based on the regular pattern of TPI-inflation shown in Figure 4.7 supported by Table 4.3 the analysis tends to support the view that the UK TPI-inflation is to some extent related to the UK trade cycle. However, this trend is inconclusive with respect to BCI-inflation.

4.6 Conclusion

In this chapter, we have examined the behaviour of TPI in terms of trends, cyclical movements, volatility and annualized growth rate. The trends in TPI have been generally increasing with a growth rate of 3.21 per cent between 1974 and 1990. However, disaggregated analysis, by dividing this period into three sub-periods, that is, 1974-1979, 1980-1985, and 1986-1990, shows that 1980-1985 has a lower trend growth rate of 0.54 compared to the other two sub-periods. This has been explained

Table 4.3 TPI inflation turning points, 1974 to 1990

	Trough(T)		Peak(P)		Change in TPI Inflation During		Duration in quarters of	
t	Quarter (Q)	Inflation Rate(R)	Quarter (Q)	Inflation Rate(R)	Expansion	Preceding Contraction	Expansion	Preceding Contraction
1	1974:3	-1.0	1977:2	28.9	29.9	-	12	-
2	1977:4	6.9	1979:3	42.8	35.9	-22.0	8	3
3	1981:2	-8.7	1984:2	15.0	23.7	-51.5	15	8
4	1986:1	-0.4	1988:1	20.1	20.5	-15.4	8	8
	Average				27.5	-29.6	10.75	6.3

Expansion change rate = $PR_t - TR_t$
Preceding contraction change rate = $TR_{t+1} - PR_t$
Expansion Duration = TQ_t to PQ_t
Preceding contraction duration = PQ_t to TQ_{t+1}

Table 4.4 BCI inflation turning points, 1974 to 1990

	Trough(T)		Peak(P)		Change in TPI Inflation During		Duration in quarters of	
t	Quarter (Q)	Inflation Rate	Quarter (Q)	Inflation Rate	Expansion	Preceding Contraction	Expansion	Preceding Contraction
1			1974:3	32.3				
2	1978:2	11.0	1980:3	29.1	18.1	-21.3	10	16
3	1986:2	3.7	1989:2	15.9	12.3	-25.4	12	24
	Average				15.2	-23.35	11	20

by the sudden rise in TPI in 1980 probably due to the change in UK trade cycle and the oil crisis that are coincidental to this period followed by a period of cooling down in the following quarters. The cyclical movement analysis suggests that this is lead by the UK trade cycle and follows the same cyclical movements in GNP and unemployment.

Unexpectedly, TPI is less volatile than either construction neworder and construction output, although it is more volatile than GNP and Building Cost Index volatility.

The annualized growth rate analysis of TPI suggests that it is very close to the UK trade cycle. This corroborates the results from cyclical movements analysis. It has also been shown that recession slows down tender price inflation. The expansion phases of TPI lasted 10.75 quarters, on average, during which TPI inflation rate rose an average of 27.5 per cent points. The contractionary phases were shorter, on average, lasting 6.33 quarters with the rate of TPI-inflation declining 29.7 per cent points.

This analysis on the movement of TPI compared some selected variables movement with TPI. In the following chapter we shall examine these variables into some depth with other variables to establish the indicators of these movements in TPI.

CHAPTER 5

Leading Indicators of Tender Price Index

LEADING INDICATORS OF TENDER PRICE INDEX

5.1 Introduction

An 'indicator' makes known, shows the sign of or presence of another thing(s) (Oxford Dictionary).

The most promising traditional approach to the forecasting of cycles and their turning points is by leading indicators (Hoptroff et al, 1991). A leading indicator *y* for a cyclical series *x* is another variable whose own cyclical pattern is observed to precede that of *x* by a reasonably constant time interval.

This chapter describes the cyclical indicators for the UK economy and undertakes, through experimental approach, to identify indicators of TPI. Since the theme of the chapter is to identify the leading indicators of TPI, another "horse race" experiment is undertaken to analyze the predictive ability of the variables.

5.2 Category of Indicators

The indicators of economic activities can be categorised into three types: leading indicators, coincidental indicators, and lagging indicators all of which are distinguished by their cyclical timing. Regarding trade cycle, an economic time series is a "leading indicator" if historically it reached its cyclical peaks and troughs earlier than the corresponding turning points in a trade cycle. An indicator is "coincidental" if such series historically reached its turning points about the same time as the general trade cycle. The "lagging indicators" historically reached their peaks and trough after the corresponding trade cycle turning points.

The UK economic time series have been identified and developed into composite indices, which are categorised into longer leading, shorter leading, coincident and lagging cyclical indicators of the general economy (CSO, 1990b). Figure 5.1 shows the graphical illustration of these composite indicators displayed by their average lags. The indicator forming each group of the composite indicators has been chosen because they have had a consistent timing relationship to the historical reference chronology, and because there is an economic rationale to account for this relationship (CSO, 1990b). The time series included in the composite indicators are as follows:

Composite longer leading indicators

This composite series typically leads over GDP by 12 months. This is composed of:
Financial surplus/deficit: industrial and commercial companies, divided by GDP deflator (£m);
CBI quarterly survey: change in optimism (percentage balance);
Financial Times - Actuaries 500 share index; Rate of interest - 3 months prime bank bills; and
Total dwellings started, Great Britain (Thousands).

Composite shorter leading indicator

This leads GDP by about 4 months. This comprises:
Consumer credit: change in total borrowing outstanding (£m);
Gross trading profits of companies, excluding stock appreciation and mineral oil and natural gas extraction, divided by GDP deflator (£m);
New car registration (Thousands):
CBI quarterly survey: change in new orders (percentage balance); and
CBI quarterly survey: expected change in stocks of material (percentage balance).

Composite coincident indicators

This roughly coincides with GDP cycle in terms of turning points and comprises:
GDP(A) Factor Cost at constant prices;

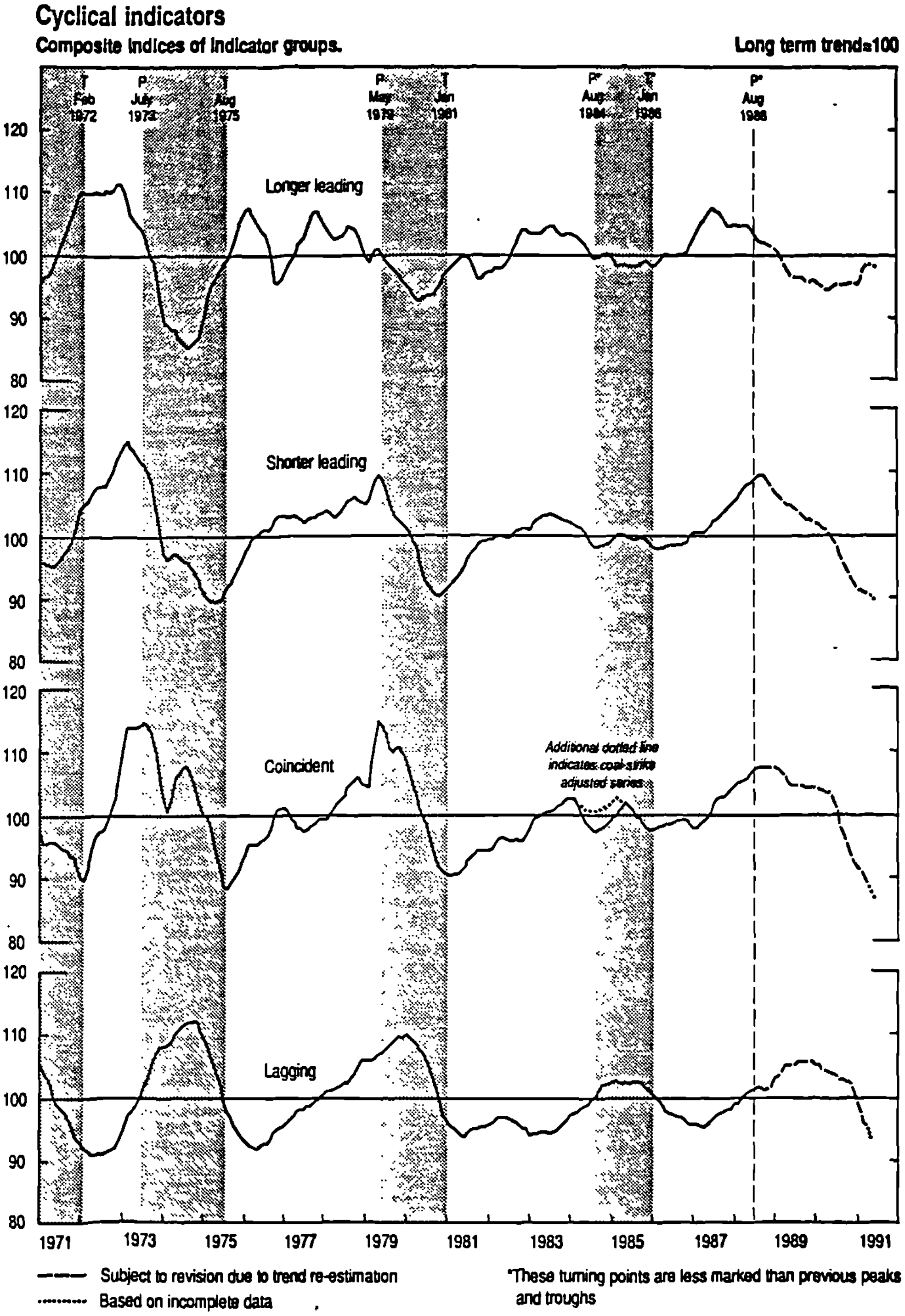

Figure 5.1. Cyclical indicators of the UK Economy

Source: Central Statistical Office (CSOb), 1990, Cyclical Indicators for the UK Economy, *Economic Trend*, Annual Supplement

Output of the production industries;

CBI quarterly survey: below capacity utilisation (percentage);

Index of volume of retail sales; and

CBI quarterly survey: changes in stocks of raw materials (percentage balance)

Composite lagging indicators

The composite series lags GNP by about 12 months and smoother than leading indicators. It is composed of:

Adult Unemployment; Employment in manufacturing industries in the United Kingdom (thousands);

Investment in plant and machinery' manufacturing industry (£m);

Engineering industries, volume index for orders on hand; and

Level of stocks and work in progress, manufacturing industry. This is used to confirm the reference cycle.

These four time series summarize the series that are considered as cyclical indicators of UK economy.

5.3 Characteristics of Indicator Variables

Roth (1986) has identified some basic characteristics of indicator variables for economic activity of interest as follows:

1. The indicator should represent an important economic process and accurately measure it;
2. Indicator variables should not be subject to occasional major revisions in terms constituents, composition and methods of measurement;
3. Indicator should bear a consistent relationship over time with movements and turns in the economic variable of interest. This is to say that the "leads or lags should be fairly constant in length and anticipate or echo a high percentage of the turning points in the process being studied" (Roth, 1986) ;

4. Indicators should not be dominated by irregular and non-cyclical movements, that is fluctuation of very short duration or 'noise' should be absent; and
5. indicators need to be promptly available and frequently reported.

An indicator (leading indicator in particular) that meets these basic characteristics is regarded as good enough to predict an economic variable of interest. However, it may be very difficult for a time series variable to satisfy these conditions over a long-run period due to random economic shock that may create fluctuation over short duration. Also the underlying economic processes that led to correlation between any indicator and the dependent economic variable of interest could change over time, that is, economic time series that appear to have performed well in the past as a leading indicator of another time series need not works so well in the future, as economic conditions change. Allowing for these changes in the correlation could lead to the periodic revision of the relationship while at times such correlation could cease from existing.

5.4 Indicators of Construction Price Level

Many attempts are being made to provide explanatory parameters for price level fluctuations in the construction industry. This section provides an overview of some of the recent work in the field.

McCaffer et al (1983) in their attempts to explain the disparity between U.K. construction cost and tender price movements found that price changes due to market conditions were highly correlated with the changes in construction output 2 to 4 quarters earlier, contract value, location and construction type. This work also found a linear association between price response and demand varying through time. The models derived from the data spanning the immediately preceding 6 years were more appropriate than those derived from data spanning shorter or longer periods. This result tends to suggest the general order of magnitude for appropriate cycle periods that will generate reliable building price information.

Taylor and Bowen (1987) provided the indicators for BER (*Bureau for Economic Research, University of Stellenbosch*) index in terms of construction demand and supply capability. This work indicates that the indices of building costs are demand determined while supply has a long term effect in price movement. The claim that factors which, underlie demand are particularly important in the prediction of future index values is emphasised by Taylor et al who referred to Kilian and Snyman's (1984) view that the BER index responds directly to changes in the general economic fortune of the nation. This work did not indicate the exact relationship noticed. However, it provides the view that the demand for construction seems to have a dominant effect and that construction price level is a result of derived demand.

Skitmore (1987) had earlier suggested the factors underlying the demand and supply of construction work, and the interactions of these as they determine price level. Skitmore expected a positive relationship between the demand for construction work (new orders) and price. Quick response in supply (number of firms registered) to meet increase in demand is expected to show very little effect on price level at least in the short run. The number of firms in the industry is regarded as responsible for intensity of competition. In other words, the higher the number of firms, the more the number of bidders expected in open tendering or that will at least respond to invitations to bid in selective tendering situations. This number of bidders is seen to determine the intensity of competition and consequently impact on price levels. In this case, a negative relationship is expected as more intensified competition will lower the price level expected.

Runeson (1988) concluded that movement in building price is the product of changes in input prices and changes due to variation in market conditions. This work provided explanations and models for the variation in market conditions, in terms of competition in the building industry, which is highly correlated with the industry cost structure. The market condition predictors identified incorporated both demand and supply determinants. These predictors include the level of building approvals (number of approval which, measures the demand) - a positive correlation, the level of building (fixed capital formation of building, a measure of current capacity or output of the industry) - a negative correlation and the level of unemployment (measuring capital utilization) - a negative correlation. This model, based on OLS multiple regression analysis, has high r^2 (0.8556). However the first predictor - level of building approval - has a lag ranging from 1 to 4 quarters while the other two variables lag periods were zero. With these lag periods it may be expected that this model will have little application in price forecasting. This is because it takes a while for the economic statistical data required for the model to become generally available.

Fellows (1988) produced a study of some leading indicators of construction price using correlation and regression techniques. This study employed a typical diagrammatic work flow through the UK building industry to isolate an initial impression of possible casual relationships between TPI and potential leading factors. This flow chart suggested that Interest rate, Investment in Buildings (intentions), Architects' New Commissions, Architects' Production Drawings, Enquiries; Orders, Volume of work (expected), BCI, in that sequence lead TPI.

The result from subsequent analysis showed a consistent high positive correlation between TPI and BCI for both raw and trended data at zero quarter lead (r^2 being 0.98 using 56 and 40 quarters' data). The correlation between TPI and interest rate based on 56 quarter data is positive and strongest ($r^2 = 0.667$) using trended data with 8 quarter lead. This study also showed that the correlation between TPI and some of the factors identified in the work flow changed in both strength of relationship and lead period with time period. Strong correlations were shown between TPI and some variables regression residuals. The analysis also showed that trends in orders had maximum correlations with TPI at zero lead ($r = -0.863$). While the variables with strong correlation at more than one quarter lead have application in forecasting of TPI, variables with strong coincident relationships with TPI offer little application in price forecasting. This study concluded that robust leading induction of TPI could be developed using correlation and regression techniques.

5.5 Identification of Tender Price Index Indicators - An Experimental Approach.

5.5.1 Procedure

A list of potential indicators of tender price levels was prepared. This list comprises the variables identified in section 5.4 and the macro economic variables included in the composite cyclical indicators of the UK economy. The list includes the variables of composite cyclical indicators of the UK economy having concluded in chapter 5 that the growth rate of TPI is very close to the UK trade cycle. Apart from this, in the preparation of this list, three major criteria for the selection of the indicators were considered as follows:

1. That the indicators are very important to the whole economy;
2. That they are reasonably amendable to further analysis; and
3. That they have a fairly close relationship (directly or indirectly) to the activities of the construction industry.

Considering these criteria 23 economic time series were identified as follows:

1. Sterling Exchange Rate (SER)
2. Industrial Production (IOP)
3. Level of Unemployment (EMP)
4. Construction Output (PUT)
5. Ratio of Price to Cost Indices in Manufacturing (MAN)
6. Building Cost Index (BCI)
7. Implicit GDP Deflator - market prices (GDF)
8. Construction Neworder (ORD)
9. Gross National Product (GNP)
10. Capacity Utilisation (UTC)
11. Bank Base Rate (BBR)
12. Retail Price Index (RPI)
13. Real Interest Rate (Bank Base Rate - Inflation) (RIR)

14. Work Stoppage in the construction industry (STR)
15. All Share Index (ASI)
16. Income per Capital - Whole Economy (GNP/Head) (GPH)
17. Corporation Tax (CTX)
18. Money supply (M3) (MSS)
19. Output per Person Employed - construction industry (Productivity) (PRO)
20. Industrial and Commercial Companies - Gross profits (ICP)
21. Wages/Salaries/Unit of Output - Whole Economy (AEA)
22. Number of Registered Private Contractors (FRM)
23. Producers Price Index - Output Prices (PPI)

The seasonally adjusted quarterly data on these economic time series from 1974:1 to 1990:2 were collected. Data not collected in seasonally adjusted form were adjusted for seasonal variations. This seasonal adjustment of data eliminates most of the effects of changes that normally occur at about the same time and in about the same magnitude every year that would have obscured underlying cyclical behaviour of an economic process. Since the seasonal effects are of no interest in the study of the cyclical properties of an economic process, the annualized rates analysis were calculated on seasonally adjusted data. Hence, the growth rate of these deflated economic series data based on six-month smoothed rate, annualized, were calculated (after Moore and Kaish, 1983; Niemira, 1984; Moore, 1986) except for capacity utilisation, the ratio of price to cost indices in manufacturing and Bank Base Rate. The annualized growth rate of each of these economic series is plotted against TPI annualized growth rate as shown in Figures 5.3 to 5.22. This is to determine the indicators' relationship with TPI in terms of lead, lag, coincidental and the patterns in their movements. Swift (1983) and Killingsworth, Jr. (1990) used the same principle by graphically plotting the annual percentage change in variable and the annual percentage changes in its potential determinants, to establish the degree of correlation that exists between them.

Concerning this work therefore, the followings need further explanation:

TPI Leading indicator

A series which, when lagged, correlates highly with another series. That is the turning points and the pattern of the dependent variable of interest are lead by the independent economic series. (Lagged means a situation where the past values of a series are brought into the current case.)

The leading indicators of TPI could be very useful in predicting TPI. To be of practical and/or commercial value, the leading indicator should consistently lead TPI historically. An indicator time lead will generally determine the forecasting time frame to which the indicator may be applicable. An indicator with less than a month time lead will at best be useful for immediate forecasting while a lead time of up to three months may be required for short term forecasting. Medium and long terms forecasting will require longer lead time.

TPI leading indicator is a variable when lagged 1 to 8 quarters (-1 to -8) is correlated in terms of turning points and patterns of movement with the TPI annualized growth rate.

TPI Lagging indicator

A series which, when led, correlates highly with another indicator. This lacks forecasting potentials for the dependent variable (TPI in this case), but the dependent variable in actual sense becomes a leading indicator of the independent economic series. (Led means a situation where future value of a series is brought into the current case.)

TPI lagging indicator is a variable when led 1 to 8 quarters (+1 to +8) is correlated in terms of turning points and patterns of movement with the TPI annualized growth rate.

TPI Coincident indication

This relates to the series that correlates to another series at the same time. The series (both the dependent and the independent) are peaked, and troughed at the same time; and have the same movement patterns.

TPI coincidental indicator is a variable that correlates with TPI at the same time (t), and in this case t equals zero.

The graphical illustration of indicator types in relation to TPI is shown in Figure 5.2

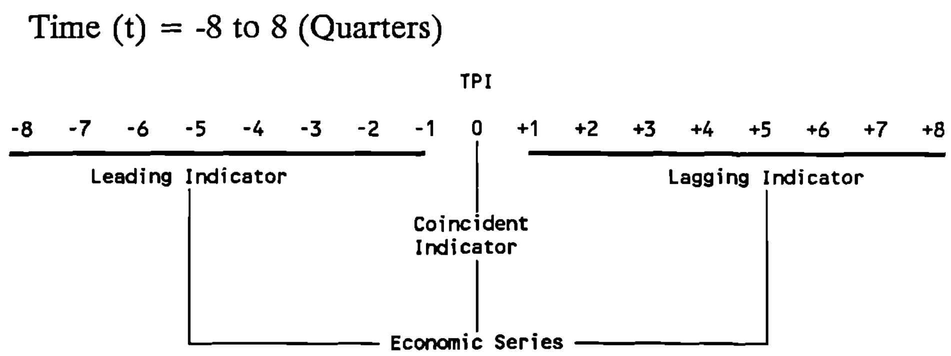

Figure 5.2 Graphical illustration of TPI indicators

5.5.2 Analysis of growth rate of the economic series

This section looks into the variability of the economic time series compared with TPI using standard deviations as the measure of the degree of variability (Beeston, 1983). Table 5.1 which, shows the standard deviations of the growth rate of the time series and compares the volatility of these variables with TPI. They are arranged such that the time series growth rates that are before TPI have less variability and the one above TPI greater variability.

This analysis excludes four time series that are not expressed in terms of annualized growth rate - capacity utilisation, ratio of price to cost indices of manufacturing, real interest rate and bank base rate.

The position of TPI in this table shows that it is relatively volatile compared to its potential indicators. However, construction neworder, construction output and unemployment levels are more volatile than TPI.

Table 5.1 Standard deviations of the growth rate movements of the potential indicators of TPI

Variables	Standard Deviation	Mean
IOP	6.08	1.61
GPH	6.66	15.53
GNP	6.67	15.94
PPI	7.55	12.47
BCI	8.30	14.39
GDF	8.49	13.49
PRO	9.57	1.59
RPI	10.01	13.66
SER	10.38	-2.77
AEA	10.43	13.48
TPI	11.44	10.01
OUT	11.56	13.66
FRM	13.38	6.96
ORD	23.90	12.23
ICP	24.37	16.60
MSS	29.30	10.57
EMP	32.62	11.99
ASI	38.92	16.60

5.5.3 Analysis of the Experiment: Results; and Description and Source of the Economic Series

Figure 5.3 to 5.22 bring together the line graphs of each of the listed potential indicators compared with TPI-inflation. Identification of turning points were based on two criteria; the size of the change in the rate of growth and the length of time over which the change took place. The turning points of the potential indicators of TPI adopted a general rule of thumb (after Roth, 1986) that a change of at least one and half percentage points was required over a period of at least six months. The turning points (peaks and troughs) in TPI-inflation are marked. Also the turning points in the economic series are marked and identified as lead, lag, coincidental or extra turning points compared with TPI-inflation turning points. This section also gives a brief description of the economic series(main source CSO, 1990a,), the unit of measurement, the reporting organisation and the publishers. In the sub-sections that follow, analysis of the experiment on each of the potential indicators are reported.

5.5.3.1 Sterling Exchange Rate

This is reported quarterly in 'Economic Trends' - a quarterly publication of the Government Statistical Service. This is produced as a composite index of other national currencies in relation to pound sterling and is collated from 'Monthly Digest of Statistics and Financial Statistics' (a monthly publication of the Government Statistical Service). The source of this series is Bank of England/HM Treasury.

Figure 5.4 suggests that the turning points in sterling exchange rate exhibit leading, lagging and coincident indicators of TPI and hence, difficult to arrive at conclusion as to the dominant indicator and movement pattern.

5.5.3.2 Wages and Salaries per Unit of Output for the Whole Economy

This is a series that calculates the wages and salaries (numerator) per output measure of gross domestic product at factor cost in constant prices. Employment Gazette (1986) produces the method of calculating this and the process of incorporating the earnings of the self-employed. The source of this series is the Department of Employment and it is published quarterly in "Economic Trends' and 'Employment

Gazette' among others.

Figure 5.4 suggests that this is a lagging indicator of TPI by 2 to 6 quarters.

5.5.3.3 Unemployment

The source of this series is the Department of Employment and it is published quarterly in 'Economic Trends' and 'Employment Gazette', and monthly in 'Monthly Digest of Statistics' among others. This is in numerical figures and relates to people claiming benefit -unemployment benefit, income support or national insurance credit- at Unemployment Benefit Offices on the day of the monthly count, who on that day were signed on as unemployed and available to do any suitable work. It is expected the changes in this figure have impact on the consumers buying power and consequently the demand side of TPI.

The level of unemployment rate is commonly used as an indicator of future inflation. When unemployment is judged to be below (above) its long run or "natural" rate, inflation is projected to rise (fall) in the future (Judd and Trehan, 1990). This negative correlation between unemployment and inflation (that is prices) is fundamental to Keynesian (Ball et al, 1988).

Figure 5.5 shows that this series is a consistent leading indicator of TPI with 1-3 quarters lead with opposite movements to the growth rate trends in TPI.

5.5.3.4 Industrial Production

This is reported quarterly in 'Economic Trends' - a quarterly publication of the Government Statistical Service. It is an index of the output of the production industries, that is, a weighted arithmetical average of 287 separate indicators, each of which describes the activity of a small sector of industry. It has its source from

Central Statistical Office. This series produces a comparison in the volume of output of the production industries. The rational for including this in this experiment is that the movement in this output level is hypothetically related to construction investment.

Figure 5.6 tends to suggest that this series is a leading indicator of TPI by 1-3 quarters. However, coincident indicator is shown about 1977:4 trough in TPI.

5.5.3.5 Income per capital for the Whole Economy (GNP/Head)

This is income per head of the United Kingdom home population. This is published quarterly in 'Economic Trends' - a quarterly publication of the Government Statistical Service. It is produced by the Central Statistical Office. This is a numerical value in pounds sterling at current prices. It is expected that changes in the consumers' level of wealth has effect on the demand side of TPI.

Figure 5.7 suggests that the pattern of movements in Income per capita and TPI are similar with coincident indicator or leading indicator by not more than two quarters.

5.5.3.6 Gross National Product

This is published quarterly in 'Economic Trends' - a quarterly publication of the Government Statistical Service; monthly in 'Monthly Digest of Statistics' and 'United Kingdom National Accounts' (Yearly Edition). It is produced by the Central Statistical Office. This is a numerical value in million pounds sterling at market (current) prices. It is expected that changes in the national income are related to consumers level of wealth/business confidence, all are expected to have effect on the demand side of TPI.

Figure 5.8 suggests that the GNP is coincident or leading indicators of TPI with 1-2 quarters, except for the troughs in TPI. The turning points in GNP are fewer than the turning points in TPI.

5.5.3.7 London Clearing Banks' Base Rate

The frequency of producing this series is monthly and its unit of measurement is percentage. This reflects the Bank of England minimum lending rate. A change in this rate signifies a marked change in the level of short term market rate; hence this is widely used as an indicator of the broad level of interest rate. In essence it bears on the long-run lending interest rate to business organisations. The source of this is the Bank of England and it is published in "Economic Trends', 'Financial Statistics' and 'Bank of England Statistical Abstract'. It is also available On-Line of "Datastream International Ltd On-line" - A company of Dun and Bradstreet corporation.

Figure 5.9 shows that this has coincident or lagged indication with TPI and was fairly stable in the mid 1980s. Where there is coincident relation between the two it can be observed that TPI will follow the same coincidental trends as Base Rate. The TPI also responds more along the coincidental trend to a small change in Base Rate.

5.5.3.8 General Retail Price Index (Total non-food)

This is base-weighted index resting on 'basket of goods' concept. Although this is not an index of building costs, it serves as a convenient measure of purchasing power within an economy (i.e., a measure of inflation rate) and is generally acceptable as a measure of depreciation (Kilian and Snyman, 1980). This is compiled by the Central Statistical Office. It measures the change from month to month in the average level of prices of the commodities and services (non-food) purchased by all types of household in UK. The quarterly movement in this series is published in 'Economic Trend' and 'Employment Gazette' among others.

Figure 5.10 suggests that this series is predominantly a lagging indicator of TPI.

5.5.3.9 Producers Price Index - Output Prices

This is the index of output prices of home sales of all manufactured products in UK. It is also a base-weighted index resting on 'basket of goods' concept. It is published quarterly in 'Economic Trends' - a quarterly publication of the Government Statistical Service; monthly in 'Monthly Digest of Statistics' and 'Business Bulletin'. The source of this series is the Department of Trade and Industry. Prior to 1983 this was published as wholesale price index (British Business, 1983). The rebased version of the wholesale price index with a new classification that adopted the 1980 version of the standard industrial classification is the producers price index.

Figure 5.11 suggests this as lagging indicator of TPI in 1970s and fairly stable in the 1980s. The period 1974 to 1982 tends to suggest a leading indication of about 8-10 quarters. In general the figure does not suggest a close trend relationship between the movements of these two price series.

5.5.3.10 Money Supply (M3)

This series is the wider measures of money within an economy measure in million pound sterling (Begg et al, 1984). It includes the narrowest M1 measure of money (narrow range of assets that can immediately and without restriction be used to make payments eg. cash in circulation and private sector sterling sight deposit-banks cash reserves) and near money (sterling time deposits of the private sector and total sterling deposits of the public sector; and residents' deposits in foreign currency). Time deposits are interest-bearing deposit accounts on which cheques may not be drawn directly. It is compiled by 'Financial Times' and has its source from Bank of England. It is published by "Financial Statistics' and 'Bank of England Statistical Abstract'. It is available On-Line of "Datastream International Ltd On-line" - A company of Dun and Bradstreet corporation.

Figure 5.12 shows that the turning points in money supply (M3) growth rate are fewer than TPI growth rate. It is observed that where TPI peaks, M3 is stable and where there is a trough in TPI, M3 rises. The M3 shows a lagging indication compared with TPI at the few turning points observed from the chart.

5.5.3.11 Construction Output

This series relates to work done by contractors, that is, the total amount chargeable to construction clients at current prices excluding VAT for building and civil engineering work done in the relevant period. Added to this is the estimate of unrecorded output by small firms and self employed workers, and output by public sector direct work. This is published quarterly in 'Economic Trends' and 'Housing and Construction Statistics'. The source of this series is the Department of Environment.

Figure 5.13 tends to suggest that it has more turning points than TPI - highly volatile - which tends to make the cyclical interpretation somewhat inconclusive. However, the Figure suggests in part that the series is coincident indicator during 1979:1 peak in TPI and leading indicators by 2-4 quarters during other turning points of TPI.

5.5.3.12 Number of Registered Construction Firms

This is the number of private firms that are registered as building and/or civil engineering contractors in UK. The 'firm' as used in the register of private contractors is a reporting unit. For example a large firm could present and register its organisation as different reporting units on regional division basis or the type of work being undertaken by each of the units. The series is compiled by the Department of Environment and published in 'Housing and Construction Statistics'.

Figure 5.14 tends to suggest that the turning points in the growth rate in this series are fewer than TPI turning points. The troughs in number of registered firms lead the peaks in TPI by 4-6 quarters. However, this is a leading indicator over TPI by 6-7 quarters with the exceptions of 1981:2 and 1988:2 peaks in TPI.

5.5.3.13 Ratio of Price to Cost Indices in Manufacturing

This ratio is a measure of market condition or trends in profitability in the manufacturing sector. Acceptance of the fact that capital investments are undertaken from profit suggests that movements in this ratio would affect the demand side of TPI. This ratio is derived by dividing the Output price index (i.e., home sales of manufactured products) by the index of materials and fuel purchased by manufacturing industry for the relevant period. These output and input price indexes are published quarterly in 'Economic Trends' under "Producer price index".

Figure 5.15 suggests that out of seven turning points in TPI growth rate, this series leads TPI 5 times with about 3-6 quarters.

5.5.3.14 Implicit GDP Deflator

The implicit gross domestic product deflator is the price index obtained by dividing the current price expenditure-based estimates of gross domestic product by the corresponding constant price values. (i.e., dividing by corresponding estimates at base year prices). The base year prices used is this case is 1974. The expenditure-based measure of GDP is the total expenditure made either in consuming the finished goods and services or besides wealth created less expenditure on imports. The source of this information is Central Statistical Office and is published in "Economic Trend" under 'National accounts aggregate: index numbers'.

Figure 5.16 suggests that this is predominantly a lagging indicator of TPI.

5.5.3.15 General Building Cost Index

This measures the trends in costs of labour, materials and plant used in the procurement of construction works. This is produced by the Building Cost Information Service. The index is base-weighted resting on 'basket of goods' concept. The input to this index are the Work Category Indices (Series 2) prepared by the Property Services Agency for use with the NEDO formulae which allows for changes in the costs of nationally agreed labour rates, material prices and plant cost. This index does not necessarily reflect changes in contractors' actual site costs but it is likely that it correlates with this. It is published in Building Cost Information Service Manual, Section ABb.

Figure 5.17 tends to suggest that this index is more or less a coincident or lagging indicator of TPI except for the peak in the second quarter of 1977.

5.5.3.16 Output per Person Employed in the Construction Industry - Productivity

Output per person employed in the construction industry has been used to capture trends in the productivity level, as other means of measuring movements in construction productivity are unavailable. Butler (1978), for example, used a measure of gross output per person as the best way of adjusting labour cost index for variations in productivity from quarter to quarter. These index numbers are calculated by dividing the index of construction output by an index of the numbers of manual and non-manual staff employed in the industry. The source of this data is Central Statistical Office and is published quarterly in UK 'Employment Gazette' as "Indices of output, employment and output per person". 'Economic Trends', 'British Labour Statistics', and 'Monthly Digest of Statistics' also publish the same information about the whole economy, manufacturing industry and production sector.

Figure 5.18 tends to suggest that an inconsistency in movements of the productivity series compared with TPI and this comprises of longer leading and shorter leading indicators. The chart suggests that there are many turning points in the output person employed growth rate.

5.5.3.17 Construction Neworder

This series is published quarterly in 'Economic Trends' and 'Housing and Construction Statistics' and its source is the Department of Environment. It measures the value of contracts for new construction work awarded to main contractors by clients in both public and private sector, including extensions to existing contracts and construction work in 'package deals' at current prices. Another estimate of work included in this figure is speculative work, undertaken on the initiative of construction firms, where no contract or order is awarded.

Figure 5.19 suggests that the construction neworder annualized growth rate is highly volatile with many rapid and irregular fluctuations. Despite this some leading indication of TPI could be identified though not distinct with 1-4 leading quarters.

5.5.3.18 Capacity Utilisation of Firms Generally

Economists often turn to capacity utilisation as a measure of the ability to increase prices (Lynch, 1989): A good reason for this is that this is a good predictor of price movement in many industries. Low level utilisation results in reduced prices and high level, on the other hand, often puts upward pressures on prices.

The impact of capacity utilisation is linked to its effect on marginal cost. In times of high utilisation, marginal costs become equal to fixed plus variable cost of new investment; or existing capacity suffers from diminishing returns as it is used more intensively than designed for. In the construction industry this is linked to the level of demand for construction investment and ability to respond to the demands by contractors in the short and long runs. In essence, this is linked to both the demand and supply sides of TPI.

The source of this series is the Confederation of British Industry (CBI) survey of firms not working below capacity. This is expressed in percentage.

Figure 5.20, which compares the turning points in the percentage of firms not working below capacity with the annualized growth rate in TPI suggests that this series is either a coincident indicator or lagging indicator of TPI.

5.5.3.19 Industrial and Commercial Companies - Gross Trading Profit

It is an accepted business practice that most capital project investments are made from profit. This is the basis of the cash flow theory of investment (Kopcke, 1985). Since both the industrial and commercial sectors of the economy constitute the bulk of private investment into construction work, it is expected that fluctuations in their trading profit would affect the demand side of TPI. The Source of this series is Central Statistical Office and is published quarterly in 'Economic Trends' and 'Financial Statistics'. It is also available On-Line of "Datastream International Ltd On-line" - A company of Dun and Bradstreet corporation.

Figure 5.21 suggests that this series is highly volatile with many turning points. Though, the types of indicators seem inconclusive, it can be said that some leading indication of TPI are exhibited.

5.5.3.20 All Share Index

This is 'Financial Times' summary of all share index. It measures the monthly movement in the aggregate share prices at the stock market. It is a base-weighted measure of share prices across many industries. This is compiled by 'Financial Times' and is available On-Line of "Datastream International Ltd On-line" - A company of Dun and Bradstreet corporation.

Figure 5.22 tends to suggest that the growth rate in this series is erratic and hence the movements of the all-share index compared with TPI is not very convincing. However, the peaks in TPI growth rate are coincidental with troughs in all share index and vice versa.

Note

- • TPI turning points
- × Variable turning point leading TPI turning point
- ▵ Variable turning point lagging TPI turning point
- ▫ Variable turning point coincidenting TPI turning point

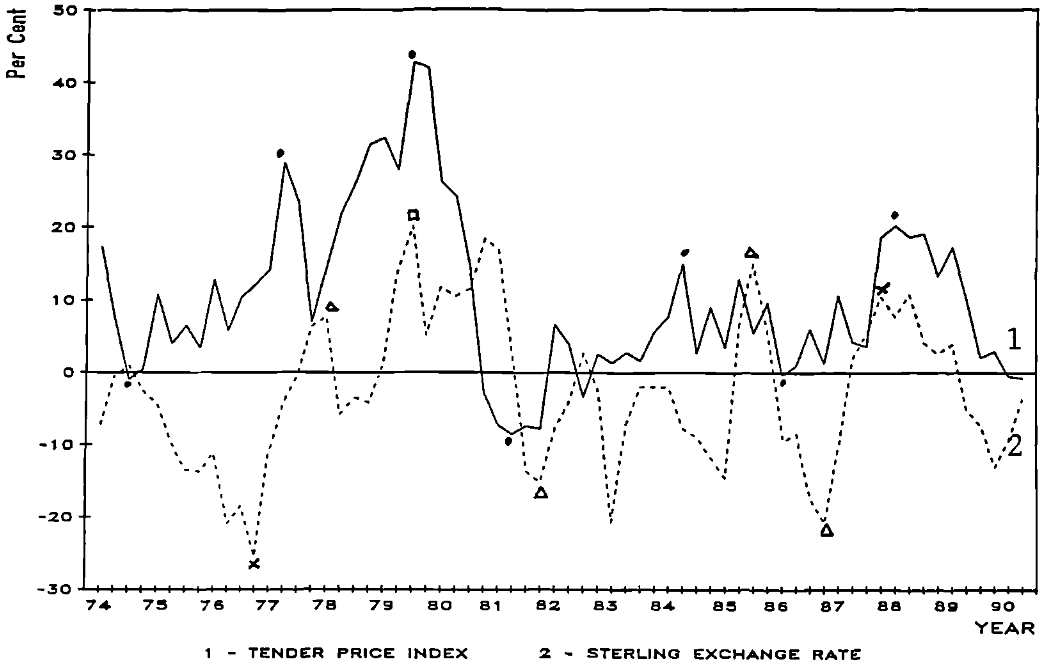

Figure 5.3 Annualized growth rate of Sterling Exchange Rate compared with TPI

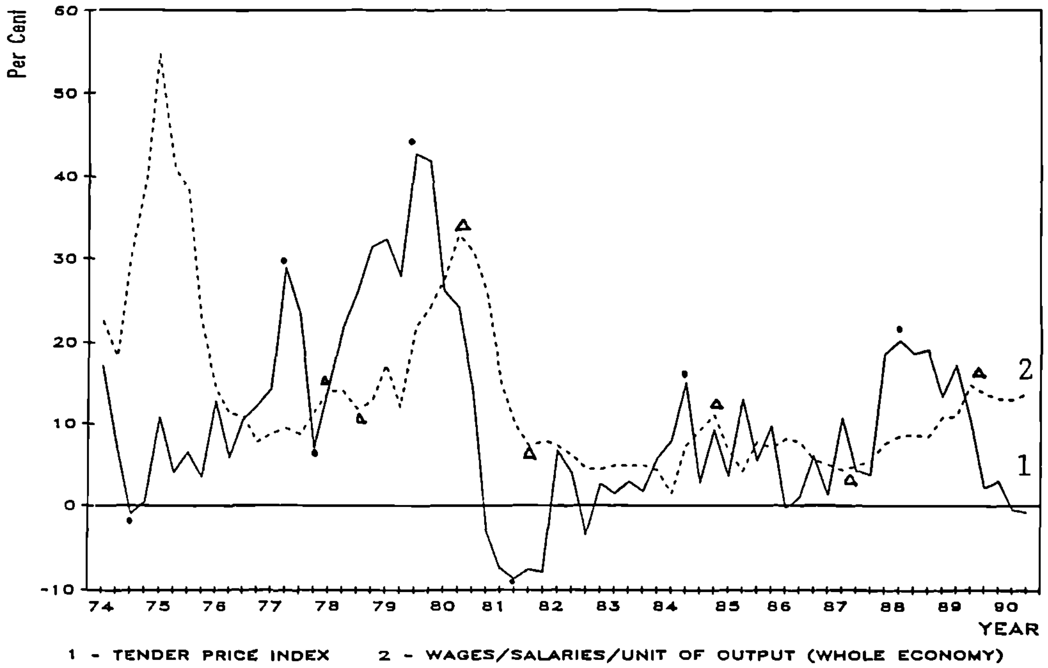

Figure 5.4 Annualized growth rate of Wages & Salaries/Unit of Output compared with TPI

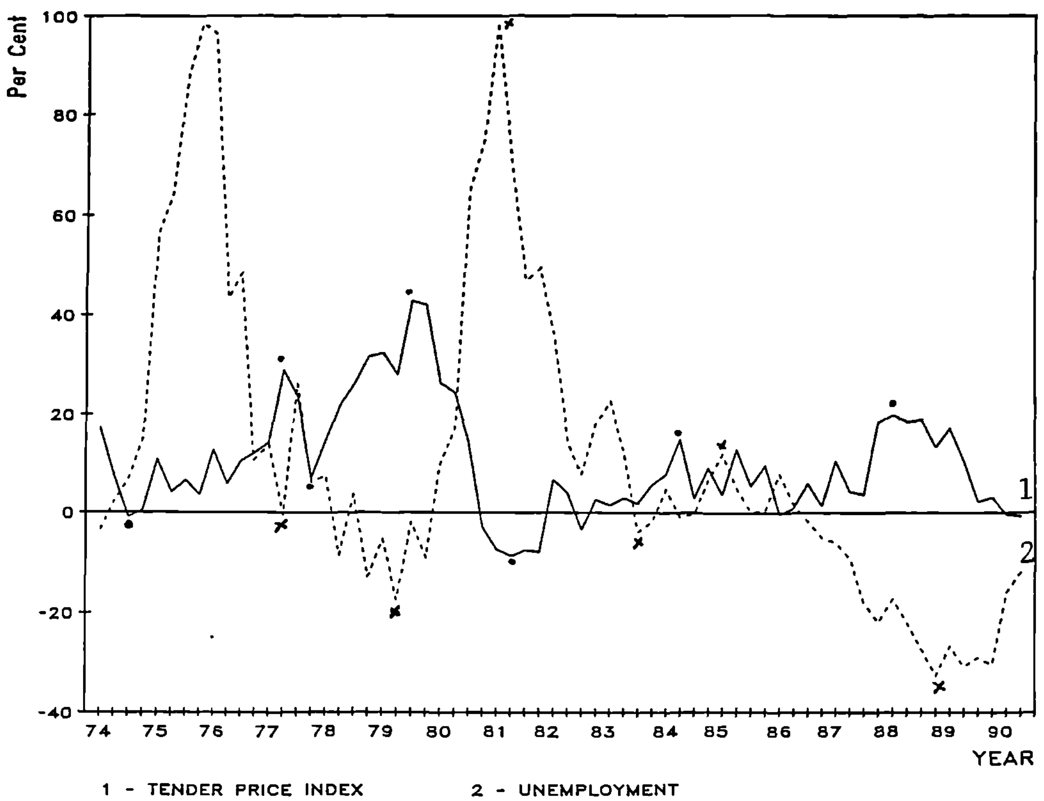

Figure 5.5 Annualized growth rate of Unemployment Levels compared with TPI

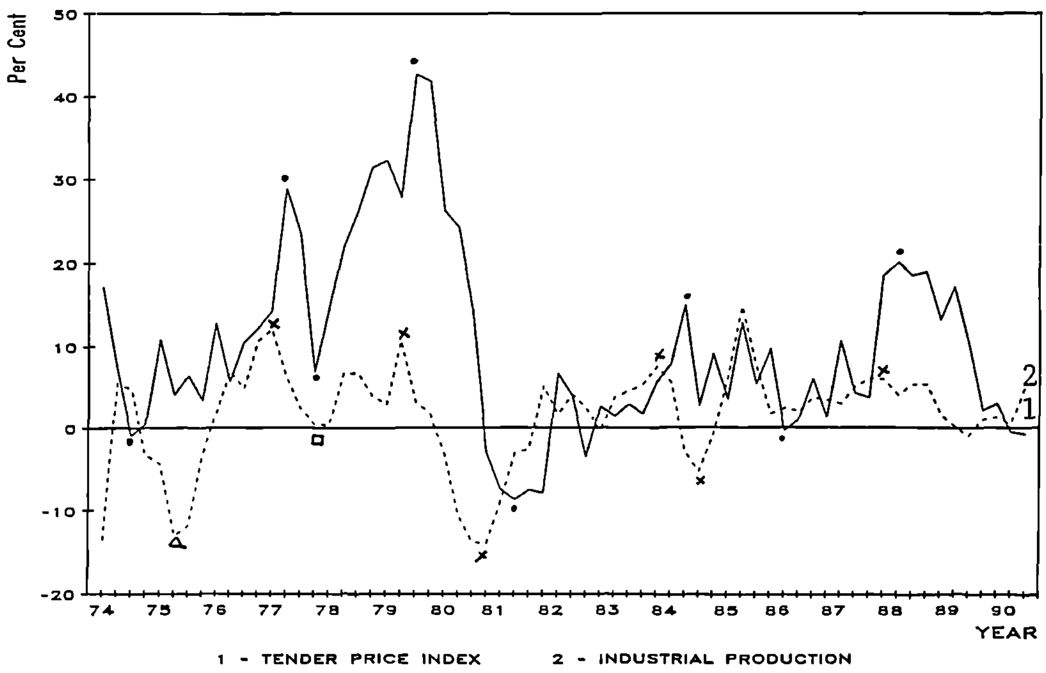

Figure 5.6 Annualized growth rate of Industrial Production compared with TPI

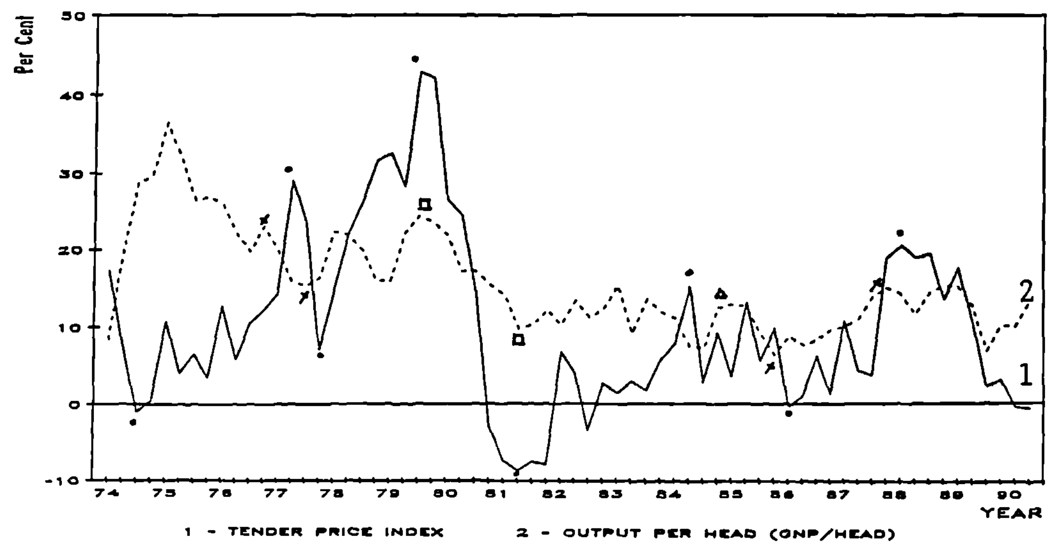

Figure 5.7 Annualized growth rate of Output per Head compared with TPI

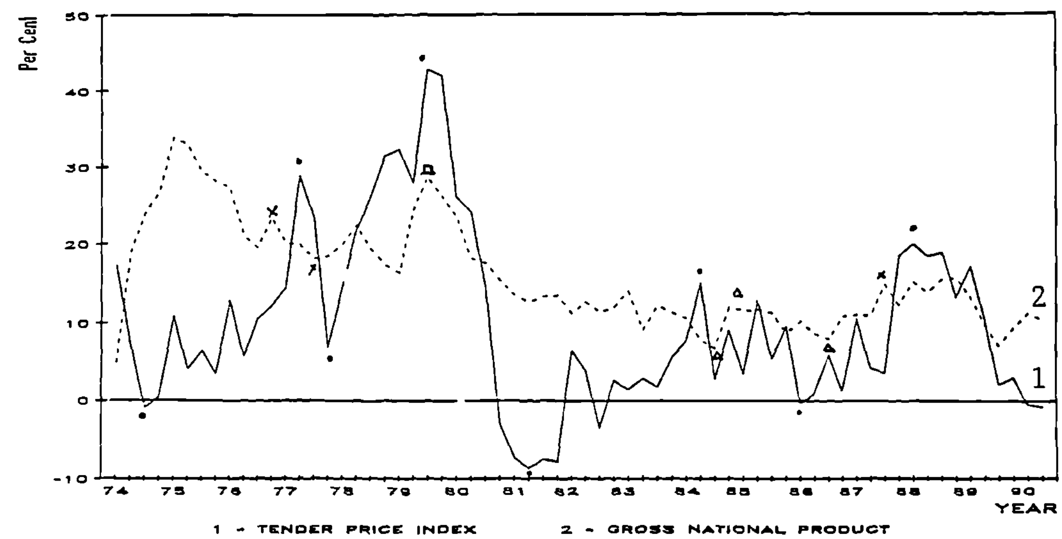

Figure 5.8 Annualized growth rate of Gross National Product compared with TPI

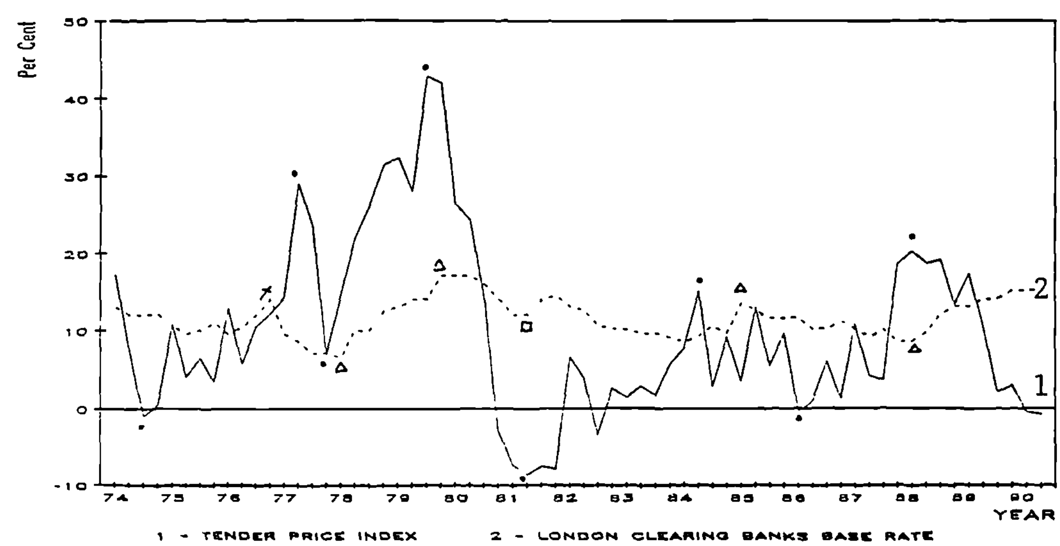

Figure 5.9 Annualized growth rate of Bank Base Rate compared with TPI

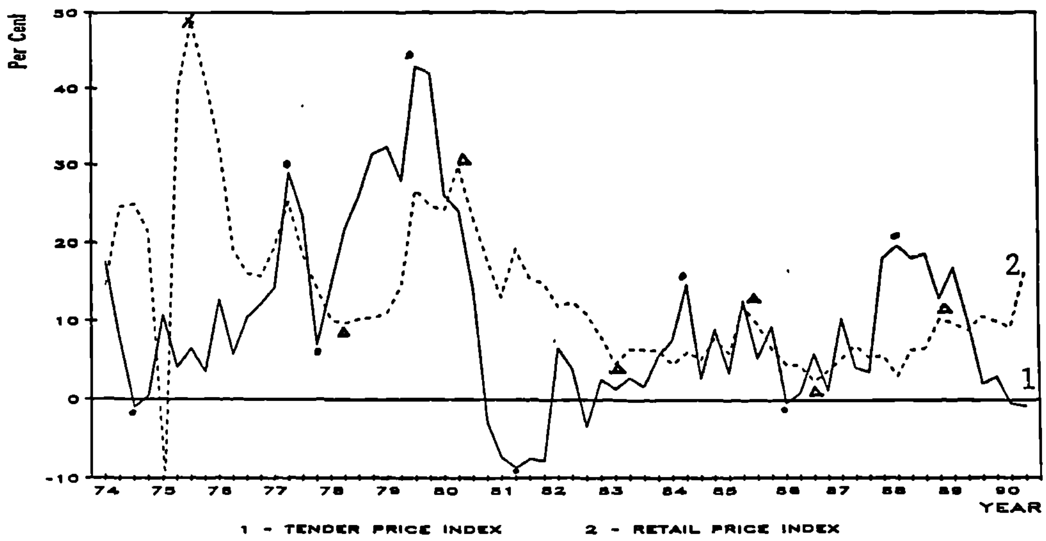

Figure 5.10 Annualized growth rate of Retail Price Index compared with TPI

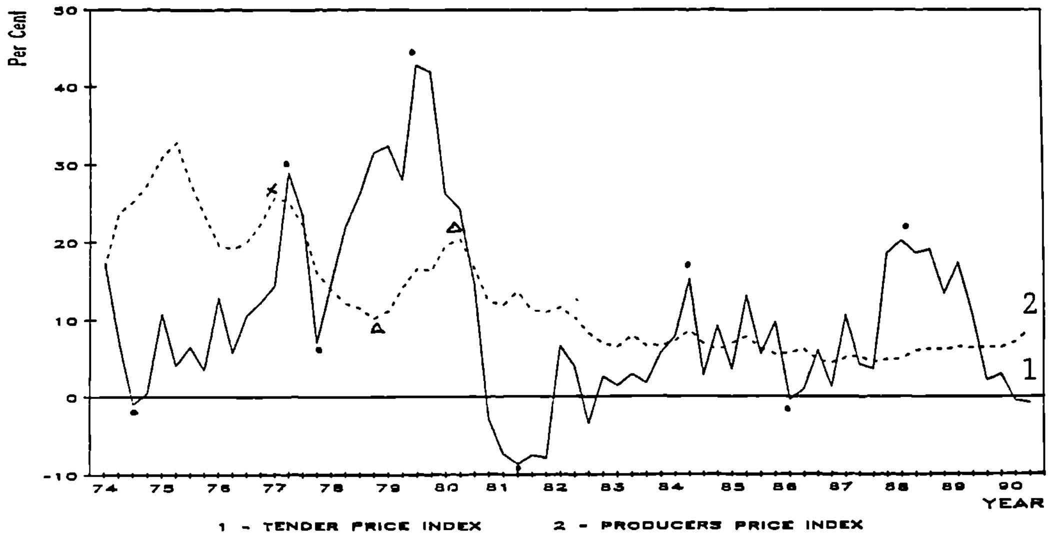

Figure 5.11 Annualized growth rate of Producers Price Index compared with TPI

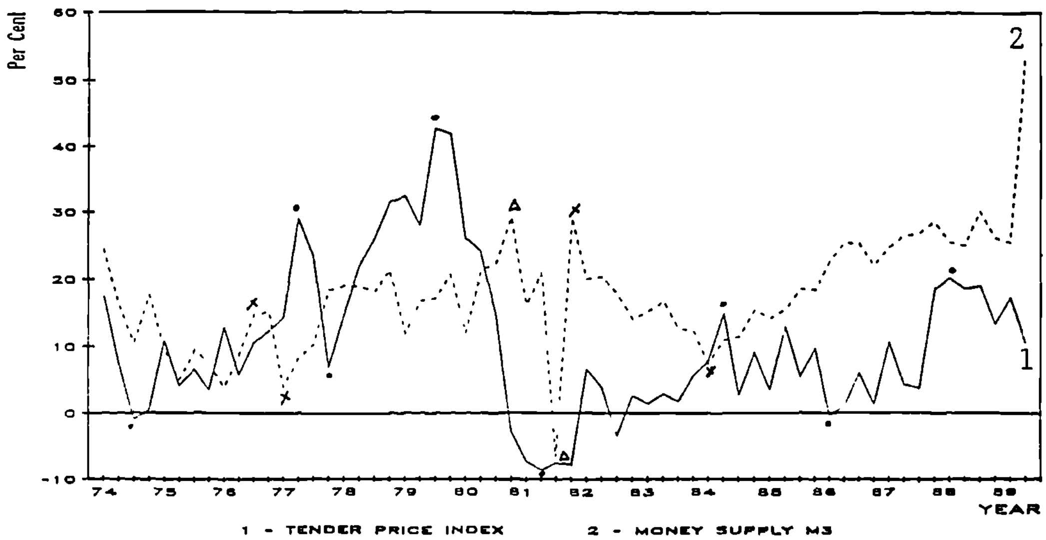

Figure 5.12 Annualized growth rate of Money Supply (M3) compared with TPI

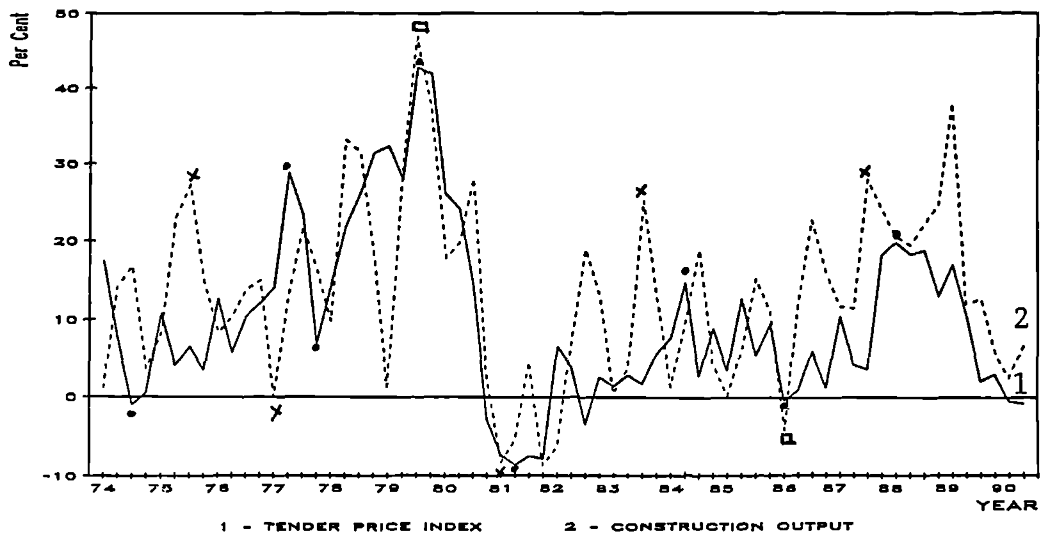

Figure 5.13 Annualized growth rate of Construction Output compared with TPI

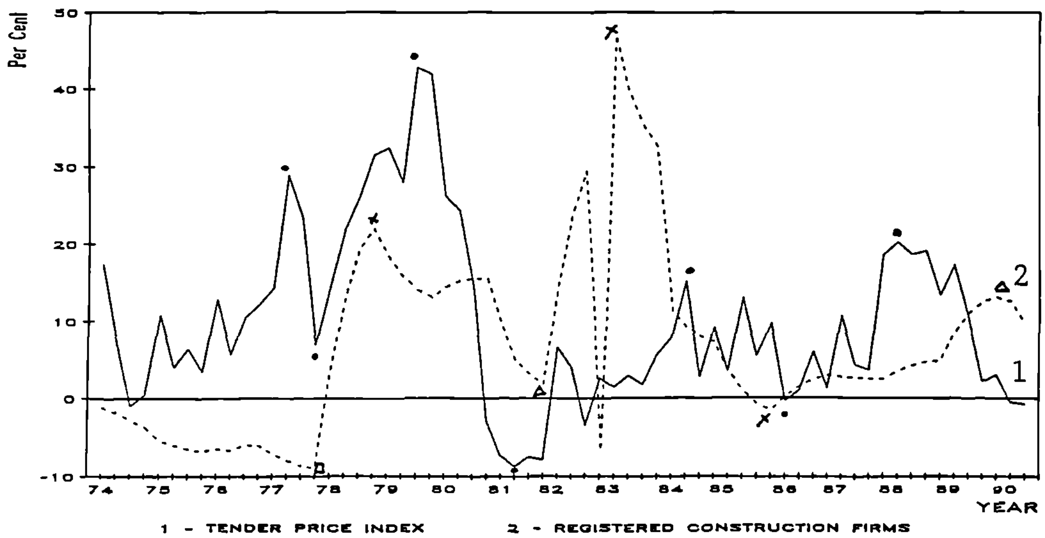

Figure 5.14 Annualized growth rate of Registered Construction Firms compared with TPI

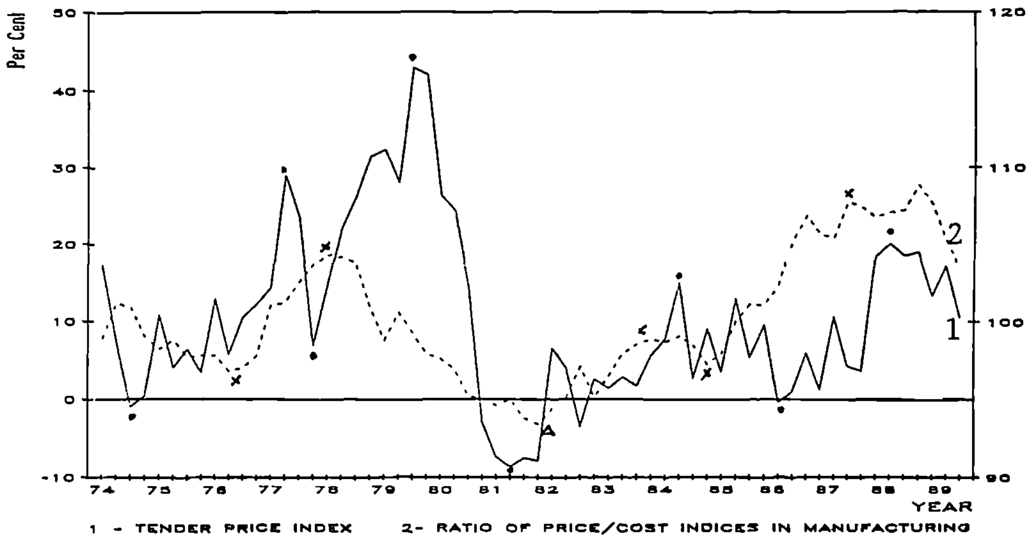

Figure 5.15 Ratio of price/cost indices in manufacturing compared with annualized with TPI

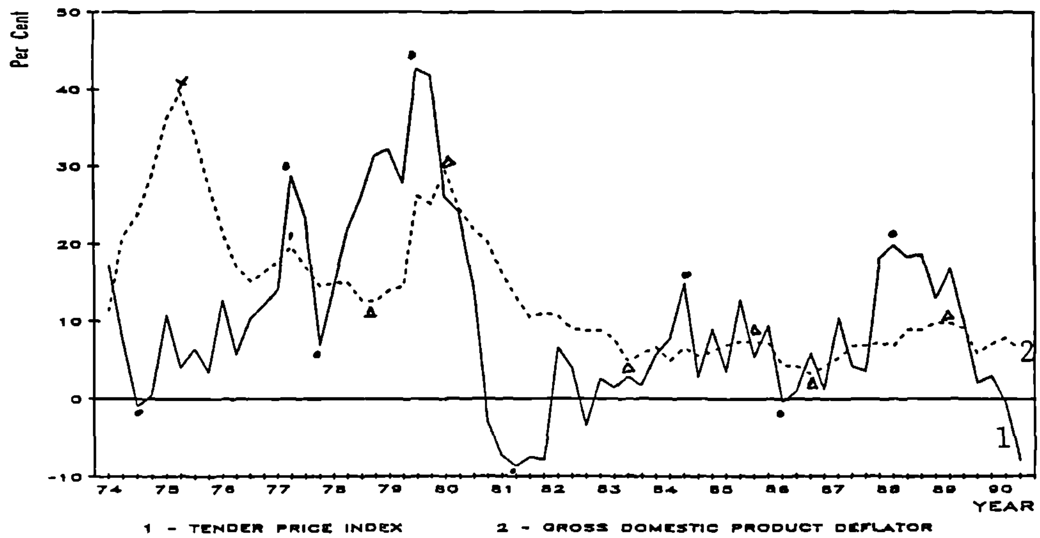

Figure 5.16 Annualized growth rate of Gross Domestic Product Deflator

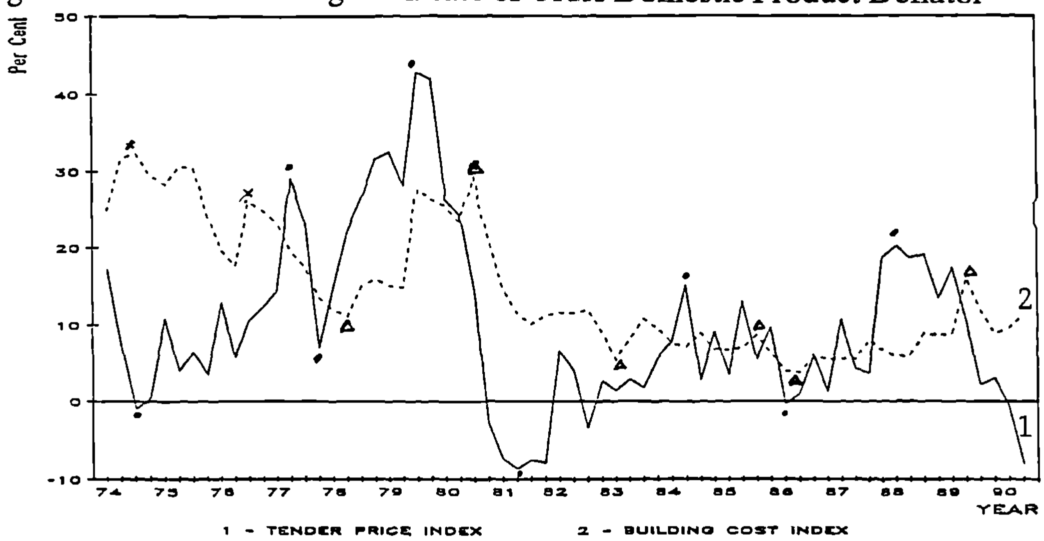

Figure 5.17 Annualized growth rate of Building Cost Index compared with TPI

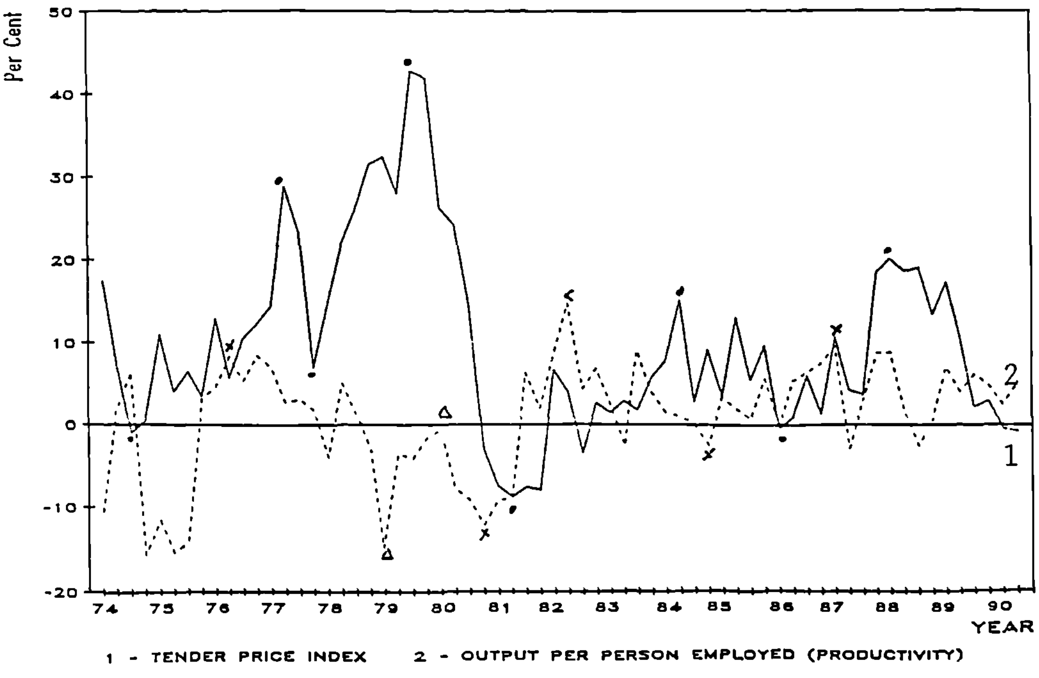

Figure 5.18 Annualized growth rate of Productivity compared with TPI

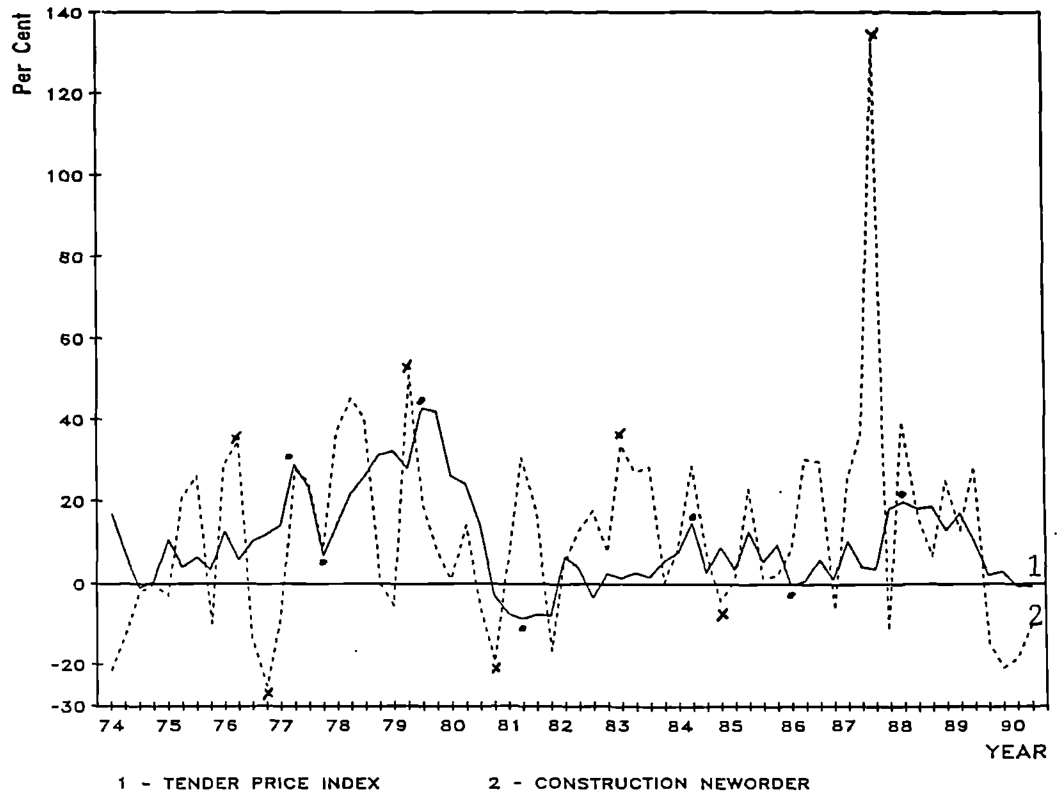

Figure 5.19 Annualized growth rate of Construction Neworder compared with TPI

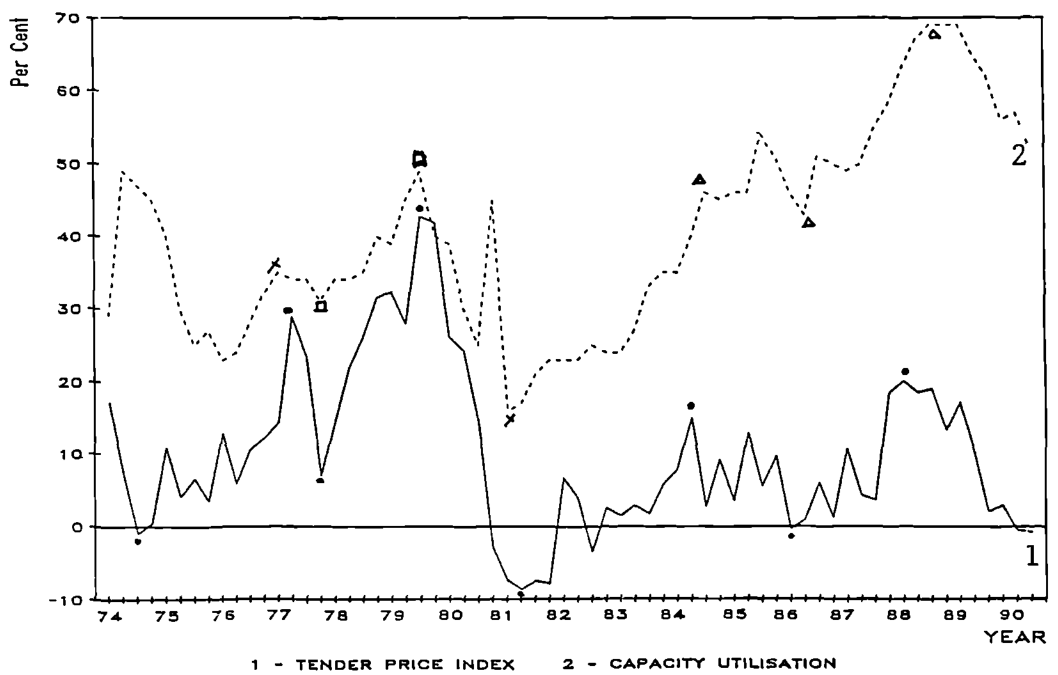

Figure 5.20 Capacity Utilization compared with annualized growth rate of TPI

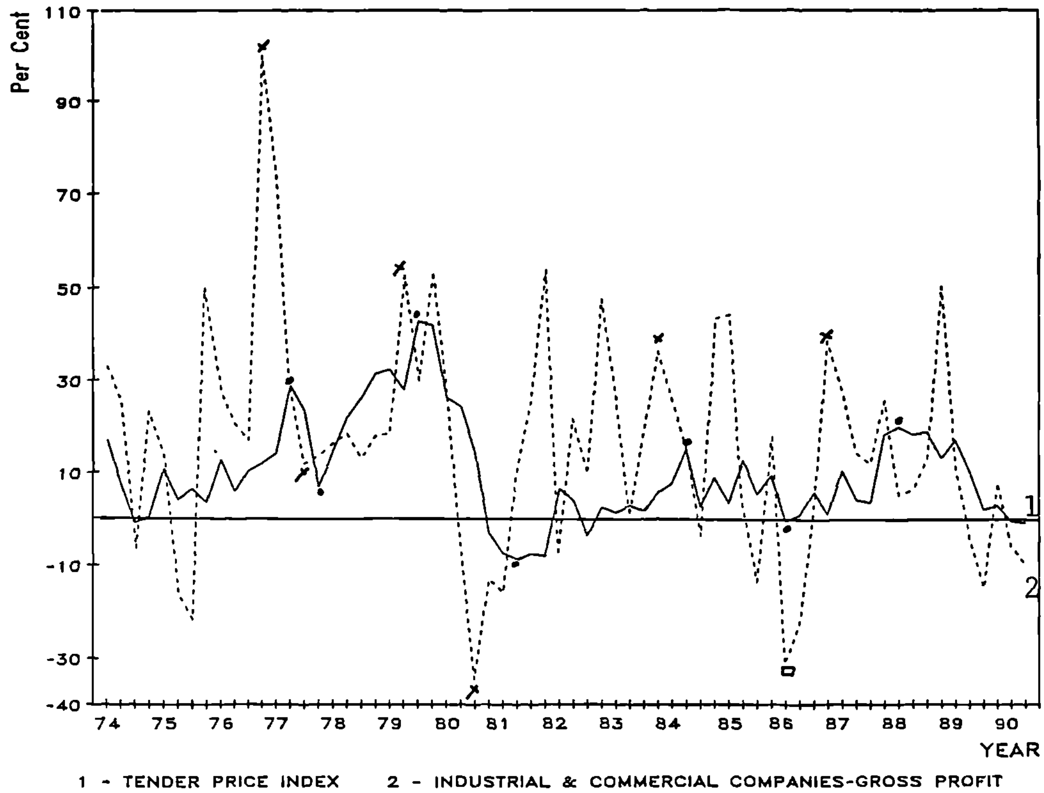

Figure 5.21 Annualized growth rate of Industrial & Commercial Companies Gross Profit compared with TPI

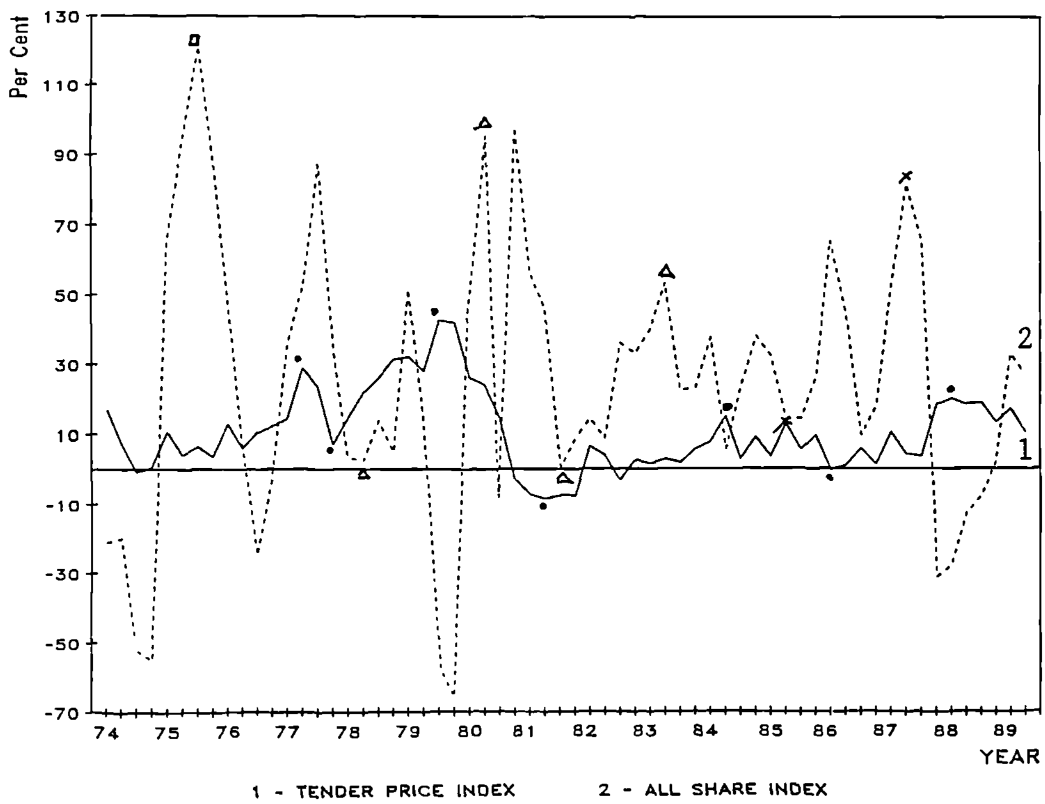

Figure 5.22 Annualized growth rate of All Share Index compared with TPI

5.6 Predictive Power of the Indicators of TPI - An Experimental Approach

The preceding section attempted categorisation of the potential indicators of TPI into leading, lagging and coincident indicators. As earlier mentioned, these classes of indicators have different importance in economic process analysis. The most important to the theme of this research are the ones that are more informative about the future course of the tender price index. Obviously, this will mean the leading indicators. This section gives the results of another approach to determining the nature of the 23 potential indicators. The method of analysis takes after Bernanke (1990) by running a "horse race" between the potential indicators and testing the ability of each of them to predict the TPI. This analysis looks into the strength of the variables in predicting TPI overtime. The ones that produce a consistent prediction of TPI overtime can be considered leading indicators of TPI.

5.6.1 Univariate Forecasting power of the indicators

Taking the variables one at a time we would try to determine more precisely which, of these variables could be leading indicators of TPI. Hence, the ability of the variables to predict TPI is examined.

The univariate forecasting power of the individual variables is evaluated using regression analysis. For the TPI and each variable, nine in-sample (zero to eight quarters ahead) prediction equation were estimated. In this case, TPI being forecasted is regressed on a constant, a trend, a quarter lag of itself, and lags of the variable of interest (see equation 5.1) using quarterly data for 1974-1986.

$$TPI = Constant + \alpha_1 \, Trend + \alpha_2 \, TPI_{-1} + \alpha_3 \, Variable_i \qquad \text{Eqn 5.1}$$

Based on the estimated forecasting equations, the hypothesis that the lags of the relevant variable could be excluded from the equation, (i.e., the relevant variable -

each lag of the listed variable - lacks marginal predictive power) was tested. Table 5.2 shows the result for each of the variables with the leads of 0-8 over TPI. This Table gives the probability that the relevant variable can be excluded from the prediction equation. Statistically, low probability values imply strong marginal predictive power and vice versa. For example, probability value of 0.0001 means that there is only one chance in 10,000 that the particular lag of a listed variable does not belong in that particular prediction equation.

Using Table 5.2 to determine which, of the variables within the sample are best predictors of TPI seem a difficult task. To solve this problem Bernanke (1990) proposed a simple and informal way of quantifying the impressions given by the univariate results where points are assigned to each probability value as follows:

Less than		0.001	=	5
0.001	-	0.01	=	4
0.01	-	0.05	=	3
0.05	-	0.1	=	2
0.1	-	0.2	=	1

A variable with the predictive power must lead TPI by at least one quarter. Hence, leads of 1 to 8 are considered in the entry of points. For each variable the entered points of the probability values that meet the point classification above are added. The total points for each listed variable forms the basis for arranging the predictive power of the variable (i.e., the first variable on the list has the highest predictive power within the sample and the last, has the least). The scores using this procedure are included in Table 5.2.

Also shown in Table 5.2, against each of the variables, is the dominant sign. For each variable within a period (for example 1974-1986) nine regression analyses are produced (one for each of the leads 0 to 8 quarters). Which means that 9 signs (- or +) are produced against each variable for a period. The dominant sign recorded against a variable is the sign that has more than two-third signs (i.e., 6 out of 9 signs) recorded for that variable otherwise -/+ is recorded for a variable that fails to meet this condition.

The Table suggests that sterling exchange rate, ratio of price to cost indices in manufacturing, industrial production, bank base rate, productivity, construction output are promising leading indicators of TPI within the in-sample period. Unexpectedly, building cost index, gross national product and construction neworder exhibited a coincident indicator as shown by their low probability at zero quarter. These results corroborate the outcome of the first experiment in many respects particularly concerning ratio of price to cost indices in manufacturing, industrial production, construction output, building cost index, gross national product and construction demand relationships with TPI.

Table 5.2 TPI predictive information content of the Variable 1974-1986 (52 Quarters)

Variables	Scores	Dominant Sign	Forecasting Horizon in Quarter (Variables as coincident/leading indicators)								
		-/+	0	1	2	3	4	5	6	7	8
SER	38	-	0.2707	0.0009	0.0000	0.0001	0.0009	0.0001	0.0003	0.0007	0.0206
MAN	25	+	0.1738	0.0307	0.0061	0.0110	0.0251	0.0001	0.0013	0.0193	0.2906
EMP	20	-	0.0025	0.0010	0.0106	0.0090	0.4976	0.2008	0.0496	0.0312	0.0117
IOP	20	+	0.0000	0.0002	0.0000	0.0029	0.4002	0.0025	0.8495	0.4993	0.0827
BBR	19	-	0.2543	0.5247	0.4671	0.1794	0.0638	0.0060	0.0007	0.0028	0.0208
PRO	15	+	0.1751	0.1145	0.0000	0.4823	0.3598	0.0041	0.0018	0.3447	0.1487
PUT	12	-/+	0.0001	0.3350	0.0418	0.6289	0.9243	0.3433	0.0621	0.0065	0.0219
ASI	10	+	0.4866	0.8194	0.1235	0.0232	0.0249	0.5148	0.1997	0.1369	0.1126
PPI	8	+	0.0000	0.2115	0.3484	0.1702	0.0221	0.0091	0.2385	0.9937	0.5182
ICP	8	+	0.0001	0.0417	0.3692	0.0605	0.1525	0.6376	0.0778	0.2528	0.3128
AEA	8	-	0.0023	0.0002	0.0719	0.1233	0.8510	0.3584	0.7810	0.4934	0.8632
UTC	8	+	0.0101	0.0053	0.0713	0.1571	0.6458	0.1877	0.6340	0.3965	0.6169
FRM	8	-	0.1844	0.1581	0.1848	0.2081	0.1833	0.0001	0.2651	0.8601	0.6035
FLA	7	-	0.3354	0.2299	0.0848	0.0532	0.0264	0.5718	0.3540	0.7161	0.8246
BCI	6	-	0.0000	0.0009	0.5689	0.4695	0.6908	0.7983	0.7888	0.1631	0.3659
RIR	6	+	0.1143	0.1134	0.1797	0.2494	0.3000	0.1699	0.1933	0.1234	0.1043
GNP	4	+	0.0000	0.8370	0.1756	0.3205	0.1508	0.3302	0.4789	0.1353	0.1242
GPH	4	+	0.0000	0.8476	0.2028	0.4349	0.1213	0.1822	0.8077	0.3189	0.2531
STR	3	+	0.0947	0.3825	0.5954	0.1404	0.7558	0.0711	0.3263	0.5177	0.6923
ORD	2	+	0.0726	0.3420	0.0643	0.3317	0.2812	0.4875	0.2675	0.4623	0.3077
CTX	2	-/+	0.0504	0.9837	0.1684	0.1967	0.9454	0.8873	0.5635	0.6416	0.2055
MSS	1	+	0.0946	0.7377	0.7575	0.5276	0.4618	0.1948	0.9267	0.7143	0.6458

5.6.2 Periodic and Out-of-Sample forecasting power

This section examines the periodic and out of sample predictive power of the variables by grouping the data base into three periods, that is 1974-1979, 1980-1985, 1986-1990. This is somewhat dissaggregated analysis of the data. The period, 1986-1990, is regarded as out-of-sample period, though four quarters out of this period, 1986:1-4, were considered in the previous analysis. This is included in the out-of-sample analysis to have enough observation for requisite degree of freedom. Test runs suggest that this does not affect the interpretation of the subsequent results.

Having disaggregated the database into three periods of almost equal observations such that each period included one trade cycle, the univariate forecasting power analysis of each of the variables was undertaken. This was to test the proposition that the predictive power of some of the variables may not be consistent over time as suggested by the aggregate analysis above. This analysis is also intended to show that a variable that maintains a consistent predictive power, considering these three periods, with consistent signs could be regarded coincident and/or/ leading indicator of TPI. The same procedure of analysis used in aggregate data is used in this disaggregated analysis. Table 5.3, 5.4 and 5.5 indicate the probability that each of the lags of the variables could be excluded from the prediction equation, the scores for each variable and the dominant sign for the periods, 1974-1979, 1980-1985 and 1986-1990 respectively.

The Tables tend to suggest that unemployment, ratio of price to cost indices in manufacturing and Industrial production are consistent leading indicators of TPI in terms of lead quarter, scores and dominant sign. Apart from this, unemployment produces element of coincident indicator between 1974-1979. Gross national product and Income per capital are predominantly coincident indicator, though both acted as leading indicator between the period 1986-1990. The Sterling exchange rate is an inconsistent indicator of TPI as shown by the disaggregate analysis considering the scores and signs, despite the fact that it has the highest predicting power in the aggregate analysis. Capacity utilisation and producer price index (output price) are marginal leading indicators of TPI with consistent positive signs.

Construction neworder and number of registered private contractors are important leading indicators of TPI in 1980s as suggested by the Tables. Unexpectedly, building cost index is a rather coincident indicator of TPI. The leading indication exhibited by building cost index is between 1986-1990. The nominal(bank base rate), real interest rate (bank base rate - inflation) and productivity produced inconsistent results in terms of scores and signs. Corporation tax (though important between 1986-1990), Money supply (M3) and wages and salaries per unit of output, as suggested by the Tables, cannot be regarded as coincident/leading indicators of TPI considering their scores; and the inconsistency in signs and leads. Industry and commercial companies gross profit produces a consistent sign but with low scores, this variable cannot be considered a leading indicator of TPI.

Table 5.3 TPI predictive information content of the Variable, 1974-1979 (24 Qrts)

Variables	Scores	Dominant Sign	Forecasting Horizon in Quarter (Variables as coincident/leading indicators)								
		-/+	0	1	2	3	4	5	6	7	8
SER	12	+	0.0349	0.0066	0.1246	0.0554	0.0021	0.1114	0.3231	0.8674	0.9749
UTC	12	+	0.0090	0.0267	0.1379	0.3101	0.1766	0.0047	0.0625	0.1510	0.3821
EMP	11	-	0.0061	0.0040	0.0980	0.3538	0.7186	0.0004	0.4055	0.2094	0.6895
IOP	11	+	0.0757	0.0805	0.0157	0.2490	0.3563	0.0126	0.0876	0.1847	0.9691
CTX	10	-/+	0.0058	0.8981	0.0335	0.0126	0.6639	0.1476	0.0363	0.3398	0.9319
PRO	9	-/+	0.0984	0.8610	0.0006	0.0148	0.5113	0.3303	0.0227	0.3864	0.6568
MAN	8	+	0.7683	0.5684	0.2223	0.4004	0.7633	0.0003	0.0105	0.2060	0.8443
FLA	8	-	0.4582	0.2753	0.1695	0.1109	0.0542	0.5835	0.7698	0.1404	0.0382
RIR	7	+	0.2060	0.1104	0.1322	0.1448	0.1382	0.9156	0.7575	0.1654	0.0977
ASI	7	+	0.7724	0.0012	0.7411	0.1084	0.0985	0.2217	0.7911	0.6574	0.9918
FRM	4	+	0.0177	0.0508	0.1441	0.2837	0.4631	0.1511	0.5574	0.7842	0.5918
ORD	4	+	0.0366	0.7550	0.1764	0.3996	0.1916	0.0946	0.6495	0.8266	0.3462
PUT	4	+	0.0001	0.6503	0.0981	0.4322	0.6589	0.1848	0.1987	0.9056	0.8174
PPI	4	+	0.0017	0.0079	0.5674	0.8708	0.6089	0.8650	0.5148	0.9570	0.8498
BCI	3	-/+	0.0001	0.0112	0.6726	0.6941	0.8080	0.9001	0.4026	0.9515	0.8143
GPH	3	+	0.0001	0.0315	0.8090	0.7012	0.8171	0.8859	0.6095	0.7797	0.7824
GNP	3	-/+	0.0000	0.0182	0.8951	0.9220	0.7850	0.7912	0.5670	0.8060	0.7597
AEA	3	-	0.0070	0.0150	0.2844	0.3345	0.8461	0.4949	0.9164	0.5273	0.5079
BBR	1	+	0.2160	0.1637	0.5321	0.7228	0.7388	0.4141	0.7890	0.4818	0.7618
STR	1	-/+	0.8515	0.6817	0.4354	0.7034	0.1022	0.3753	0.7217	0.6160	0.8123
MSS	1	+	0.0000	0.5917	0.5995	0.3836	0.1693	0.2179	0.4671	0.5081	0.8642
ICP	0	+	0.0030	0.4425	0.8962	0.2664	0.2548	0.3362	0.4071	0.3027	0.7990

Table 5.4 TPI predictive information content of the Variable, 1980-1985 (24 Qrts)

Variables	Scores	Dominant Sign	Forecasting Horizon in Quarter (Variables as coincident/leading indicators)								
		-/+	0	1	2	3	4	5	6	7	8
EMP	19	-	0.1760	0.0119	0.0381	0.1275	0.7386	0.0180	0.0050	0.0065	0.1856
MAN	14	+	0.7642	0.1226	0.1235	0.1198	0.8319	0.1672	0.0103	0.0072	0.0155
PPI	14	+	0.0907	0.5406	0.3661	0.1044	0.0016	0.0459	0.2069	0.1064	0.0008
IOP	14	+	0.2589	0.0935	0.0219	0.1961	0.2513	0.5133	0.1354	0.0491	0.0021
ICP	12	+	0.4699	0.0246	0.4838	0.6708	0.0333	0.0725	0.5123	0.4614	0.0030
GNP	12	+	0.0027	0.3746	0.3498	0.6922	0.0015	0.0050	0.1376	0.2442	0.0185
ORD	11	+	0.5313	0.8620	0.0706	0.0201	0.9443	0.7254	0.1590	0.0002	0.3687
UTC	10	+	0.7820	0.0182	0.9976	0.4757	0.7067	0.0002	0.1063	0.9353	0.1107
PUT	9	+	0.3074	0.3772	0.1694	0.7794	0.9844	0.0566	0.0011	0.0620	0.9344
FRM	8	+	0.6254	0.9572	0.9465	0.8319	0.5335	0.1503	0.0622	0.0262	0.0705
PRO	8	+	0.0522	0.0425	0.0584	0.9057	0.6463	0.4507	0.1911	0.0648	0.0439
MSS	8	+	0.8649	0.0961	0.0028	0.3878	0.1722	0.3395	0.9292	0.7076	0.1614
FLA	6	+	0.1423	0.0789	0.9439	0.2650	0.8603	0.1403	0.8291	0.0383	0.3989
ASI	6	+	0.1579	0.9644	0.1967	0.1426	0.1677	0.1378	0.4511	0.0887	0.2340
BCI	4	-/+	0.5671	0.7061	0.9363	0.4463	0.1783	0.0761	0.1098	0.7387	0.4709
STR	4	+	0.2987	0.5757	0.7363	0.4405	0.2232	0.7651	0.2061	0.0014	0.2195
RIR	3	-	0.2671	0.4146	0.6021	0.4923	0.4769	0.2132	0.5575	0.0345	0.3487
SER	3	-	0.1762	0.2174	0.3882	0.4905	0.7631	0.8686	0.1933	0.1891	0.1759
CTX	1	+	0.5207	0.8700	0.9903	0.5377	0.2203	0.6942	0.6419	0.7264	0.1966
AEA	1	-/+	0.9165	0.4034	0.2313	0.6676	0.3234	0.1998	0.9565	0.4516	0.5768
BBR	0	+	0.4934	0.2521	0.7445	0.5555	0.6300	0.4400	0.3407	0.6152	0.9022

Table 5.5 TPI predictive information content of the Variable, 1986-1990 (18 Qrts)

Variables	Scores	Dominant Sign	Forecasting Horizon in Quarter (Variables as coincident/leading indicators)								
		-/+	0	1	2	3	4	5	6	7	8
FRM	23	-	0.0383	0.0107	0.0038	0.0004	0.0211	0.0280	0.2041	0.0289	0.1380
CTX	15	-/+	0.0182	0.0891	0.3910	0.0664	0.0140	0.1119	0.5882	0.0288	0.0072
BCI	12	+	0.0072	0.5706	0.0258	0.1200	0.0373	0.8064	0.0702	0.0860	0.1840
EMP	11	-	0.9305	0.7713	0.1326	0.0716	0.0218	0.1533	0.2816	0.1693	0.0265
GNP	11	+	0.0013	0.0608	0.0435	0.5174	0.0485	0.3848	0.3157	0.0968	0.1724
ORD	10	+	0.2566	0.0291	0.0467	0.5869	0.5583	0.3738	0.0576	0.2252	0.0865
MAN	9	+	0.1875	0.8668	0.2512	0.4504	0.0658	0.0437	0.0434	0.9017	0.8801
IOP	9	+	0.2025	0.0647	0.0025	0.1300	0.7387	0.8188	0.5608	0.3245	0.0881
BBR	8	-	0.0798	0.2631	0.0857	0.0350	0.4958	0.0651	0.3734	0.1020	0.6318
AEA	8	-	0.7814	0.1890	0.0460	0.0818	0.7877	0.5069	0.9620	0.0761	0.7971
RIR	7	-	0.3221	0.4457	0.0283	0.0512	0.7661	0.7937	0.5388	0.0586	0.8182
GPH	7	+	0.0004	0.0033	0.1340	0.9434	0.1933	0.3618	0.5849	0.1316	0.6055
ICP	7	+	0.2173	0.0062	0.8044	0.2787	0.3057	0.0469	0.4969	0.9294	0.8754
UTC	6	+	0.0005	0.0117	0.0214	0.9814	0.4016	0.9622	0.5858	0.3311	0.8516
PUT	5	+	0.0013	0.1615	0.0938	0.1555	0.3833	0.7825	0.3440	0.1342	0.8618
PPI	5	+	0.0019	0.1869	0.1179	0.2341	0.0195	0.8060	0.1788	0.2899	0.1102
FLA	5	-	0.1096	0.3872	0.6274	0.2976	0.5930	0.0478	0.0633	0.9964	0.7623
MSS	3	-	0.7458	0.4140	0.0791	0.4645	0.2022	0.3172	0.2018	0.1288	0.6862
SER	2	-	0.2043	0.3384	0.5822	0.5859	0.0898	0.2112	0.6912	0.8286	0.2394
STR	1	+	0.7860	0.8334	0.4199	0.9711	0.1953	0.2594	0.9566	0.4937	0.4669
ASI	1	+	0.0631	0.8081	0.1360	0.4373	0.4836	0.5675	0.5293	0.2558	0.2414
PRO	0	-/+	0.0854	0.7550	0.5112	0.7354	0.2476	0.6776	0.5787	0.6021	0.2857

5.7 Conclusion

This chapter has described the various types of economic indicators regarding the UK economy. Potential indicators of TPI have been listed based on available literature. Using two experimental approaches, variables have been analyzed to determine the type of indicators they are with respect to TPI. Though, the second experimental approach gave a straight forward interpretation of the results the two experiments actually complemented each other.

The following conclusions could be drawn:

1. Some of the time series are not clear and consistent indicators of TPI. Most exhibit combinations of leading, lagging and coincident indicators of TPI over time.

2. Leading indicators change with economic cycle. Some were variables that were leading indicators of TPI in the 1970s and early 1980s only to be replaced by others in the late 1980s. Examples of these are sterling exchange rate, producers price index (output prices) and productivity (output per person employed in the construction industry).

3. Number of registered private contractor and construction demand are inconsistent leading indicators of TPI in 1970s, however, they are good leading indicators from mid 1980s.

4. The building cost index, gross national products and income per capital appear to be more of coincident indicators of TPI and at best leading indicator (though not consistent) by not more than two quarters.

5. The experiments tend to suggest that unemployment, construction output, industrial production (which also contain element of coincident indicator) and ratio of price to cost indices in manufacturing are consistent leading indicators of TPI.

6. Nominal interest rate, inflationary rate, real interest rate, all share index and

money supply (M3) produced inconclusive results.

7. Industrial and commercial companies gross profit has the expected sign with TPI but this is extremely volatile that it becomes difficult to conclude precisely the type of TPI indicator, though it has coincident indicator tendencies.

8. The annualized growth rate experiment tends to suggest the retail price index and wages/salaries per unit of output (whole economy) are lagging indicators of TPI.

9. The variability analysis of these listed variable suggest that construction neworder, construction output and unemployment, among other, are more volatile than TPI.

10. The results from the predictive power of the variables suggest that utilization capacity is a strong leading indicator of TPI but Figure 5.20 produces a picture of coincident indicator.

CHAPTER 6

Demand for Construction

DEMAND FOR CONSTRUCTION

6.1 Introduction

From the two experiments in the last chapter it has become clear that it is difficult to identify clear cut leading indicators of tender price index. Due to this reason, the need to examine tender price from another perspective becomes obvious. Literature from economics seem to produce the answer. The classical economic theory models price of goods and services in terms of demand and supply.

In contrast to consumer goods, there is little theoretical or empirical work on the nature of demand for construction work. Although the literature in economics seem to provide a good theoretical background for studies, the construction industry has generally failed to utilise this opportunity (Hillebrandt, 1985).

Construction contractors are often faced with the need to understand the factors that influence construction demand, as this largely determines their workload and pricing strategy (Carr and Sandahl, 1978). This causes construction firms to scrutinise government annual budget in an attempt to predict the impact of public sector construction demand and the ramifications on private sector investment. Lansley et al (1979) give some support to this, claiming that the size of government budget and changes in public expenditure policy are particularly significant to the industry.

The demand for construction work can broadly be divided into two sectors: public and private (HMSO, 1989). The relative demand for these two sectors has varied tremendously in recent years. Figure 6.1 shows the ratio of UK private and public sectors' construction demand over the years 1974 to 1988. Many factors could have been responsible for this difference, not least the substantive increase in private sector investment. There is a general decline of public expenditure on construction work. Apart from this, the economy has witnessed a major shift into a freer market. Also, the scope of public sector construction investment has changed over the period, particularly because of privatisation. These structural changes in the composition of construction expenditure would probably have affected construction price and the volume of construction demand.

This chapter examines the construction demand equation in relation to construction price and other explanatory variables. It reviews the broad theory of investment demand for capital goods and investment in relation to construction work. Based on this, the determinants of construction investment that are used in the estimation of construction demand equation are identified. Lastly a construction demand equation is developed.

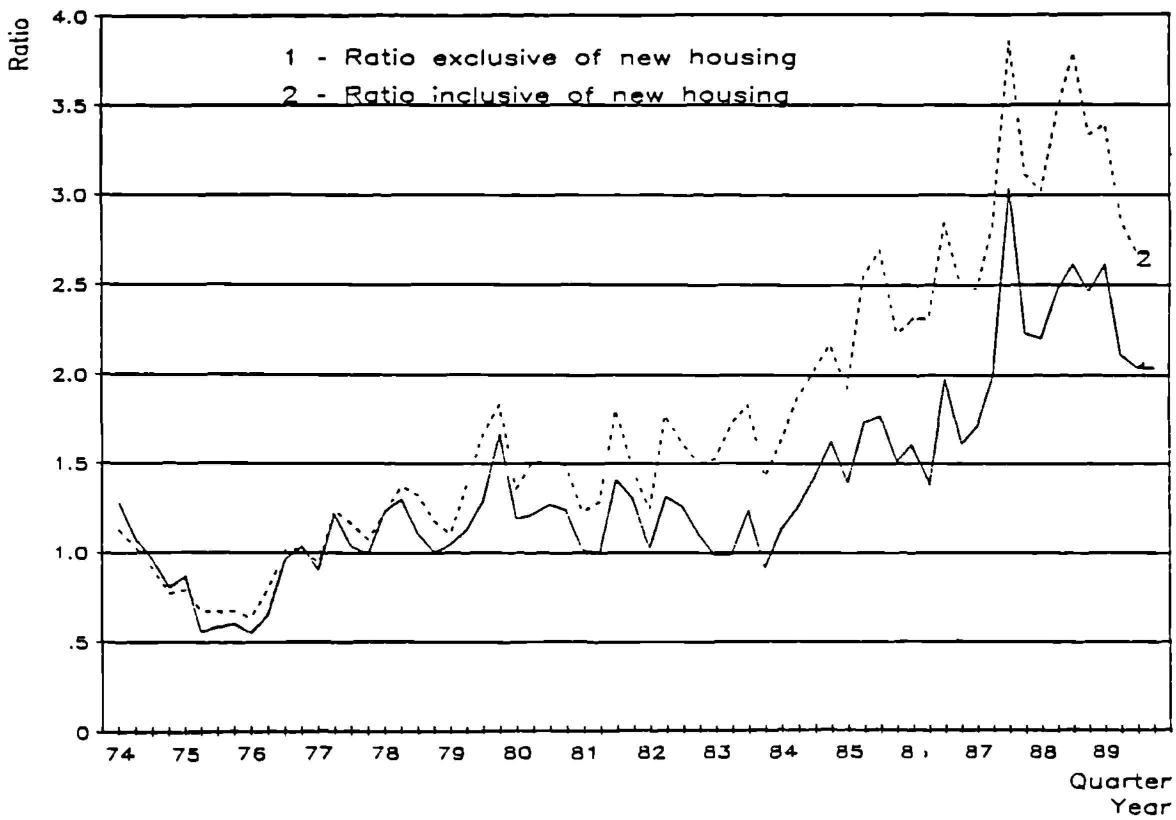

Figure 6.1 Ratio of Private Sector to Public Sector Construction Neworder obtained by UK Contractors

6.2 Theories of Investment demand

6.2.1 Classification of investment spending

Investment spending can be classified into two categories: replacement investment and net investment. The total of the two is gross investment spending. Replacement investment relates to replacing worn out capital items like plant, equipment and maintenance of residential/nonresidential construction. The proportion of the gross investment beyond these replacements of capital goods is regarded as net investment. Net investment which, is usually regarded as derived investment increases the capital stock, that is the capacity to produce goods and services. Most theories of investment spending tend to explain the net investment rather than the gross investment by treating replacement investment as a constant proportion of the capital stock. Nonetheless, Feldstein and Foot (1971) suggested another treatment for replacement investment where this is not replaced on fixed schedule. Refurbishment work falls into this category. Refurbishment often adds to the capital stock particularly when including extension work.

6.2.2 Models of investment spending

Economic textbooks and journals abound with models of capital investment spendings each rooted in different economic theories. Kopcke (1985) identified five approaches for modelling investment functions that are described as elementary descriptions of investment spending. Most investment equations adopted in macroeconomic models are modifications or blends of these five investment spending approaches:

1. The accelerator model
2. The neoclassical model
3. The q model
4. The cash flow model

5. The autoregression model.

On the other hand, Taylor (1987) identified six approaches for modelling nonresidential construction investment which, are thereafter broken down into roughly three groups - accelerator, profits and marginal cost - as follows:

1. Flexible accelerator
2. Cash flow
3. Standard neoclassical (based on the assumption that capital and labour must be substituted in a way that leaves the capital and labour shares of output constant. It also assumes that capital and labour are close substitutes).
4. Bischoff (based on the assumption that capital once purchased cannot be replaced by labour, and they allow labour and capital to substitute in a way that does not force the shares to be constant).
5. Generalised neoclassical (the same as Bischoff but differ in the form of specification).
6. Net return

Taylor classified the cash flow and net return under profit, while standard and generalised neoclassical and Bischoff are grouped under marginal cost.

The rest of this section reviews the different types of investment spending models in relation to established economic theories and draw heavily on discussions on investment spendings Gordon (1984), Kahn (1985), Kopcke (1985) and Taylor (1987).

6.2.2.1 The Accelerator Approach

Accelerator models are based on the principle that net investment depends on expected changes in the demand for business products, that is the expected sales. Simply the return on capital essentially depends on the size of the capital stock relative to the level of output. In this case when the expected sales accelerate which induces the firm to alter its productive capacity, the stock capital (the investment) increases. According to Kahn (1985), "investment is simply the change in the desired capital stock and since the desired capital stock depends on changes in expected sales, investment depends on changes in expected sales. Because expected sales react with varied responses to such volatile variables as business and consumer confidence, net investment can be highly volatile". However, Gordon (1984) claimed that this principle is too simple to explain the year to year fluctuations in investment. This is due to timing and size of the responses of investment to changes in real sales in terms of variable lag and unstable coefficient. So also, Kopcke (1985) claimed that a model that depends on no other economic variables except on short history of output and lagged capital stock is rather too simple a description of investment behaviour.

On the other hand, the mathematical representation of the accelerator investment model (equation 6.1) recognises through the lag (*t-i*), that net investment gradually respond to the growth in demand for business products. This lag becomes necessary in construction work because of the financial and planning hurdles that must be passed through before new investment is in place (Taylor, 1987).

$$I_t = a + \sum_{i=0}^{n} Q_{t-i} + cK_{t-1} \qquad \text{Eqn 6.1}$$

Where

Q = real output
I = investment
K = real capital stock

6.2.2.2 The Neoclassical Approach

This rests on the principle that changes in user cost of capital influences investment behaviour. The user cost of capital is associated with the principle of marginal cost, that is, firms purchase capital until the rate of return on an extra or marginal unit just matches its cost. In essence, firms evaluate the merit of investment by comparing the marginal product of capital (MPK) with the real user cost of capital. New investment projects are undertaken up to the point where the marginal product of capital just equals the real user cost (UCK) (Kahn, 1985). By definition, MPK is change in revenue divided by the cost of investment project expressed in percentage. Decision rule is as follows:

MPK/UCK	= 1	No further investment
MPK/UCK	> 1	Profitable to firm to invest further
MPK/UCK	< 1	Firm incurs losses, hence no incentive for further investment.

Kahn (1985) also identified 3 factors determining user cost of capital:

a. interest cost: This comes into investment capital cost in form of either the interest paid on loans or foregone interest by tying up funds in the purchase of capital. The higher the interest rate, the higher the cost of capital and the lower the investment rate expected;

b. depreciation cost: The need to replace capital wearing out through normal use is imperative if it is intended that the same level of productivity is to be maintained by the capital stock. The cost of maintaining the constancy of capital stock is the depreciation rate. The faster the capital depreciates the higher the user cost; and

c. inflation: This raises the cost of new capital and the value of existing ones. It acts as a capital gain that offset the user cost by lowering the UCK.

Another determinant of user cost of capital is tax. This could act directly or indirectly in relation to the three determinants identified above to add another dimension to user cost. Three ways through which tax laws influence the UCK are identified as follows (Kahn, 1985):

a. corporate income tax: the higher this tax, the higher the user cost as firms incur more interest rate;
b. depreciation rate: tax policy that allows the firms to deduct the value of their

capital depreciation from their corporate income tax reduces the user cost; and

c. investment tax credit: the tax law that entitles firms to credit on their corporate tax bill to a specific proportion of their capital investment has influence on the user cost. This lowers the tax liabilities (that is, lower user cost) and increases profits, all of which act as incentive to increase investment.

From the neoclassical point of view it becomes clear that factors which affect the user cost of capital have impacts on the net investment that are summarised as follows:

1. Increases in interest rate, economic depreciation rates, or effective tax rates raise user cost and depress net investment;
2. Inflation raises user cost and lower investment by interacting with an unindexed tax code, but lower user cost raises investment by providing capital gains; and
3. Increases in expected output that are associated with increases in real GNP growth, raise the desired capital stock and increase investment spending.

Kopcke describes this as a more general description of investment behaviour than the accelerator approach. Kahn (1985) on the contrary, noted that there is more empirical uncertainty about the relative importance of the user cost determinants and how they interact with each other.

6.2.2.3 The q Approach

This is based on the principle that investment spending varies directly with the ratio (commonly known as "q") of the market value of business capital assets (MKV) to the replacement value of those assets (RPV). This ratio compares the yield on investment projects with rates of return required by lenders and savers (Tobin and Brainard, 1977; Abel, 1978; Summers, 1981). The decision rule for the investment spending based on q-Theory is as follows:

values of $q \geq 1$ encourage the growth of the capital stock

$q < 1$ discourage investment spending

The investment spending in respect of the q approach depends on the relationship between the demand price for capital assets (the price at which firms are willing to pay for an investment project after assessing its prospective returns) and its supply price (the cost of producing new capital goods). Excess demand price (caused by technology or business conditions, for example) over supply price create profitable investment opportunities until the time that these are exploited and exhausted.

Auerbach (1979) argued that the values of q just below unity need not deter investment spending as demand price for capital goods depended both on their economic returns and the tax treatment of those returns.

The q ratio rises when the returns on existing or prospective investments rise relative to the cost of replacing those investments. This approach is more relevant to investment spendings on plant and equipment rather than construction work. Construction work has some peculiarities in nature that do not exist when compared with plant and equipment. For example, construction is fixed to land (not mobile), mostly massive, and cannot be easily traded. The model is therefore not very popular with investment spending analysts.

6.2.2.4 The Cash Flow Approach

This approach correlates the investment spending to the cash flow available to a firm. This approach recognises that firms investing in capital goods rely on three general sources of funds: internal cash flow, loans and debit issues, and sales of equity. It also recognises that the cost of using each of these sources is not recognised entirely by its yield.

Internal cash flow

This is useful to meet the financial obligation of firm. It could be traded in securities bearing market yields, hence, the cost of using these funds to acquire capital assets roughly equals the market yield under a profit maximization condition.

Loans and debit issues

These are restrictive sources of capital asset funding in the sense that it places different restrictions from the lender on the capital budgeting decisions of investors and is characterised by volatile cash flow. Such restriction could include minimum value attached to:

Loan to value ratios (amount of debt relative to the value of property or securities)
Coverage ratios (profit divided by interest payments)
Working capital ratios (current assets less current liabilities all divided by outstanding long-term debit)

These restrictions and volatility in the amount of cash flow have impacts on the investment spendings of firms or investment control by the firms' owners. Firms that are unable to meet the minimum restriction values are most unlikely to have at their disposal loans to invest in capital projects. Also the cost of financing these loans and debit issues may be more expensive than their yields particularly due to increasing firms dependency on borrowed funds.

Equity sales

This form of improving cash flow has to do with sales of shares to meet current or prospective investments in capital project(s). The financing of this could be as equally expensive as loans and debit issues than its yield particularly in the short-run until the funding starts contributing to the profit level of firms.

This approach to investment, therefore, relies on the general principle that firms commit their retained earnings to fund capital budget before considering the other two sources of funding and that the size of the capital budget (investment spending) depends on firms' available cash flow.

6.2.3 Summary and comments.

Considering these different approaches to investment spendings it becomes obvious that the factors that influence capital investment can be classified into three groups: business profit, expected sales or output and the users cost of capital. The users cost of capital is influenced by tax rate, inflation, prices of capital goods, real interest rate and depreciation cost.

These three broad groupings of factors in investment spendings are theoretical in nature. Subjectivity of investor is an aspect of investment decision that is very difficult to model. This may relate to anything, including investors' perspectives of constraints (political, social etc), prospects for growths and motives for investment amongst other things.

6.3 Measurement of Construction Demand

Demand in economics is the willingness and ability to purchase goods and services. The New Collins Concise Dictionary of the English language defines demand among others as "the amount of a commodity that consumers are willing and able to purchase at a specified price". 'Consumers' of construction works are usually referred to as 'clients'. The two main qualifications of demand are "willingness" and "ability". "Willingness" can be defined as "readiness", "favourably disposed", or "acceptable". "Ability" on the other hand, is "possession of necessary power" and "natural capability". In construction, an investor must demonstrate the readiness and possess the necessary power (funding) before such can claim to demand for construction work. However, to come to the conclusion as to the measure of construction demand in the construction industry there is the need to answer the following:

1. Who is a construction industry client?
2. What constitute clients' construction needs?
3. At what stage does a client shows his willingness and ability to purchase construction work?

4. At what price does a client purchase construction work.

6.3.1 Types of clients

Construction clients can be broadly categorised into two: public sector client and private sector client (HMSO, 1990). Jepson and Nicholson (1972) identified four types of clients that are subsets of the two broad groups: a speculator or developer investing in building for profit; a public body, investing in building on behalf of, or for the benefit of, the community; an occupier with a family or commercial activity or an industrial process to house; and a person or body seeking a monument.

6.3.2 Clients' construction needs

According to Wells (1985), construction is generally used to describe the activity of the creation of physical infrastructure, superstructure and related activities. These creation of construction facilities are embarked upon after the clients have realised the needs for them (Hillebrandt, 1985). Construction needs by client can, therefore, be classified into five broad categories as follows on the basis of needs from public and private clients (HMSO, 1989):

Public sector - new housing

Public sector new housing comprises construction needs for dwellings commissioned by governmental institutions/departments. This includes local authority housing schemes, hostels, quarters for the services and police, old people's homes, orphanages and children's remand homes, and the provision within housing sites of roads and services for gas, water electricity, sewage and drainage.

Private sector - new housing

This encompasses all privately-owned buildings for residential use, such as houses, flats, maisonettes, bungalows, cottages, and provision of services to new development. Also included is speculative work where no contract or order is recorded.

Public sector - other new work

This relates to any other construction work undertaken by governmental institutions apart from public sector housing. This includes construction work for education, transportation, health, social services, commerce, and agriculture provided from public funds.

Private sector - industrial work

Construction investment in private sector industrial work is diversified, and includes industrial production and processing, the oil and power generating industries provided by the private sector. Examples of this includes factories, warehouses, electricity and gas installation, and in recent times construction works commissioned by privatised establishments such as British Telecom and British Gas.

Private sector - commercial work

This relates to private sector construction needs in the field of commerce. It includes the construction of office blocks, hotels, schools and colleges, agriculture, health, churches, and garages.

6.3.3 Conversion of construction needs to demand

After the identification of construction needs by clients, there is a need to convert this to effective demand or real demand. Skitmore (1989) has identified the factors relating to meeting the clients' construction needs as procurement methods and contractual methods. In essence, to meet the clients' construction needs require the bringing together of the consultants (architects, quantity surveyors, civil engineers, construction managers, services engineers etc) and the contractors (sub-contractors, suppliers, main contractors etc.). The need is defined using design that could be got through various methods (Jepson and Nicholson, 1972) as follows:

1. By offering a range of models that are within the understanding of the client and from which he may choose one for development,
2. By offering a range of evaluated designs from which the client may choose the form of a design for development,
3. By offering to translate client wishes into a design in the course of a dialogue, or
4. By persuading the client that what he needs is represented by some design.

Having arrived at the design the next stage is to commission a construction firm or groups of construction firms to build the design. The commissioning of a firm or groups of firms takes place through adoption of specific procurement method and contractual arrangement. Ireland (1985) and Morris (1989) have identified procurement methods in common use: a single lump-sum contract on a fully documented project; provisional or partial quantities contracts; cost reimbursement (cost-plus); package deal (design and construct or turnkey); cost management; and project management. The Junior Organisation quantity surveyors committee (1989) has carried out survey of the contractual arrangement in use and Hancock (1987) has identified the issues involved in selection of contractual arrangement.

Considering the procurement methods and the contractual arrangement the client, with the advice of his consultant moves into the process of giving out the work to a firm or group of construction firms to building through a process of tendering. The tendering procedures in contract procurement can be classified into three broad classification: selective competitive, open competitive and negotiated (Smith, 1981).

Through one, or a combination of these tendering procedures, tender or bids are submitted to clients by competing firms (Hunt, 1970). However, one (or a group) of construction firm are identified, considering their prices and other factors that may interest the client/consultants, to do the job. The client thereafter enters into contract with such firm(s). At the stage at which the client decides to enter into contact with the contractor(s) the willingness is established and the construction need(s) becomes an effective demand.

6.3.4 Price of effective demand

The building industry is generally accepted as very competitive (Runeson and Bennett, 1983). Hence, the choice of contractor and the accepted construction price by the client is mostly through the process of competition (selective or open tendering) or negotiation (negotiated tendering). Construction firms meet in competition on the same project and put forward their tender prices, each with the aim of winning the contract. Each tenderer considers what the market will bear, that is, the maximum price the client will accept and the tender price other competitors will submit (Hancock, 1990). In selective tendering it is not unusual to pick the lowest tender price as the successful tender. In essence, the most interesting of all the tenders submitted to the client for of his construction need is the successful one. This determines the price that the client is going to pay for the work (Runeson, 1988). If the client decides to enter into contract with the successful tenderer based on his tender price (or the negotiated price), the successful tender price (or the negotiated price) for that project becomes the market price for the project. In essence, the price is determined for each project individually through the bid/negotiation process (Hillebrandt, 1985).

6.3.5 Measuring construction demand

The condition under which client's construction need becomes effective demand and the price associated with this effective demand have been identified. Regarding consumer goods the demand is the quantity demanded at the specified price. The theory of demand for consumer demand assumes that the various quantity of goods needed at different prices have the same quality. This means that the products are undifferentiated; and each unit of product has identical input cost (Liversey, 1976); and with the same unit of measurement. Unlike the consumer goods that are produced by manufacturing firms, the physical nature of the construction product is massive (Hillebrandt, 1985) and highly differentiated, with a variety of product types and project sizes (Killingsworth, 1990). A construction work may constitute a very huge proportion of a construction firm annual turnover (Akintoye and Skitmore, 1991). With these differences or special characteristics of construction products it becomes very difficult to count one by one or quantify them like consumer goods.

Despite these difficulties, there is a need to identify the aggregate construction demand in a measurable term. Runeson (1988) measures this as the value of building approvals. This does not seem to tally much with the definition of effective demand as the approval of construction work only ensures that design meet building regulations. This does not guarantee that the client will go on to the point of getting into contract with a construction contractor to construct the project. Tan (1989) used the gross floor area of construction start. This also falls short of the definition of demand as the price per gross floor area is highly variable depending on the size, quality, type etc of the building. Herbsman's (1983) use of the volume of construction out for bid as a measure of demand for construction is misdirected. This is more of potential demand than effective demand. On the other hand, Killingsworth Jr.(1990) used value of new construction put-in-place as a measure of construction demand. This is likely to correlate with effective construction demand but does not have the same meaning as effective demand. By 'putting construction in place' it may be assumed that they have already been or being paid for through interim certificates. If this is the case, the amount paid on put-in-place new construction could not be regarded as the market price but commercial price (commercial price includes prices arrived at on claims, variation etc through negotiation without recourse to market price). If the value of new construction put-in-place fails to meet the condition of "market price" then it cannot be regarded a measure of construction demand.

A measure of construction demand that has received some acceptability is the value of construction neworder obtained by contractors. Lea and Lansley (1975) adopted this as a measure of construction demand. This measure was found to be responsive to changes in economic policy in respect of tax, interest rates, government expenditure, etc. However, the outputs were found to depend to a marked degree on the orders placed in the preceding year. The order is the aggregate of the accepted tender prices by contractors. To ensure that this value has a constant price it can be deflated by GDP deflator. The Department of the Environment defines value of the construction neworder as: "value of contracts for new construction work awarded to main contractors by clients in both public and private sectors, including extensions to existing contracts and construction in 'package deals'. Also included is speculative work, undertaken on the initiative of firm, where no contracts or order is awarded, the value of this work is recorded in the period when foundation works are started eg on houses or offices foe eventually sale or lease" (CSO, 1990). This definition appears to meet the description of effective demand as they are backed up with the willingness and ability of client to pay by entering into contract with contractors at a market price. The word "value" after being deflated in the above definition is literarily interpreted as "quantity demand"

Hence, the construction demand at current prices after being deflated constitute our effective demand and literarily used as construction investment.

6.4 Investment in Construction

The products of the construction industry are usually regarded as investment goods (Hillebrandt, 1985), and part of fixed capital formation, which is essential for a rapid or continuous economic growth. Investment in construction work averaged between 8% and 12% of the U.K Gross National Product within the past two decades indicating the importance of construction products even in a developed economy.

The needs for investment spending can be generally classified as (1) expansion (to create additional capacity) and (2) rationalisation (to reduce cost, so that the profit margin could be maintained). Investment undertaken primarily because need for expansion leads to economic growth. Construction investment for expansion may be either "growth-initiating" and "growth-dependent" (Drewer, 1980). When investment expenditure influences the trend and cyclical components of economic growth, such investment could be regarded as "growth-initiating". Construction could bring about growth due to its multiplier effect on the economy. In developed countries, however, most investments in construction are growth-dependent, which makes construction investment a derived demand.

6.5 Trends in Construction Investment

Figures 6.2, 6.3 and 6.4 show clearly the fluctuation in the construction investment between 1974 and 1988 (DoE). Figures 6.2 and 6.3 show the investment by construction type at current and real prices (1974 rebased) respectively. Figure 6.4 shows the shares of the construction type in the total quarterly construction investment within this period.

Except for private sector industrial work none of these investment types have been stable over the years (Akintoye and Skitmore, 1991). There have been large fluctuations in the share of individual construction types, notably the rising share of private sector commercial work and housing, and drastic fall in the share of public sector housing.

The 1970s witnessed low emphasis in private sector construction investment and were characterised by large scale public sector construction investment both in housing (10%-25% share) and other new works (25%-35% share). In the 1980s however, the private sector construction investment was dominant with 20%-35% investment shares in both private sector housing and commercial work.

The trough in construction investment between 1980 to 1984 was probably due to the recession within this period. However, these years coincided with the beginning of an acceleration in private sector investment in housing. The spontaneous rise in private sector industrial work in the second quarter of 1987 was due to an element of European Channel Tunnel investment included in the value of industrial work. Otherwise, private sector industrial work had been stable.

Changes in the pattern of investment in construction types over the period is, perhaps, associated with changes in government policies and the rapid changes in the determinants of fixed investment in construction and manufacturing.

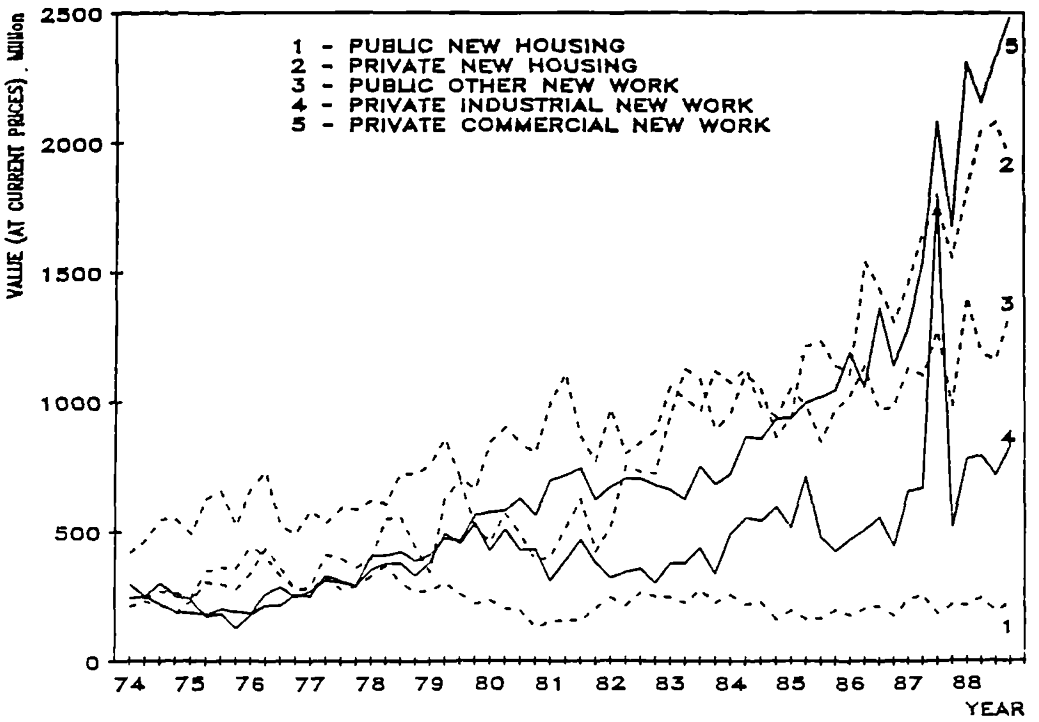

Figure 6.2 Sectorial investment on new construction works at current prices

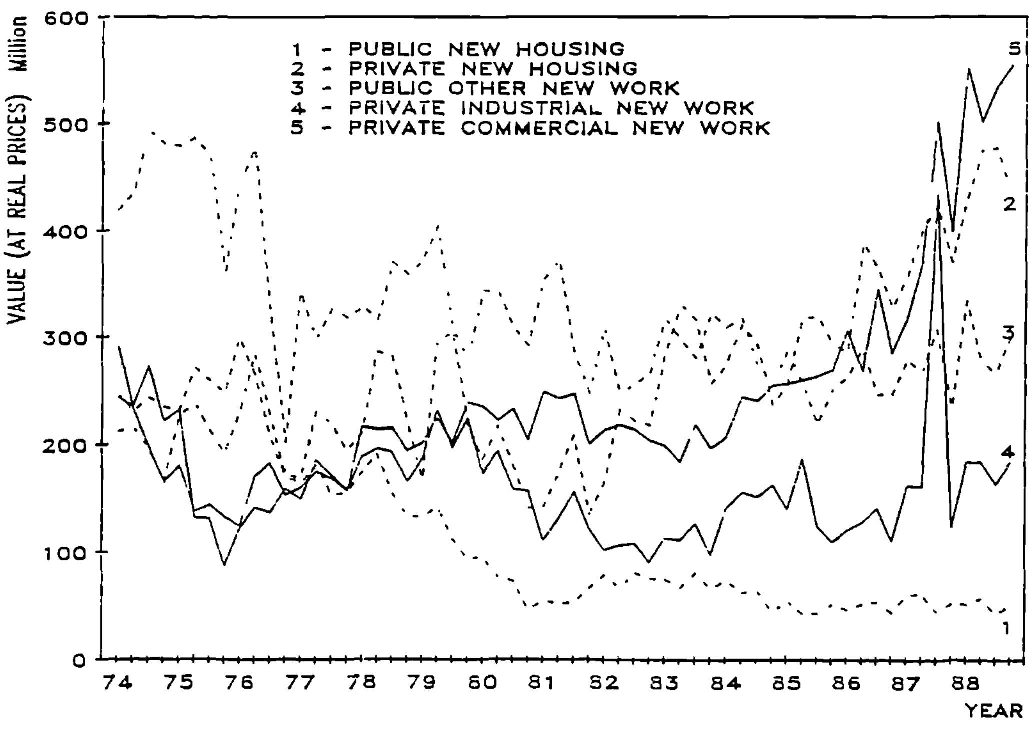

Figure 6.3 Sectorial investment on new construction works at 1974 price

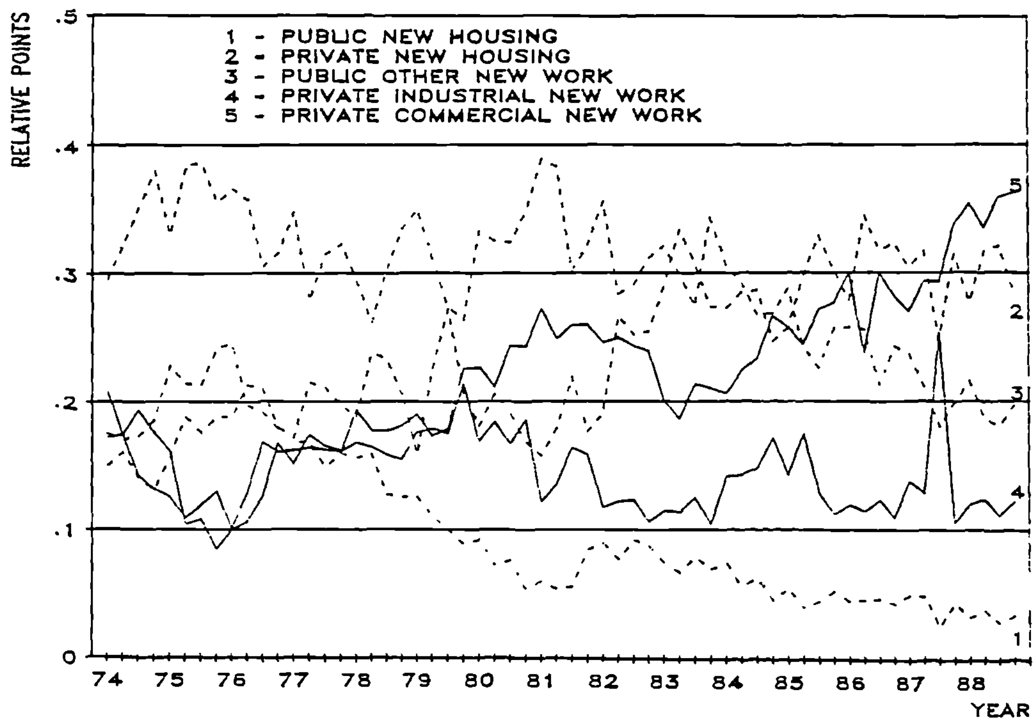

Figure 6.4 Relative sectorial investment in construction works.

Recent government policies place more emphasis on a freer market economy, while both individuals and firms are being encouraged to invest more in construction work. The increase in the private sector new housing in the 1980s compared with the the 1970s was perhaps as a result of government policies. This includes low mortgage interest rates relative to the inflation rate and the tax savings available to home-owners, which grew in importance as marginal tax rate rose. These inducements could have led to the boom in the private sector housing investment. However, there is slump in private sector construction investment at present, probably due to the current recession.

6.6 Factors influencing Construction Demand

Economic theory provides the basis for identifying factors affecting demands for goods and services. In the construction industry, these can conveniently be categorised as general and local factors. There are five basic groups of general factors: political, economical, social, technological, and legal/legislative (Bahrami, 1981). Local factors include a combination of building types, procurement types and geographical location (Skitmore, 1987). Hillebrandt (1985) had earlier identified leading indicators of construction demand that were summarised by Killingsworth, Jr. (1990) as follows:

1. population,
2. interest rate,
3. shocks to economy,
4. the demands for goods,
5. surplus manufacturing capacity,
6. the ability to remodel (meeting demand through renovation),
7. government policy (monetary, fiscal eg, tax policies),
8. expectation of continued increased demand (demand for manufacturing goods),
9. the expectation of increased profits (on the activities of those that demand construction),
10. new technology.

These factors have been investigated as the potential leading indicators of USA construction demand by Killingsworth (1990) using graphical representation and multiple regression. The results of this investigation suggested economic shock (with six quarters lead), interest rate (with two quarters lead) and demand for goods (with three quarters lead) as leading indicators of construction demand.

From construction literature and investment spendings theory it becomes obvious that the price of construction, economic condition, utilisation capacity, real interest rate and profitability appear to occupy a central role in the make up of construction demand.

6.6.1 The State of the Economy

The construction cycle is closely linked with the general business cycle (Tan, 1987). Among other factors, the quantity and to some extent quality of construction demand is dependent on the national economy. There is a relationship between construction demand and the growth in gross national product (GNP), as a measure of the economic well being of a nation (Hutcheson, 1990). The mechanism for this is thought to be that the demand for construction works is derived from the demand for consumer goods. A period of economic prosperity tending to raise consumer demand for goods and services which, in turn, triggers up the demand for construction space (Kilian and Snyman, 1984). Kopcke (1985), Kahn (1985) and Taylor (1987) have all identified the real GNP growth with growth in expected sales and consequently growth in investment spendings.

6.6.2 Tender Price Level

The relationship between the demand and price is a recurring theme in economics. Runeson and Bennett (1983), McCaffer *et al* (1983) and Runeson (1988) have shown that construction price levels are dependent on the demand for construction. Taylor and Bowen (1987) also showed that a fluctuating demand for construction leads to fluctuating prices, and *vice versa* suggesting that demand for construction may depend on the relative price level of construction.

6.6.3 Real Interest Rate

Real interest rate, that is the difference between the nominal interest rate and the inflation rate, may be used as a proxy variable for credit market conditions (Hess, 1977). Sharpe and Alexander (1990) produced an explanation for real interest rate rather than nominal interest rate in investment decisions. In periods of changing prices the nominal interest rate may prove a poor guide to the real return obtained by investor, hence, the cost-of-living indices or consumer price index that provides a rough estimate of changes in prices are incorporated into interest rate to arrive at real interest rate as a measure of credit market conditions for the investors.

Investments in construction are most likely to be financed from loan credit or organisation profit, hence real interest rates constitute an important cost factor in construction. Even where investment is financed from organisation profit, interest rates is still an element in the decision making process as the return from alternative investments such as fixed interest bearing securities may be very attractive (Buyst, 1989). This evaluation of alternatives ensures that investment projects are undertaken only if they yield stream of returns that, in discounted present value, exceeds the cost of financing. Thus, while inflation rate is often measured by changes in the retail price index, the nominal interest rate is usually represented by the bank base rate. The credit market condition is expected to decline in times of high real interest rates, thereby depressing investment opportunities.

6.6.4 Unemployment

An increase in unemployment or even a declining rate of growth of employment in an economy may discourage investment in construction. This is due to the linkage between construction demand and the total purchasing power of the population. There is a need to include both the ability and willingness to pay in modelling demand for capital investment. Ability to pay is often taken to be represented by an income variable (like GNP for the whole economy). On the other hand, unemployment is often used as a proxy for the willingness to pay and it often enters the demand equations with negative sign (Evans, 1969). Increases in unemployment may raise the level of financial uncertainty among potential investors in construction and cause them to defer or abandon investments with a resulting decrease in total new construction volume. Conventionally therefore, low unemployment is regarded as favourable for investment (Raftery, 1990). In the USA for example, there is a negative relationship between unemployment and construction investment which, outweighs the beneficial effects of investment tax cuts (*Construction Review*, 1982).

6.6.5 Manufacturing profitability

The manufacturing price/cost ratio is a proxy for the profitability in the manufacturing industry. High profitability in the manufacturing sector may encourage investment to enable increases in production. This may affect the construction industry either directly as capital investment in new buildings or indirectly in the form of increased pay to personnel and increased returns to shareholders, encouraging increased spending on housing.

6.7 A Model of Construction Demand

6.7.1 Structure of the model

Causal relationships for econometric models have to be derived from some relevant theory, although the strength of relationships may often be usefully estimated empirically by econometric techniques. From preceding reviews five variables are posited as potential leading indicators of construction demand - GNP, price level, real interest rate, unemployment and manufacturing profitability. The strength of the relationships to construction demand are estimated by multiple regression econometric technique.

To reduce the dominating effects of general inflationary trends, it becomes necessary to deflate the values of affected variables (demand, price, and GNP). These have been rebased to 1974 by dividing them by the retail price index.

The model of construction demand and these five variables can be represented as shown in Equation 6.2.

$$Q^d_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y^d_t + \alpha_3 r_t + \alpha_4 U^e_t + \alpha_5 M^P_t + U_t \qquad \text{Eqn 6.2}$$

where

Q^d = construction demand
P = Tender price level
Y^d = Gross national product
r = real interest rate
U^e = Unemployment
M^p = Manufacturing profitability
U = disturbance term
t = time lead (quarterly)

Elasticity of response of the dependent variable to independent variables is a point of interest in this study. The elasticity of the dependent variable is the proportionate change in dependent variable in response to a tiny proportionate change in independent variables (Hebden, 1981).

In this case, equation (6.2) was expressed as log-linear or double-log as shown in equation (6.3). Double-log in the sense that both the dependent and independent variables have been expressed in natural logarithm except for real interest rate. The raw real interest rate was used due to the presence of negative values.

$$\ln Q^d{}_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 \ln Y^d{}_t + \alpha_3 r_t + \alpha_4 \ln U^e{}_t + \alpha_5 \ln M^P{}_t + U_t \qquad \text{Eqn } 6.3$$

6.7.2 Methodology

The method of analysis was based on the OLS multiple regression and anticipates lead relationships between the dependent and independent variables. The estimation of the lead values, *t*, is based on the multiple regression program discussed in Appendix B using neworder as the dependent variable with the five independent lead variables (P, Y^d, r, U^e, M^p) having an integer range of 0 to 8 lead periods. This program produced a total of 59049 separate regression models at a complete run of the program for examination in relation to construction demand. (a total of 9^v

regression models is expected to be produced at a complete run of the program where v = number of independent variables that take on integer range 0 to 8 lead periods). Table 6.1 shows the computer output print-out from the complete run of the program. The examinations of the models were carried out to identify the model that suit our theoretical expectations in terms of lead period relationship. Based on the examinations the appropriate model was chosen

Table 6.1 Construction demand OLS multiple regression program output

PROGRAM ENTERED

DATA IN

TP	PA	EM	BB	GP	SEE							
0	0	0	0	0	0.00836	-9.528	-0.617	0.883	-0.451	0.002	1.537	60
0	0	0	1	0	0.00735	-10.673	-0.724	0.679	-0.446	-0.002	1.791	59
0	0	0	2	0	0.00712	-10.463	-0.809	0.471	-0.466	-0.001	1.902	58
0	0	0	6	0	0.00700	-7.558	-0.839	0.640	-0.495	0.006	1.549	54
0	3	0	0	0	0.00666	-11.423	-0.766	1.110	-0.367	-0.005	1.680	57
0	3	0	1	0	0.00651	-12.095	-0.730	1.018	-0.360	-0.006	1.773	57
0	4	0	0	0	0.00627	-12.503	-0.704	1.586	-0.297	-0.007	1.538	56
0	4	0	0	5	0.00621	-11.203	-0.773	3.547	-0.189	-0.003	0.530	55
0	4	0	1	0	0.00601	-13.532	-0.631	1.574	-0.271	-0.009	1.613	56
0	4	0	6	0	0.00600	-7.310	-0.905	2.431	-0.348	0.005	0.720	54
0	4	5	1	1	0.00588	-13.467	-0.386	3.570	0.010	-0.012	0.566	55
0	4	8	1	0	0.00582	-14.684	-0.425	3.410	-0.030	-0.013	0.780	52
1	4	0	6	5	0.00562	-7.940	-0.951	2.643	-0.339	0.005	0.706	54
2	4	7	1	0	0.00557	-13.985	-0.462	2.968	-0.065	-0.011	0.930	53
2	4	7	1	1	0.00553	-14.090	-0.521	3.061	-0.062	-0.011	0.924	53
2	4	8	1	1	0.00552	-13.965	-0.496	3.149	-0.037	-0.014	0.859	52
3	4	0	1	6	0.00544	-11.107	-0.540	3.813	0.015	-0.013	0.285	54
3	4	1	1	6	0.00542	-11.172	-0.500	3.893	0.039	-0.014	0.235	54
3	4	2	1	6	0.00541	-11.148	-0.475	3.898	0.050	-0.014	0.220	54
3	4	3	1	0	0.00520	-13.216	-0.706	1.757	-0.219	-0.012	1.525	56
* 3	4	4	1	0	0.00510	-14.052	-0.766	1.765	-0.249	-0.011	1.632	56

OK,

SV14 (user 77) logged out Thursday, 31 Jan 91 19:02:48.

Time used: 05h 54m connect, 79m 12s CPU, 00m 20s I/O.

6.7.3 Results and Analysis of the Construction Demand Model

Parameter estimate of construction demand is provided in Tables 6.2 using quarterly data from the first quarter of 1974 to the fourth quarter of 1987. {For parameter estimation of sectorial construction demand - private sector and public sector construction demands - see Akintoye and Skitmore, 1991a & b}. The Table which, is a computer output print-out based on SPSS-X statistical package shows all the relevant statistics connected with the model.

The model in Table 6.2 is statistically good (R^2 *Adj=0.82, DW=1.92*). At five per cent level of significance, the DW statistics imply non-rejection of the null hypothesis of zero autocorrelation. The signs are consistent with the theoretical view and the t-values indicate all the estimated coefficients are statistically significant at the five per cent level or lower.

Since the equation is log-linear, the standard error of the estimates (Rmse) implies an average within-sample prediction error of seven per cent.

Table 6.3 summarises the unsigned beta coefficient contribution to variability in sectorial construction demand, expressed in percentages. The beta coefficient signs are in parenthesis.

From the model, it becomes clear that the small shift in the demand function in relation to price movements (elasticity = 0.766) suggests that construction demand is price inelastic. Price absolute beta coefficient contribution is less than 20 per cent with 3 quarters lead period.

Construction investments have a positive elastic relationship with GNP. The simultaneous response at lead period $t=0$ tends to support the importance of national income or economic conditions to construction investment. It has the highest beta contribution (27 per cent).

Employment is negatively and inelastically related to construction investment with lead period of 4 quarters. This has two implications (1) an increasing

Table 6.2 Analysis of Construction Demand: Statistics

**** MULTIPLE REGRESSION ****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. NEWORDER

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number	1..	AGNP	
	2..	BTPI	LAGS(ATPI,3) on 27 Mar 91 at 10:10
	3..	BMAN	LAGS(AMAN,4) on 27 Mar 91 at 10:10
	4..	BRIR	LAGS(RIR,1) on 27 Mar 91 at 10:10
	5..	BEMP	LAGS(AEMP,4) on 27 Mar 91 at 10:10

Multiple R	.91308	Analysis of Variance			
R Square	.83371		DF	Sum of Squares	Mean Square
Adjusted R Square	.81708	Regression	5	1.27896	.25579
Standard Error	.07143	Residual	50	.25510	.00510

F = 50.13553 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
GNP	1.631811	.284817	.826349	5.729	.0000
TPI	-.765830	.167940	-.601661	-4.560	.0000
MAN	1.764624	.460120	.385921	3.835	.0004
RIR	-.010641	.003622	-.399879	-2.938	.0050
EMP	-.248549	.070351	-.804832	-3.533	.0009
(Constant)	-14.051591	1.762484		-7.973	.0000

End Block Number 1 All requested variables entered.

Table 6.3: Absolute beta coefficient contribution of variables (in per cent) to variability in construction demand equations

	P	M^P	U^e	r	Y^d
NEWORWKL	19.9 (-ve)	12.8 (+ve)	26.7 (-ve)	13.2 (-ve)	27.4 (+ve)

unemployment rate has a declining effect on construction investment generally and (2) changes in the unemployment level in an economy is good indicator of the trend in construction investment.

The real interest rate has the expected negative correlation with construction demand at the lead of one quarter. The beta coefficient contribution is 13 per cent.

The manufacturing profitability absolute contribution to the model is 13 per cent with the lead period $t=4$. This tends to suggest that the manufacturing industry activities lead construction industry's by a year. High profitability in the manufacturing sector will tend to suggest that there will be enough dividends for the shareholders and retention for further investment in capital project.

6.7.4 Analysis of the Model Residuals

6.7.4.1 Statistics

Table 6.4 shows the results (minimum, maximum, mean and standard deviation) on the different statistical analysis of the residuals. Appendix 6.1 produces the statistics on casewise basis.

Statistical analysis of the residuals confirms that the model is statistically significant. Relevant to this are the results on the expected value of the residuals $E(U_i)$ and the expected value of the standardized residuals that are zero (s^2 = 0.0681 and 0.9535 respectively) which, confirm a high probability of normal distribution of the residuals. Also the result of the leverage value (LEVER) (mean=0.0893, s^2=0.0901) shows that the mean falls below the critical leverage value (critical value = 2P/n = 2 x 4.9999/56; where p is the addition of each case leverage value, and n the number of cases). Out of the 56 cases only two cases (cases 5 and 8) have high leverage points, that is, more than the critical limit (see appendix 6.1). The high Mahalanobis' distances of these two cases are not surprising, as the calculation of this distance is based on the leverage value. Appendix C provides interpretation and the description of these residual test statistics.

6.7.4.2 Outliers

Table 6.5 indicates the standardised residual outliers (cases with large residuals). The outliers are neither many nor patterned except in cases 55 and 56 which, are third and fourth quarters of 1987 that coincided with investment in the European Channel Tunnel. This unusual construction demand during these two quarters could be regarded as "shock" to the model. Only two residuals from the 60 cases have standardized values greater than two or less than -2.00 which, is less than the 5 per cent one would expect by chance.

6.7.4.3 Shape

Figure 6.5 indicates the frequency distribution of the standardized residuals for the construction demand model. The shape suggested the model is an approximately normal distribution (a vital assumption for regression analysis).

Table 6.4 Analysis of Residuals: Residuals Statistics

	Min	Max	Mean	Std Dev	N
*PRED	6.7378	7.3396	6.9869	.1525	56
*ZPRED	-1.6333	2.3128	.0000	1.0000	56
*SEPRED	.0135	.0582	.0223	.0072	56
*ADJPRED	6.7358	7.3455	6.9853	.1500	56
*RESID	-.1513	.1904	.0000	.0681	56
*ZRESID	-2.1184	2.6656	.0000	.9535	56
*SRESID	-2.2688	2.8450	.0081	1.0120	56
*DRESID	-.1736	.2169	.0016	.0776	56
*SDRESID	-2.3713	3.0764	.0066	1.0372	56
*MAHAL	.9828	35.4861	4.9107	4.9581	56
*COOK D	.0000	.4121	.0258	.0617	56
*LEVER	.0179	.6452	.0893	.0901	56

Total Cases = 60

Durbin-Watson Test = 1.91717

Table 6.5 Analysis of Residuals: Outliers - Standardized Residuals

Case #	*ZRESID
55	2.66564
16	-2.11839
52	-1.98695
56	-1.92609
28	-1.79566
12	-1.69265
22	1.35802
37	1.31026
32	-1.27194
30	1.24961

6.7.4.4 Normal Probability

The normal probability plots in Figure 6.6 shows the standardized residuals on the vertical axis and the expected value (if the residuals were normally distributed) on the horizontal axis. Since the residuals for all cases fall near the diagonal (after Spssx-Trend, 1988), as shown in the figure it can be concluded that the residuals are approximately normally distributed, as they should be.

```
N Exp N      (* = 1 Cases,     . : = Normal Curve)

 0   .04   Out
 0   .09  3.00
 1   .22  2.67 *
 0   .50  2.33
 0  1.02  2.00 .
 0  1.87  1.67  .
 5  3.07  1.33 **:**
 2  4.52  1.00 **   .
10  5.95   .67 *****:****
11  7.02   .33 ******:****
 5  7.41   .00 *****  .
 6  7.02  -.33 ******.
 7  5.95  -.67 *****:*
 2  4.52 -1.00 **   .
 2  3.07 -1.33 **.
 2  1.87 -1.67 *:
 3  1.02 -2.00 :**
 0   .50 -2.33
 0   .22 -2.67
 0   .09 -3.00
 0   .04   Out
```

Figure 6.5 Analysis of Residuals: Histogram - Standardized Residuals

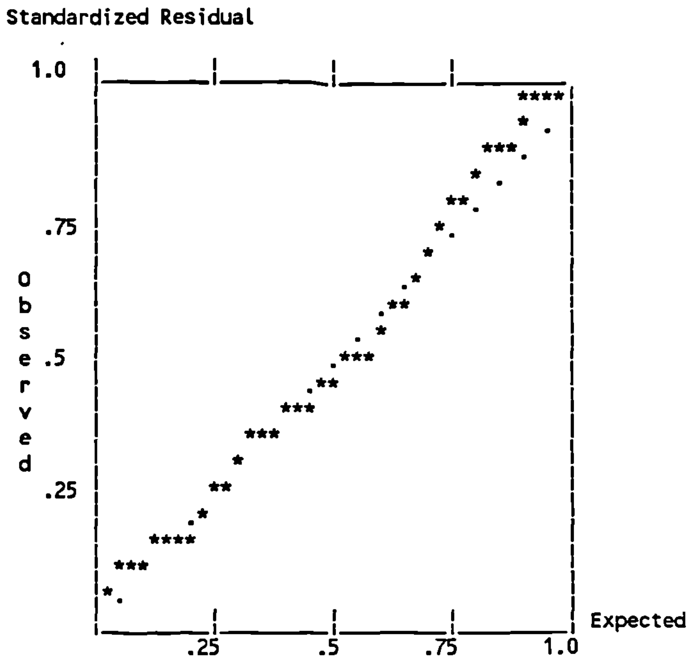

Figure 6.6 Analysis of Residuals: Normal Probability Plot

6.7.4.5 Residuals Plotting

Figures 6.7 through 6.13 indicate the plotting of the residual (not standardized) from the regression analysis against the predictor variables, dependent variable and predicted variable. One basic assumption of the regression analysis is that the variance of the residuals plot against predictor variables and predicted values should show no pattern.

Visual inspection of the figures shows that there is no pattern exhibited in the plot of the residuals values against the predicted values. Except for the real interest rate which reveals that the variance of the residuals may increase with increasing real interest rate, no patterns are shown in the plot of the residual values with the other predictor variables and the dependent variable.

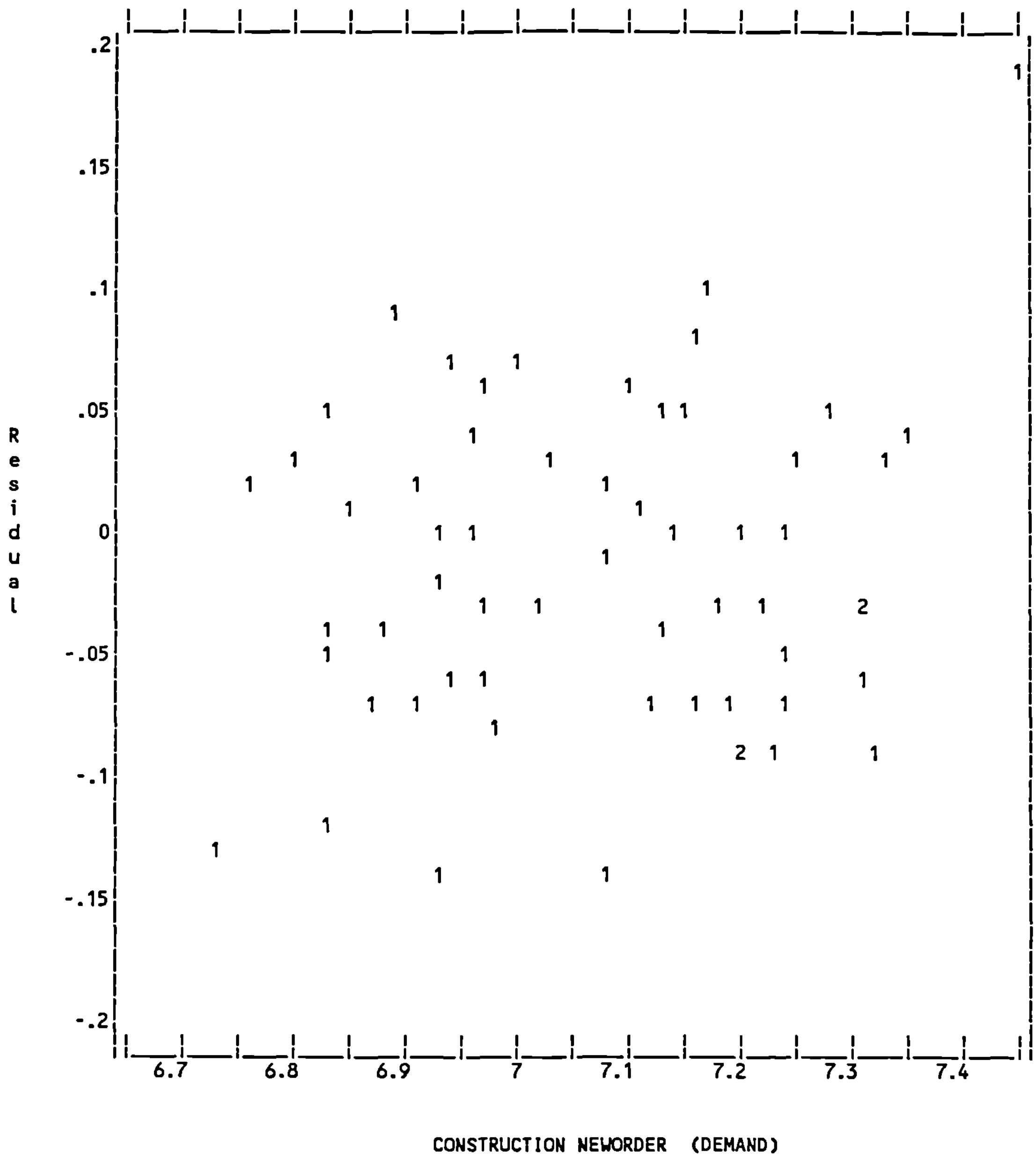

Figure 6.7 Analysis of Residuals: Plot of Residuals against Construction Demand

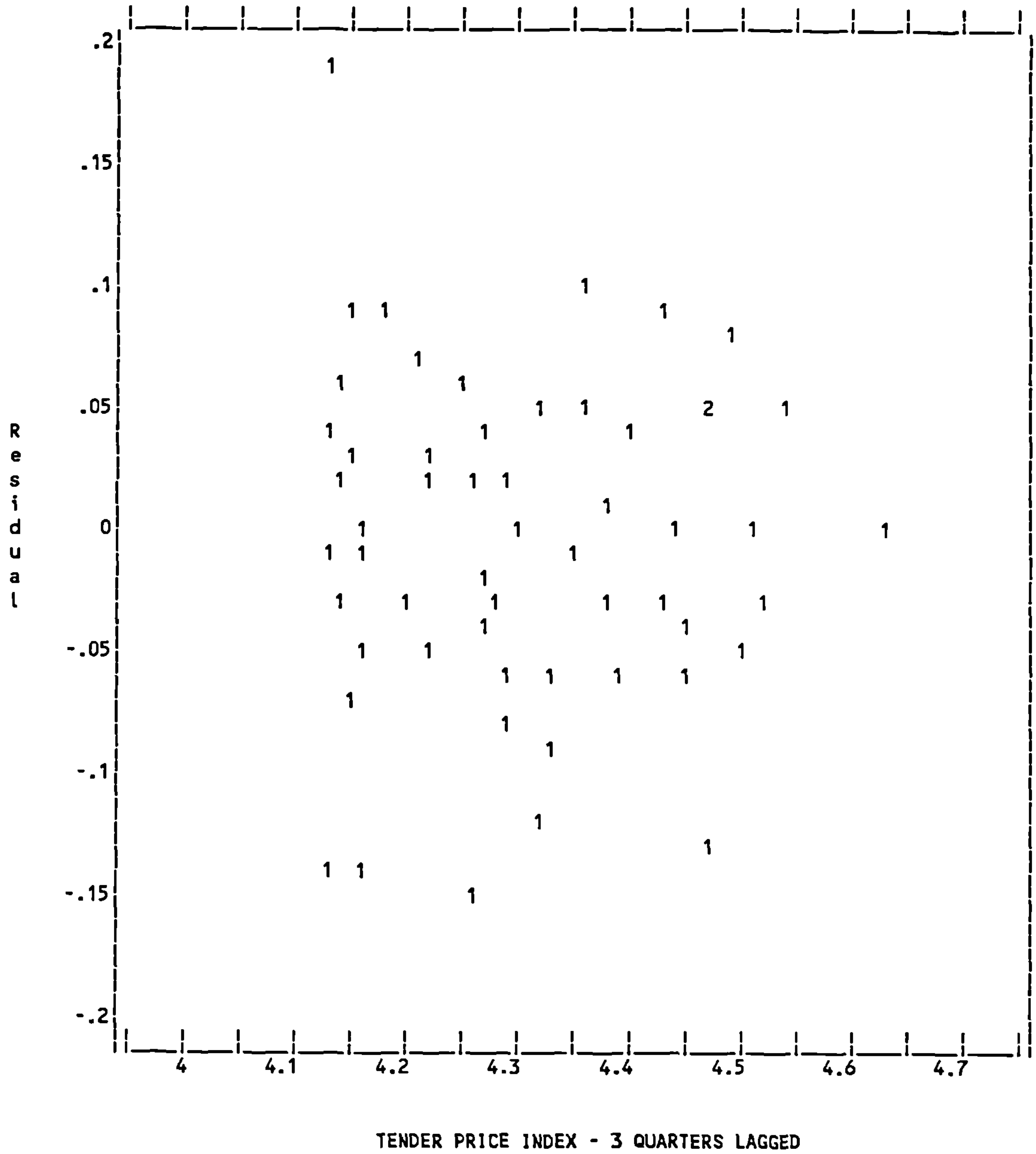

Figure 6.8 Analysis of Residuals: Plot of Residuals against Tender Price Index

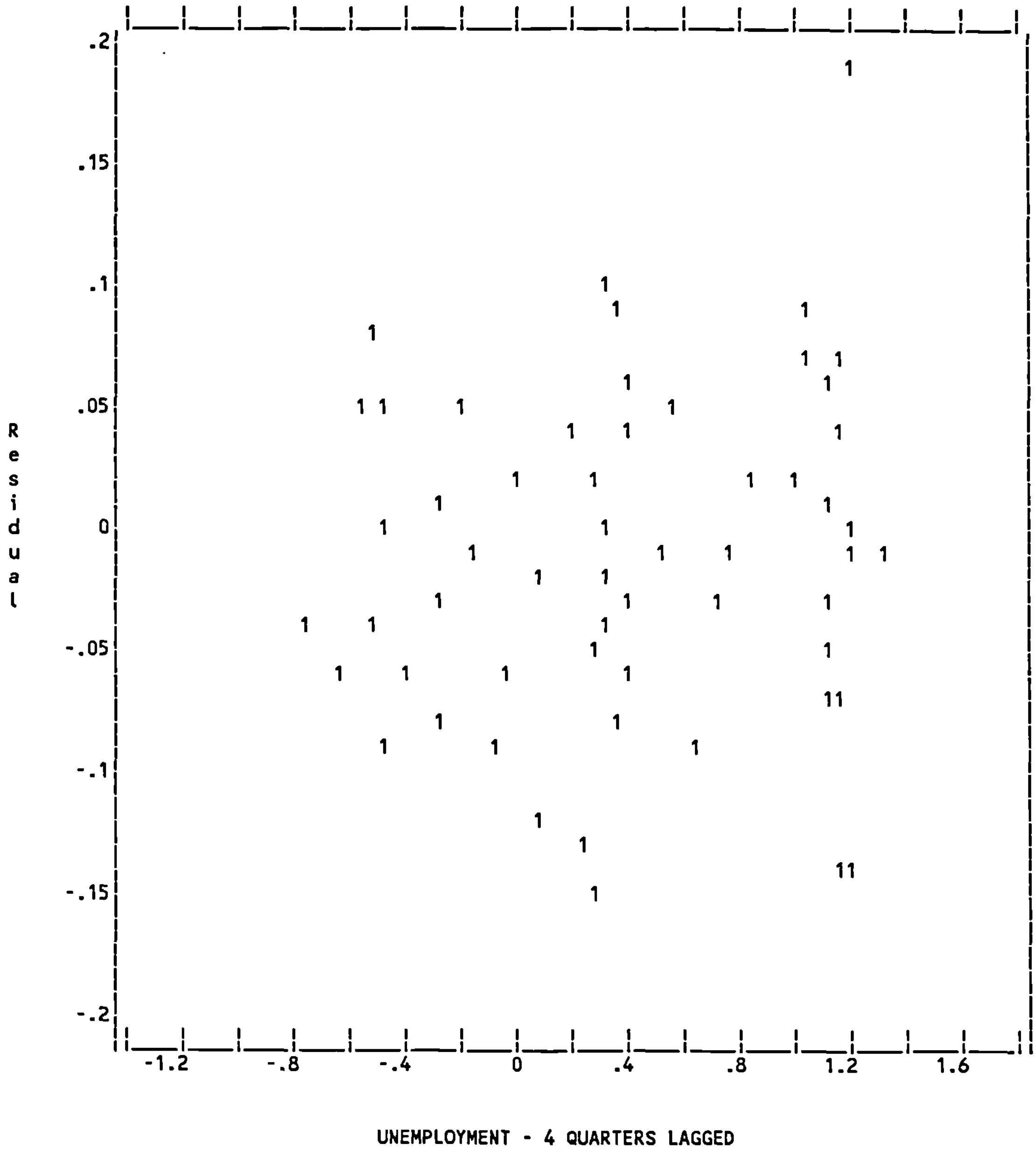

Figure 6.9 Analysis of Residuals: Plot of Residuals against Unemployment Level

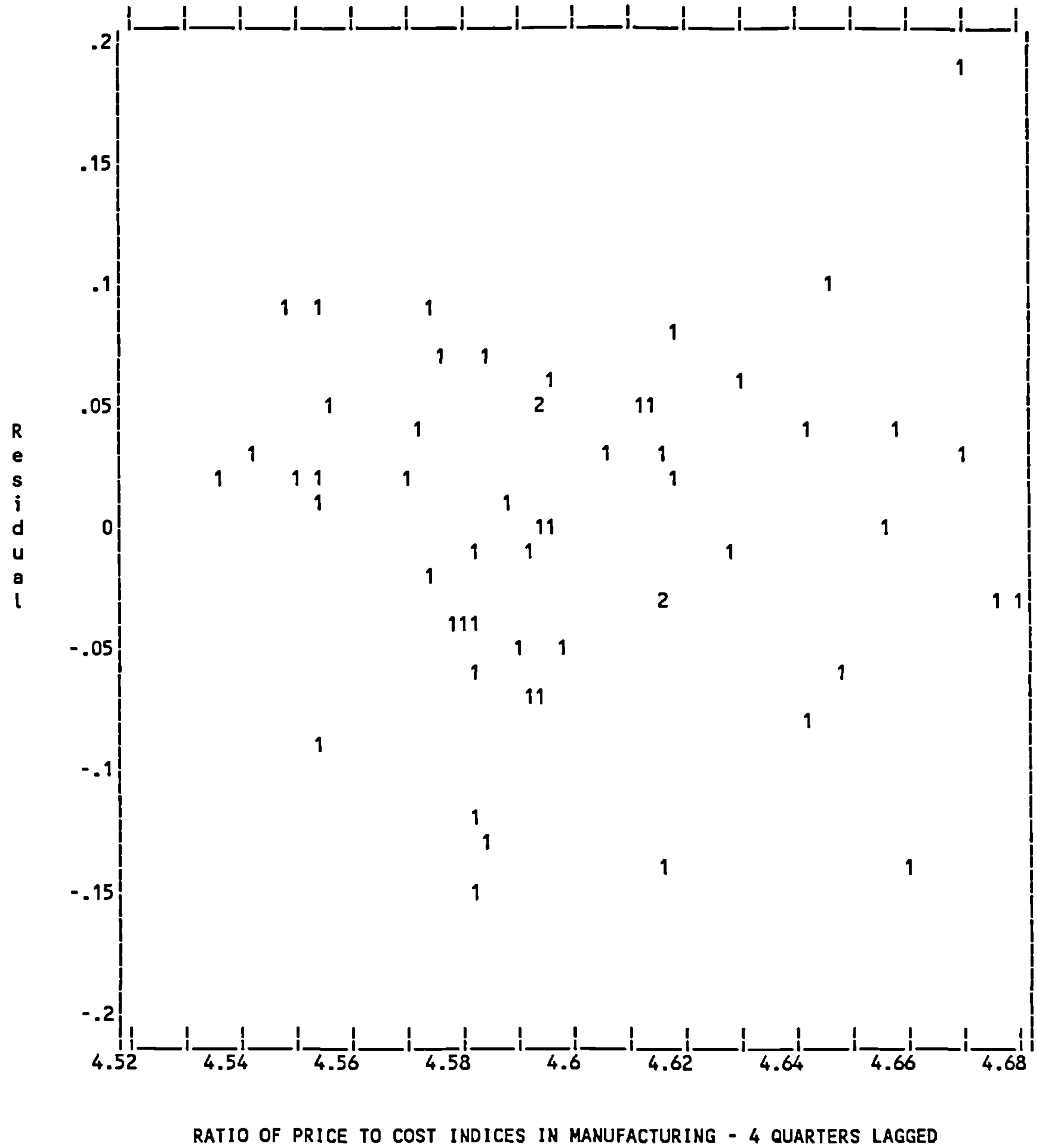

Figure 6.10 Analysis of Residuals: Plot of Residuals against Ratio of Price to Cost Indices in Manufacturing

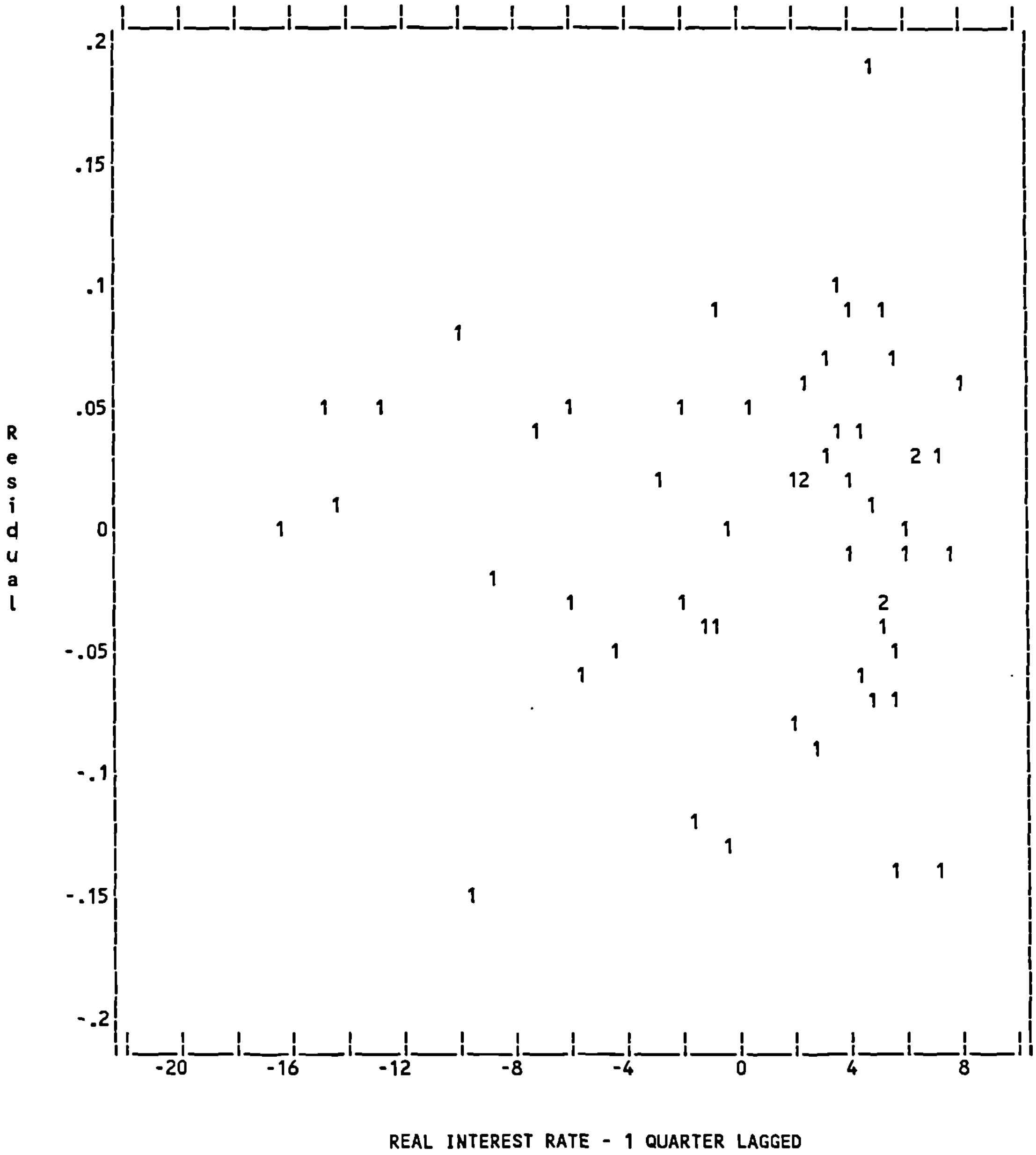

Figure 6.11 Analysis of Residuals: Plot of Residuals against Real Interest Rate

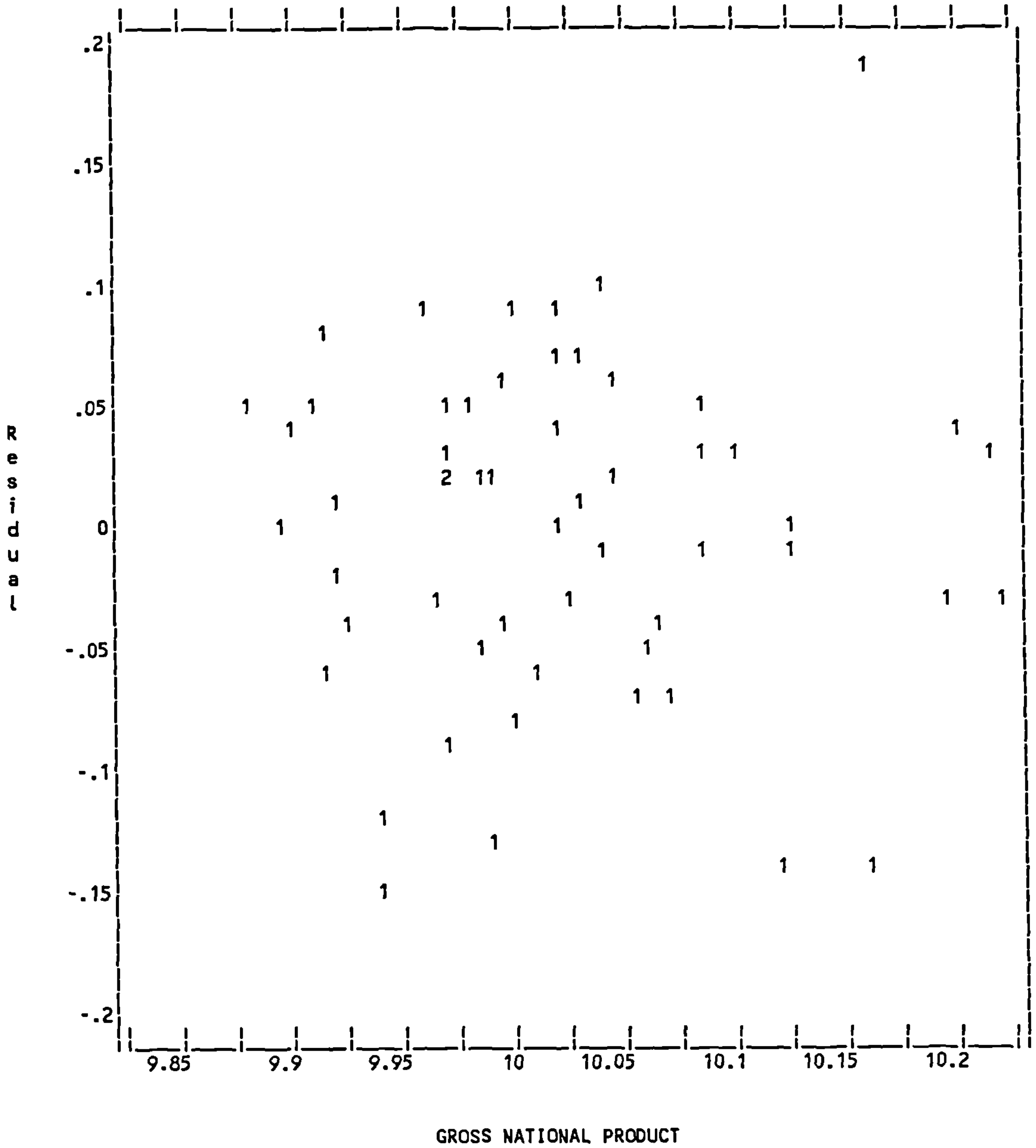

Figure 6.12 Analysis of Residuals: Plot of Residuals against Gross National Product

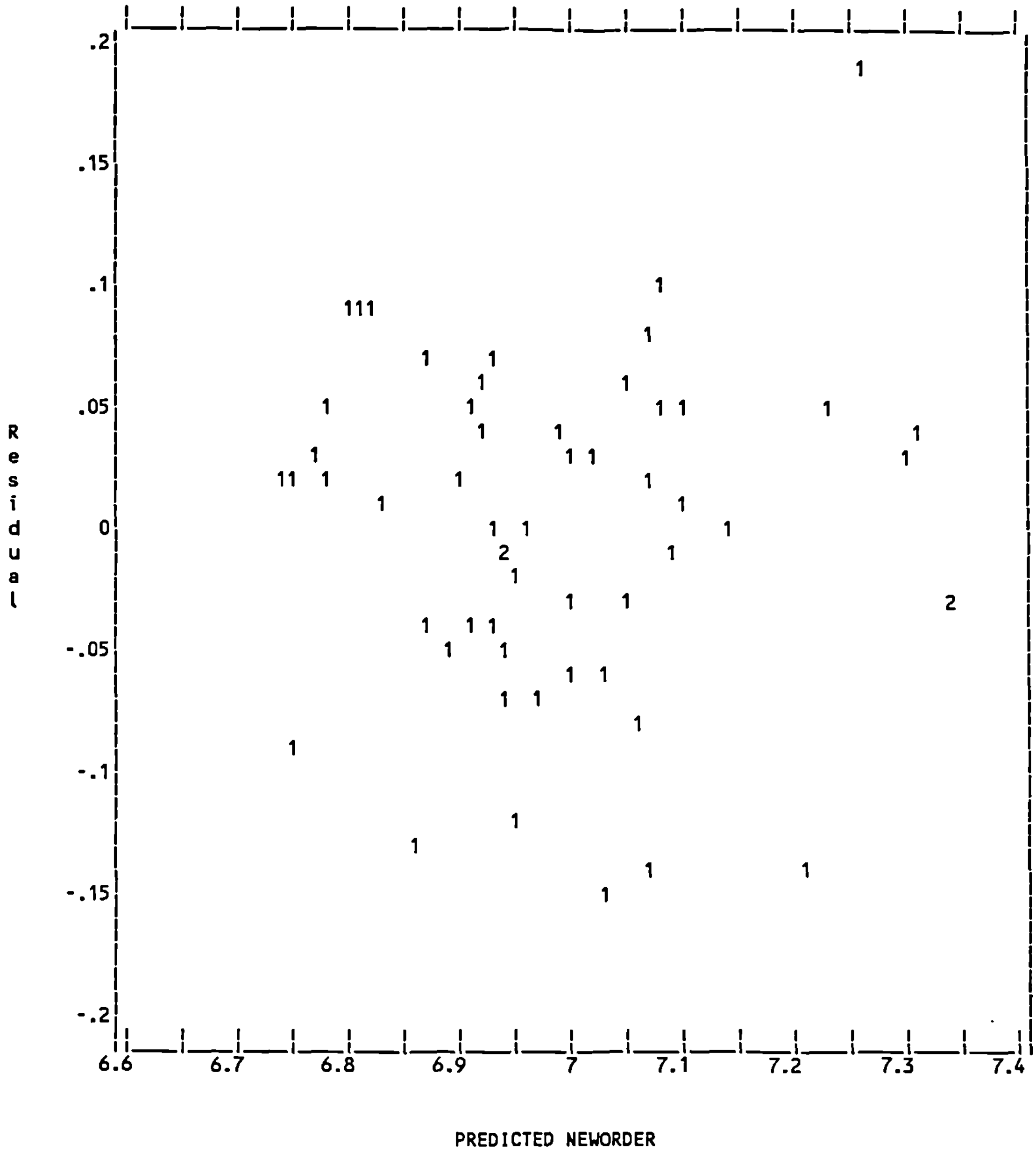

Figure 6.13 Analysis of Residuals: Plot of Residuals against Predicted Construction Demand

6.8 Conclusion

This chapter has examined the theory of investment spending and four major approaches to investment spendings have been identified - accelerator approach, neoclassical approach, q approach and the cash flow approach. However, most investments' equations adopted in macroeconomic models are modifications or blends of these four approaches. From the review of these approaches it becomes evident that business profit, user cost of capital and expected sales are important determinant of investment spending. User cost of capital is related to interest rate, inflation (price), depreciation cost and tax policy; while the expected sales (output) is related to the real GNP growth.

Determinants of construction demand were identified from literature. They are more or less the same as the factors involved in the general investment spending.

Construction demand was examined against measures that have been used in construction literature. Construction neworder is a better measure of construction demand as its description meets the definition of construction demand in terms of "willingness" and "ability" of the client to pay for his construction need at "market price". The trends in the construction investment at real prices suggest that there have been structural changes in the composition of construction demand posited by a declining public sector construction demand and increasing private sector demand.

Using quarterly data, the construction demand equation has been estimated. Construction demand has inelastic response to changes in price and simultaneous response to economic growth. Unemployment is negatively correlated with and is a good leading indicator of construction demand. Manufacturing industry profitability is positively correlated with construction demand and leads construction investment by four quarters. The adjusted r^2 values of 0.81 for the model is particularly encouraging for a deflated model of this kind. The analysis of the model's residuals suggests that the model is statistically stable with approximately normal distribution shape and lack of pattern in the plots of the residual values against the predicted values and the predictor variables.

The following chapter considers the theories behind construction supply and its modelling.

CHAPTER 7

Supply of Construction

SUPPLY OF CONSTRUCTION

7.1 Introduction

Supply relates to the amount of goods and services that producers are able and/or willing to bring to the market and, according to classical economic theory, when traded against the demand for such goods and services, is a major determinant of the (market) price of the goods and services. In construction contract services, the relationship between supply and price seems to have attracted little interest among economists.

Skitmore's (1987), examination of market effects on construction prices considered the interaction of construction supply and demand. This work linked construction supply to intensity of competition. Supply is treated as a function of the availability of people, property and money in the industry, and the organisation of resources.

The need to identify the factors determining construction supply is an important issue in economic analysis and for construction contractors. Classical economics has established in principle the importance of the supply function, along with demand function, in determining equilibrium price and quantity. Knowledge of construction price levels is important to construction contractors as this determines their bid levels, rate of contract acquisition, and workload. If construction supply levels affect construction price levels, in line with classical economic theory, then a study of the determinants of supply and its relationship with price is likely to be a fruitful activity.

This chapter examines construction supply in relation to construction price and other explanatory variables. It reviews the theory of supply of a firm and the aggregate supply to the economy. A model of construction supply is developed and the residuals of the equation are analysed.

7.2 Theory of supply

The theory of supply has to do with how much output level to produce and offer for sale. Concerning the level of output, two broad factors are of interest in respect of decisions on how much to produce and supply: cost of production and revenue.

The cost of production depends on the technology and input prices. Technology determines how many inputs are needed to produce the output. Input prices determine what firm will have to pay for these inputs (Begg et al, 1984). On the other hand, the revenue obtained by a firm depends on the demand curve faced which determines the price of firm's output and consequently the revenue. The cost of production and revenue determine choice of output level.

A firm's revenue and cost of production determine profit. In essence, a firm may be in a position to produce and willing to offer for sale much of goods and service as long as it is profitable to do so.

Theory of supply rest on the concepts of marginal cost and marginal revenue. This theory assumes the profit maximization in which case firms are assumed to make supply decisions based on the portfolio (choosing the best level of output to produce) that makes as much profit as possible. Supply theory, therefore indicates that a firm will continue to increase its level of output as long as the marginal revenue (MR) exceeds the marginal cost (MC). It is profitable to do so until the MR equals MC.

Provided it is possible for a firm to determine both its marginal revenue and marginal cost schedules it may be possible to determine the output level to produce and supply. Theoretically, marginal cost tends to be high at very low output and high at very high output. Between these two output levels is an output level when the marginal cost is lowest. The marginal revenue of firms decreases as the output level increases. Firm can only sell more at reduced price. The price for another unit sold at the reduced price constitute the marginal revenue derived from the extra sale.

The interaction of the marginal cost schedule and the marginal revenue will show that these two schedules crossed each other at a point (E_1) (Figure 7.1). The firm will choose the output at point (Q_1). At lower outputs, MR exceeds MC. At higher outputs, MC exceeds MR, which suggests that the contraction of the firm is profitable. A firm will, therefore, maximize profit by producing output level at which MC equals MR as long as the profit is positive. This constitutes the optimal output. Any shift in either the cost of production or revenue has the tendencies to shift the optimal output.

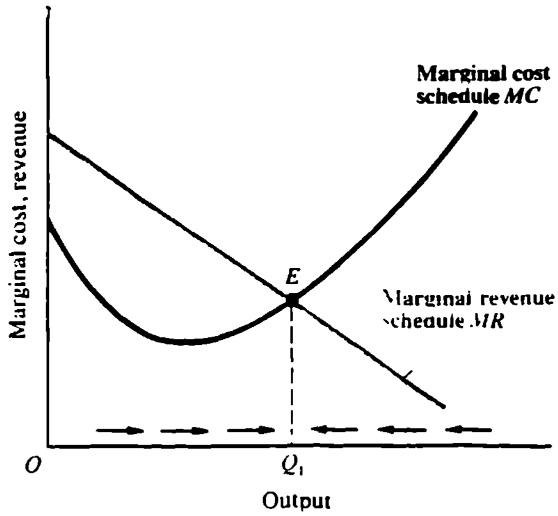

Figure 7.1 Firm's output level determined by marginal cost and marginal revenue curves

7.3 Aggregate supply theory

Aggregate supply relates to the total amount of goods or services that all firms (in an industry, sector or within economy) will produce and offer for sale at each price level. Keynesian theory of aggregate supply indicate a positive relationship between the price and supply, that is, all other things being equal, the price level and the total quantity produced are positively associated.

The positive relationship in the two suggests that firms equate marginal costs to market price (the relationship between prices and revenue is already discussed in section 7.2). A rise in price may create an incentive to firms to increase output particularly when firms are still producing below the normal capacity.

The nature of firms and the industry market structure tend to affect the aggregate supply. An industry market structure may comprise of oligopolistic firms, that is firms that are predominantly price-setters and perfect competitive firms, firms that are price-takers (Lipsey, 1988). Firms that are oligopolistic have capacity to decide to vary output as demand varies with little or no change in prices, provided that their outputs remain below the normal capacity. On the other hand, price-taker firms are faced with rising marginal cost for any attempt to raise output. Such firms can only produce more only if market prices increase to cover for increasing marginal cost.

In essence, the price-takers are faced with upward sloping supply curve. The combination of the price-setters and price-taker supply curve in the short run is described by Keynesian short-run aggregate supply curve (Lipsey, 1988). The curve is flat initially and thereafter rises. The flat part of the curve suggests that change in price is quite small compared with the change in output. This could be the case when firms are producing below their potential output. Above the potential output firms' marginal cost increases and this can only be covered by an increase in prices. This is the case represented by the upward slope in the curve.

7.3.1 Shift in aggregate supply curve

The shift in aggregate supply curve - called supply-side shock - have been associated with any change which, affects the output industry offer for sales at given price levels. Two major factors are identified as responsible for this: change in input prices and increase in productivity.

A rise in factor of production prices tends to reduce the profitability of firms. This causes the tendency to increase the price to cover the increased costs. The impact is a shift in the short-run aggregate supply curve upward, that is, a decrease in supply. On the other hand, a fall in input costs shift the supply curve downward, which is an increase in supply.

A rise in productivity reduces the unit cost of production as long as wage rates remain constant. In relation to market structure small firms may be able to produce more at any given set of output prices with the downward shift in marginal cost due to the rise in productivity. On the other hand, bigger firms, that constitute oligopoly firms, are forced to cut prices, due to the increase in productivity to raise their market share. The net result of the activity of the small and bigger firms tends to reduce the prices due to the rise in productivity. The aggregate supply curve due to rise in productivity is, therefore, characterised by a shift to the right.

7.4 Measurement of construction supply

The definition of supply is qualified by two groups of words: amount of goods and services; and producers ability and willingness to offer for sale. Therefore, any time series that will attempt to measure supply should, implicitly or explicitly, contain these two ingredients. The question then arises as to what time series would be a good measure of construction supply.

The word "amount" is the first ingredient of supply - amount of goods or service - suggests that supply could be expressed in monetary terms. On the other hand, the second ingredient - producers ability and willingness to offer for sale - refer to producers output. In other words, the ability and willingness of producers to offer goods and service for sale correlates with producers' output. It is therefore easy to understand Skitmore's (1987) description of supply as a function of availability of people, property and money in the industry and the organisation of resources. These are all relevant to output achieved within an industry.

If we accept that the output expressed in monetary terms is relevant to general supply, it can as well be said that the value of gross domestic product is a measure of a national domestic supply. The contribution of construction industry to the national output is customarily denoted as construction output, that is a component of the index of production, and hence of the output measure of GDP (Butler, 1978).

Consequently, construction output may be considered a reasonable proxy for construction supply. Patten's (1987) use of rate at which facility is being constructed as a definition of rate of supply supports this stance.

The Department of the Environment's definition of value of construction output (output of construction industry expressed in monetary terms) is the amount chargeable to customers for building and civil engineering work done in the relevant period (CSO, 1990). This definition of construction output is considered relevant to our description of construction supply.

At first sight, construction output is synonymous with construction new orders. A moment's reflection, however, suggests that the two terms are quite different. The estimated volume of new orders relating to contracts obtained by, or awarded to, contractors for new construction and is a reasonable proxy for construction demand. Construction output, on the other hand, relates to the total work done by contractors. In essence, new orders lead to construction output spread over a period of time (Butler, 1978).

The Department of the Environment (DoE) is the UK body responsible for compilation of information on construction new orders and output from building and civil engineering firms in quarterly enquiries. This department also collects information on construction work carried out by public authorities. The National Economic Development Office (NEDO - Forecasts) carries out periodic forecasts (BCIS, 1974-1990) of the figures.

7.5 Trends in construction supply

Figures 7.2 and 7.3 show the UK Department of the Environment data (CSO, 1990a) on the value of construction output. Figure 7.2 is expressed at current prices while Figure 7.3 is at the constant price (1974 price). Super-imposed on these Figures is the turning points in the UK economy cycle.

Figure 7.2 tends to suggest that the current values of construction supply can be fitted with exponential regression model. Exponential regression model is an exponential function. An exponential function typically assumes a process for situations where the rate of growth is proportional to the state of growth; and where each value can be expressed as a constant percentage of the neighbouring value (Khosrowshahi, 1991). In other words this is a technique in which current value of a series is predicted by weighted combinations of past values of the series (SPSS, 1988) and described by the following mathematical formulation (Taylor and Bowen, 1987):

$$\text{Index}_{(t+1)} = a \exp[b(t+1)] \quad \text{Eqn 7.1}$$

This formula produces monotonic, smooth and continuous curve with positive values shown in the Figure. The Figure shows that there appear to be cyclical movements in the pattern of construction supply that the exponential function fails to fit.

Figure 7.3 shows a clearer picture of the fluctuation in the construction supply. The periods 1978-1981 and 1986-1989 are particularly associated with higher value added to construction supply in real terms compared with periods 1975-1978 and 1981-1986 that are associated with declined construction supply.

The combination of the Figures in relation to the UK economy cyclical movements (identified as peaks and troughs in the Figures - the shaded portions) suggest that construction supply is related to the activity of the whole economy. For example the portions where the value of construction supply at current prices in Figure 7.2 rise above the exponential regression line coincides with the period of contraction in the economy, that is the recession period, except for August 1984-January 1986 contraction period. Figure 7.3 indicates that the construction supply at real price is a better picture of the cyclical pattern of this time series. This shows that the construction supply decreases and commence increasing during recovery period; and peaks and commences decline during recession. In fact, August 1984-January 1986 general economy cyclical period is not an exception as suggested by exponential regression fit in Figure 7.2, though this is not as pronounced as other cyclical patterns of construction supply at real prices.

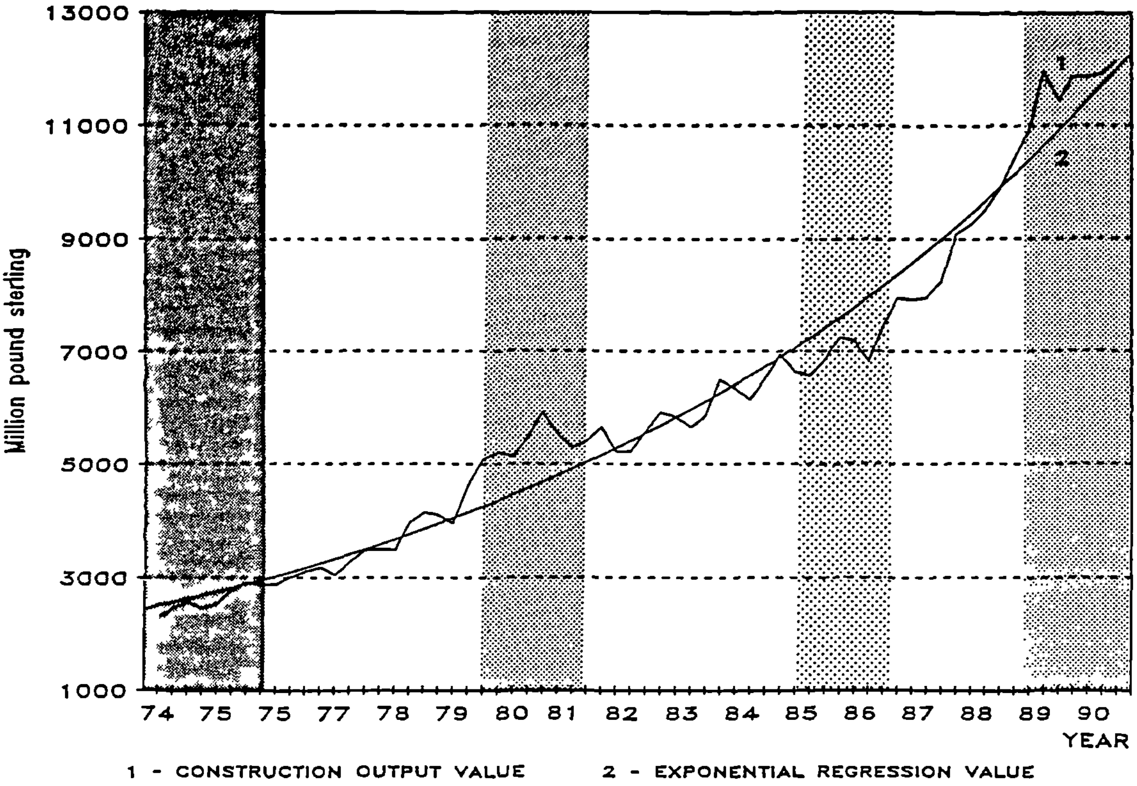

Figure 7.2 Value of construction output at current prices

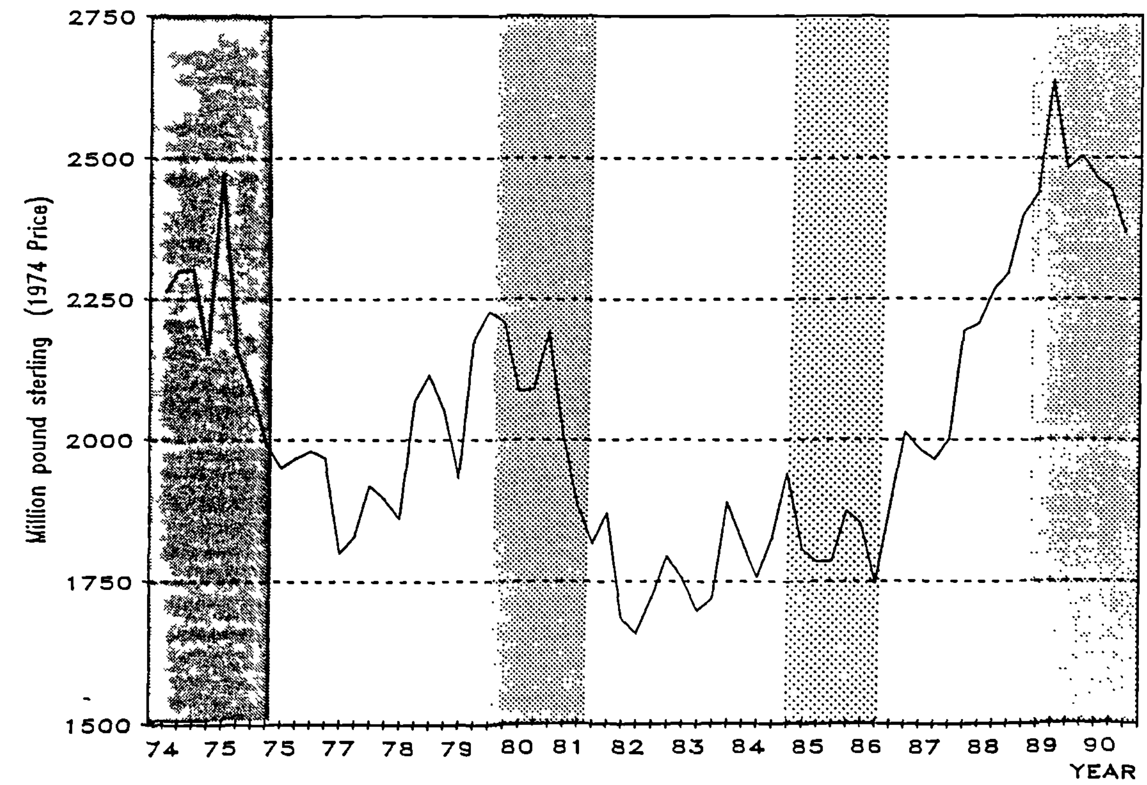

Figure 7.3 Value of construction output at constant price

7.6 Leading indicators of construction supply

Some leading indicators of construction supply have been identified and are expressed in functional form as follows:

$$Q^s = f(P, P^r, C^p, S^T, F^r) \qquad \text{Eqn. 7.2}$$

Where

Q^s = Construction supply
P = Price level of construction
P^r = Productivity level
C^p = Construction input cost level
S^T = Work stoppages (strikes)
F^r = Number of registered construction firms

Classical economics relates the quantity of goods or services produced to the price, prices of other commodities, the prices of factors of production, the state of technology, and the objectives of firm. The systematic relationship between price and quantity supplied (all other factors remaining constant) is usual in economic analysis. One problem with this approach is that there is a minimum requirement of perfect competition. It is known that the operation of construction industry is far from perfect because of the unusual characteristics of the industry (Hillebrandt, 1985).

The truly pivotal factor in construction may be as revealed in Ganesan's (1979) study, the supply of construction work is influenced by efficiency of firms, profit motive, shortages and prices of factors of production.

Intuitively, we certainly expect construction supply to respond to rather more than price. In terms of leading indicators, we hypothesise the existence of three main causal factors - price, input costs and production capacity - as follows:

7.6.1 Price of construction

Trends in construction price levels are represented by a Tender Price Index which, reflects average changes in 'desized' accepted tenders for new works (BCIS, 1989). Conventional theory suggests that real increases in the index makes construction work becomes more profitable thus encouraging firms to increase output. The tender price is considered a proxy price for construction supply. Butler (1978) discussions tended to clarify this by claiming that the current price charged for construction output (construction supply) is either wholly or mainly determined by tender prices which, have been accepted by clients in a period extending sometimes several years into the past. If the past tender price levels are relevant to the current prices of construction output, it can be concluded that the tender price is a proxy for prices in construction supply schedule. We are interested in what motivates construction firms ability and willingness to change their output, of which current tender price level may be considered an important factor.

7.6.2 Input costs

Individual construction firms have little influence upon the cost of factors of production. However when all firms in a competitive industry like construction simultaneously increase or decrease their aggregate output, they could influence the input price level. The effect of input costs on output is expected to be negative. There is a dis-incentive to increase output as construction work becomes less profitable except this is accompanied by an increase in construction prices.

7.6.3 Production Capacity

Literally, capacity corresponds to maximum amount that can be contained or produced. In economic sense, capacity relates to potential output, that is, the output level produced when there is full employment and all market clear. Increases in potential output can be traced to increases in inputs of the factors of production - land, labour, capital, raw materials - or to technical advances allowing the existing factors to produce a higher level of output (Begg et al., 1984). Production capacity, therefore, is what a firm is capable of producing. At the aggregate level this amounts to the capacity available to the industry. This is influenced by, among other things, productivity, technology available, weather, number of firms in the industry and their size, and work stoppages.

Available technology and weather conditions influence productivity. Increased productivity should lead to increased output. Bowlby and Schriver (1986) attributed changes in construction output to two general causation classes, (1) changes in the mix of types of construction output which, have different unit costs, and (2) changes in total factor productivity. The characteristics of project (in terms of type, procurement, geographical location) could constitute periodic fluctuation in productivity and this is important to construction supply (Skitmore, 1987).

The number and size of firms in the industry contribute to the capacity in the industry. Skitmore (1987) used the supply levels synonymously with the availability of contractors. Economics of scale suggest that fewer, larger firms will have a greater aggregate output than more, smaller firms. On the other hand, the construction process is often suspected to contain diseconomies of scale, in which case the converse could be true.

Strikes relate to stoppage of work due to industrial disputes connected with terms and conditions of employment. Increases in the total number of strikes, therefore, is expected to have a negative leverage on supply.

7.7 Modelling construction supply

7.7.1 Structure of the Model

The supply of construction services is specified above as a function of price, input cost, and production capacity represented by the number of firms, strike action and labour productivity. The most commonly used modelling functions are linear and log-linear functions (Ripley and Seddighi, 1988). In linear form, the construction supply function can be expressed as follows:

$$Q^{s*}{}_t = a_0 + a_1 P_t + a_2 P^R{}_t + a_3 C^P{}_t + a_4 S^T{}_t + a_5 F^r{}_t \qquad \text{Eqn 7.3}$$

Where

Q^{s*} = Desired level of construction supply
t = time lead (quarterly)

The variables are expressed in real terms to reduce the possible dominating effect of general inflationary trends.

In line with most econometric regression analyses, a log-linear model is specified. The constant elasticity or log-linear function is more widely used in estimation as shown

$$Q^{s*}{}_t = cP^{a1}{}_t \, P^{Ra2}{}_t \, C^{pa3}{}_t \, S^{Ta4}{}_t \, F^{ra5}{}_t \qquad \text{Eqn 7.4}$$

where c is a scaling constant. Taking natural logs of both sides yields the log-linear form of the model:

$$\ln Q^{s*}_t = a_0 + a_1 \ln P_t + a_2 \ln P^R_t + a_3 \ln C^P_t + a_4 \ln S^T_t + a_5 \ln F^r_t \qquad \text{Eqn 7.5}$$

where $a_0 = \ln c$ and $\ln$ = natural log. It has been shown by Lawler and Seddighi (1987) that the parameters (in this case $a_1, a_2 \ldots, a_5$) are constant elasticities, that these constants are taken as constant over time. The estimated values of these parameters directly, therefore, reveal the estimated elasticities which, make log-linear model particularly popular in empirical work.

Using ordinary least squares (OLS) regression analysis, the regression coefficients (a_0, $a_1 \ldots\ldots, a_5$) are computed. Goodness of fit between the actual and the predicted is indicated by the value of R^2 adjusted for auto-correlation.

Two features are obvious from the above structural form of equation:

1. a flexible lag period between the dependent and independent variables, hence the need to estimate values of t for each independent variable.
2. a relatively simple dynamic relationship may exist in the dependent variable. Hence, the need for a partial adjustment of the model to capture the dynamic properties of the system. To this effect Eqn 7.3 is re-specified to include an additional lagged variable as follows:

$$Q^s_t - Q^s_{t-1} = \phi(Q^{s*}_t - Q^s_{t-1}) + U \qquad \textit{Partial Adjustment} \qquad \text{Eqn 7.6}$$

From Eqn 7.3 and Eqn 7.6

$$Q^s_t = \phi a + \phi a_1 P_{t-b1} + \phi a_2 P^r_{t-b2} + \phi a_3 C^P_{t-b3} + \phi_4 S^T_{t-b4} + \phi a_5 F^r_{t-b5} + (1-\phi)X^s_{t-1} + U \qquad \text{Eqn 7.7}$$

where ϕ is partial adjustment factor and $b_1 \ldots\ldots, b_5$ are the time lead (in quarter) from time *t*. This equation (Eqn 7.7) is in linear form. Just like Eqn 7.5, this equation can be expressed as log-linear.

7.7.2 Methodology

The method of analysis was based on the OLS multiple regression and anticipates lead relationships between the dependent and independent variables. The estimation of the lead values, *t*, is based on the multiple regression program discussed in Appendix B. Construction output is used as the dependent variable with the five independent lead variables (P, P^r, C^P, S^T, F^r) having an integer range of 0 to 8 lead periods. This program produced a total of 59049 separate regression models at a complete run of the program for examination in relation to construction supply. (A total of 9^v regression models is expected to be produced at a complete run of the program where v = number of independent variables that take on integer range 0 to 8 lead periods). Table 7.1 shows the computer output print-out from the complete run of the program. The examinations of the models were carried out to identify the model that suit our theoretical expectations in terms of lead period relationship. Based on the examinations a model was chosen.

Table 7.1 Construction supply OLS multiple regression program output

PROGRAM ENTERED

DATA IN

	TP	BC	PR	FR	ST	SEE							
	0	0	0	0	0	0.0027	-1.323	0.73	0.28	0.73	0.09	-0.01	60
	0	0	0	0	3	0.0022	-0.838	0.88	-0.11	0.85	0.11	-0.02	57
	0	0	0	0	7	0.0020	-1.689	0.85	0.07	0.88	0.11	-0.02	53
	0	0	0	1	7	0.0019	-1.663	0.86	0.03	0.88	0.12	-0.02	53
	0	0	0	2	7	0.0019	-1.736	0.88	0.03	0.86	0.13	-0.02	53
	0	0	0	3	7	0.0019	-1.853	0.89	0.06	0.84	0.13	-0.02	53
	0	0	0	4	7	0.0018	-1.909	0.91	0.07	0.80	0.14	-0.02	53
	0	0	0	5	7	0.0018	-1.906	0.93	0.07	0.76	0.15	-0.02	53
	0	0	0	6	7	0.0018	-1.949	0.94	0.09	0.71	0.16	-0.02	53
	0	0	0	7	3	0.0017	-2.280	0.97	0.19	0.66	0.16	-0.02	53
	0	0	0	8	3	0.0016	-3.382	0.93	0.50	0.63	0.15	-0.02	52
	0	1	3	5	3	0.0016	2.581	0.92	-1.07	0.83	0.19	-0.02	55
	0	1	3	6	4	0.0016	1.663	0.99	-1.38	0.74	0.23	-0.02	54
	0	1	3	7	2	0.0015	1.302	0.95	-0.97	0.73	0.21	-0.02	53
	0	2	4	7	3	0.0014	1.203	0.88	-0.72	0.85	0.20	-0.02	53
*	0	2	4	8	3	0.0014	1.104	0.85	-0.59	0.77	0.18	-0.02	53

OK

SV14 (user 76) logged out Monday, 04 Mar 91 16:50:08.

Time used: 04h 56m connect, 71m 40s CPU, 00m 36s I/O.

7.7.3 Results and Analysis of Construction Supply Models

The structural form of equation of construction supply is provided in Table 7.2 using quarterly data from the first quarter of 1974 to the fourth quarter of 1987. The Table which, is a computer output print-out based on SPSS-X statistical package shows all the relevant statistics connected with the model.

The equation fits the data well with the expected signs for all the variables and an adjusted R^2 of 0.83. In this case, the log-linear model explained 83 per cent of total variations in construction supply. All the explanatory variables have significant t-values and inelastic relationships with construction supply. With the Durbin-Watson (*DW*) of 1.71 the null hypothesis of zero auto-correlation in the residuals is accepted by Stewart (1984) criteria.

The price of construction has the largest effect on the construction supply as shown by the highest beta coefficient of 0.981. The price elasticity implies that with one per cent rise in construction price, the contractors may be expected to increase their supply of construction by 0.85 per cent. The lag period ($t=0$) suggests that contractors change supply in response to prices (or *vice versa*) within one quarter of the event. This is not unlikely as contractors may make rational expectation forecasts based on statistical economic indicators, the feeling of economic movements and forecasts of construction price. Firms in the construction industry that expect price changes in the near future may well prepare for this, so that the time lag between construction output and price becomes insignificant.

The number of firms in the industry has the next highest beta coefficient with a value of 0.53 and a positive relationship with the construction supply. This suggests that an increase in the number of firms is accompanied by an increasing construction output. The construction industry has low capital investment that may encourage more firms into the industry in boom times, which consequently leads to an increasing construction supply.

Productivity (beta=0.41) is positively correlated with construction supply four quarters later. The elasticity of productivity equals 0.773 suggests that one per cent rise in

Table 7.2 Analysis of Construction Supply: Statistics

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

Listwise Deletion of Missing Data

Equation Number 1   Dependent Variable..   CONSTRPUT

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number			
	1..	BSTR	LAGS(ASTR,3) on 07 May 91 at 18:42
	2..	BPRO	LAGS(APRO,4) on 07 May 91 at 18:42
	3..	BBCI	LAGS(ABCI,2) on 07 May 91 at 18:42
	4..	ATPI	
	5..	BFRM	LAGS(AFRM,8) on 07 May 91 at 18:42

Multiple R	.91865
R Square	.84391
Adjusted R Square	.82694
Standard Error	.03925

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	.38306	.07661
Residual	46	.07085	.00154

F =   49.74057   Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
STR	-.022478	.005569	-.324850	-4.036	.0002
PRO	.773036	.155422	.416694	4.974	.0000
BCI	-.588302	.339922	-.127445	-1.731	.0902
TPI	.846447	.111772	.981777	7.573	.0000
FRM	.179839	.051746	.531202	3.475	.0011
(Constant)	1.104397	1.307768		.844	.4028

-End Block Number   1   All requested variables entered.

productivity of the industry will be expected to bring about 0.8 per cent increase in the supply of the industry. The lag period of four quarters suggests that it takes about a year before productivity completely infiltrates into construction supply.

The regression coefficient for work stoppages (strikes) (beta=-0.32) being negative implies a negative effect on supply function, with a three quarter lead on construction supply.

The beta value (-0.13) of construction input costs is relatively low which, suggests that contractors consider this to a lesser extent in the decision as to what construction supply to provide. Two explanations could be offered for this low sensitivity to input costs: (a) profit margins may be reduced to offset changes in input costs, or (b) the contract provisions allow some compensation for escalation in input costs. However, the OLS estimate of the input prices elasticity is -0.588 implying that for a one per cent rise in input costs, the construction supply is likely to fall by 0.6 per cent.

Based on Eqn 7.6 the coefficient of adjustment was estimated as 0.739. The relevant statistics of this estimation is shown in Table 7.3. Using the log-linear version of partial adjustment hypothesis shown in Eqn. 7.7, the dynamic relationship of the construction supply is calculated as shown in Eqn 7.8

$$\ln X^{S*}_t = 0.816 + 0.626 \ln P_t + 0.571 \ln P^R_{t-4} - 0.435 \ln C^P_{t-2} - 0.017 \ln S^T_{t-3} + 0.133 \ln F^r_{t-8} + 0.261 \ln X^S_{t-1} \qquad \text{Eqn 7.8}$$

7.7.4 Analysis of the Model Residuals

7.7.4.1 Statistics

Table 7.4 shows the results (minimum, maximum, mean and standard deviation) on the different statistical analysis of the residuals. Appendix 7.1 produces the statistics on casewise basis.

Table 7.3 Analysis of Construction Supply 2: Statistics

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

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. CPUT

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number 1.. SSDIFF

Multiple R	.71261	Analysis of Variance			
R Square	.50781		DF	Sum of Squares	Mean Square
Adjusted R Square	.49797	Regression	1	.06479	.06479
Standard Error	.03544	Residual	50	.06280	.00126

F = 51.58698 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
SSDIFF	.739361	.102941	.712609	7.182	.0000
(Constant)	.001015	.004931		.206	.8378

End Block Number 1 All requested variables entered.

The statistical analysis of the residuals confirms that the model is statistically significant. Relevant to this are the results on the expected value of the residuals $E(U_i)$ and the expected value of the standardized residuals that are zero with standard deviations equals 0.0681 and 0.9535 respectively which, suggests that the residuals are normally and independently distributed random variables. In this case it can be concluded that the disturbance terms corresponding to one observation is independent of the disturbance term corresponding to other observations.

The result of the leverage value (LEVER) (mean=0.0962 and standard deviation=0.0901) shows that the mean falls below the critical leverage value (critical value = 2P/n = 2 x 5.0024/52; where p is the addition of each case leverage value, and n the number of cases). Out of the 52 cases only three (cases 16, 25 and 39) have high leverage points, that is, more than the critical limit (see appendix 7.1). The high Mahalanobis' distances of these three cases are not surprising, as the calculation of this distance is based on the leverage value. Appendix C gives interpretation and the description of these residual test statistics.

7.7.4.2 Outliers

Table 7.5 indicates the standardised residual outliers (cases with large residuals). The outliers are neither many nor patterned. However, cases 27, 31 and 33 (called first period) relate to up to seven quarters following the oil crisis of 1979, third and fourth quarters. Cases 55 and 58 (called second period) are construction supply outliers following the spontaneous increase in construction neworder due to investment in the European Channel Tunnel of 1987 third and fourth quarters. The first period (cases 24 to 34) is predominantly characterised by over-estimation of construction supply by the model (7 out of 11 cases underestimated) and the second period (cases 55 to 60) is characterised by under-estimation (5 out of 6 underestimated). The most prominent shock associated with the first period is the oil crisis which, may have caused the construction supply to be lower than expected construction supply by the model. Also the second period is associated with the sporadic increase in construction

Table 7.4 Analysis of Residuals: Residuals Statistics

	Min	Max	Mean	Std Dev	N
*PRED	7.4165	7.7664	7.5737	.0867	52
*ZPRED	-1.8133	2.2243	.0000	1.0000	52
*SEPRED	.0089	.0205	.0131	.0025	52
*ADJPRED	7.4150	7.7603	7.5732	.0869	52
*RESID	-.0900	.0814	.0000	.0373	52
*ZRESID	-2.2945	2.0734	.0000	.9497	52
*SRESID	-2.3672	2.1557	.0058	1.0039	52
*DRESID	-.0958	.0880	.0005	.0417	52
*SDRESID	-2.4985	2.2488	.0039	1.0238	52
*MAHAL	1.6705	12.9070	4.9038	2.2836	52
*COOK D	.0001	.0786	.0197	.0236	52
*LEVER	.0328	.2531	.0962	.0448	52

Total Cases = 60

Durbin-Watson Test = 1.71364

Table 7.5 Analysis of Residuals: Outliers - Standardized Residuals

Case #	*ZRESID
49	-2.29450
55	2.07342
21	-2.04951
31	1.69187
33	-1.60031
50	-1.47488
27	1.40461
58	1.39032
11	1.32427
17	-1.28301

neworder (see chapter 6) which, may have caused the construction supply to increase in the following quarters than expected by the model. Failure of this model to capture these two periods tends to suggest that the economic events of these periods are "shocks" to construction supply. Only three residuals from the 60 cases have standardized values greater than two or less than -2.00 which, is about the 5 per cent one would expect by chance.

7.7.4.3 Shape

Figure 7.4 indicates the frequency distribution of the standardized residuals for the construction demand model. The bell-shaped and almost symmetrical distribution suggested the model is approximately normal distribution (a vital assumption in regression analysis).

7.7.4.4 Normal Probability

The normal probability plots in Figure 7.5 shows the standardized residuals on the vertical axis and the expected value (if the residuals were normally distributed) on the horizontal axis. Since the residual for all cases falls near the diagonal (after Spssx-Trend, 1988), as shown in the figure it can be concluded that the residuals are approximately normally distributed, as they should be.

7.7.4.5 Residuals Plotting

Figures 7.6 through 7.12 indicate the plotting of the residuals (not standardized) from the regression analysis against the predictor variables, dependent variable and predicted variable. The basic assumption of the regression analysis that the variance of the residuals plot against predictor variables and predicted values should show no

```
NExp N       (* = 1 Cases,     . : = Normal Curve)

 0   .04    Out
 0   .08   3.00
 0   .20   2.67
 0   .46   2.33
 1   .95   2.00 :
 1  1.74   1.67 *.
 4  2.85   1.33 **:*
 4  4.19   1.00 ***:
 6  5.52    .67 *****:
 7  6.51    .33 ******:
 9  6.88    .00 ******:**
 5  6.51   -.33 ***** .
 4  5.52   -.67 **** .
 5  4.19  -1.00 ***:*
 3  2.85  -1.33 **:
 1  1.74  -1.67 *.
 1   .95  -2.00 :
 1   .46  -2.33 *
 0   .20  -2.67
 0   .08  -3.00
 0   .04    Out
```

Figure 7.4 Analysis of Residuals: Histogram - Standardized Residuals

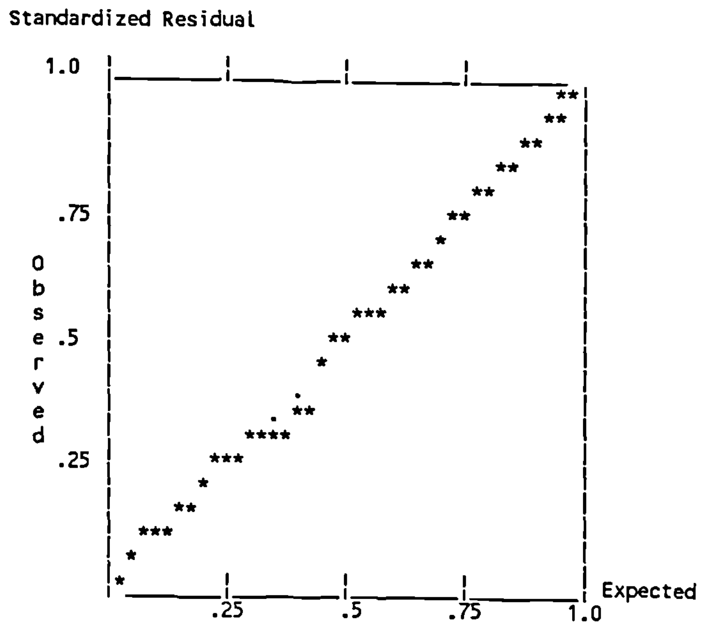

Figure 7.5 Analysis of Residuals: Normal Probability Curve

pattern is fulfilled from the visual inspection of the Figures.

The exception to this relates to plots on building cost index (input prices), and work stoppages which, reveals that the variance of the residuals increased with increasing work stoppages.

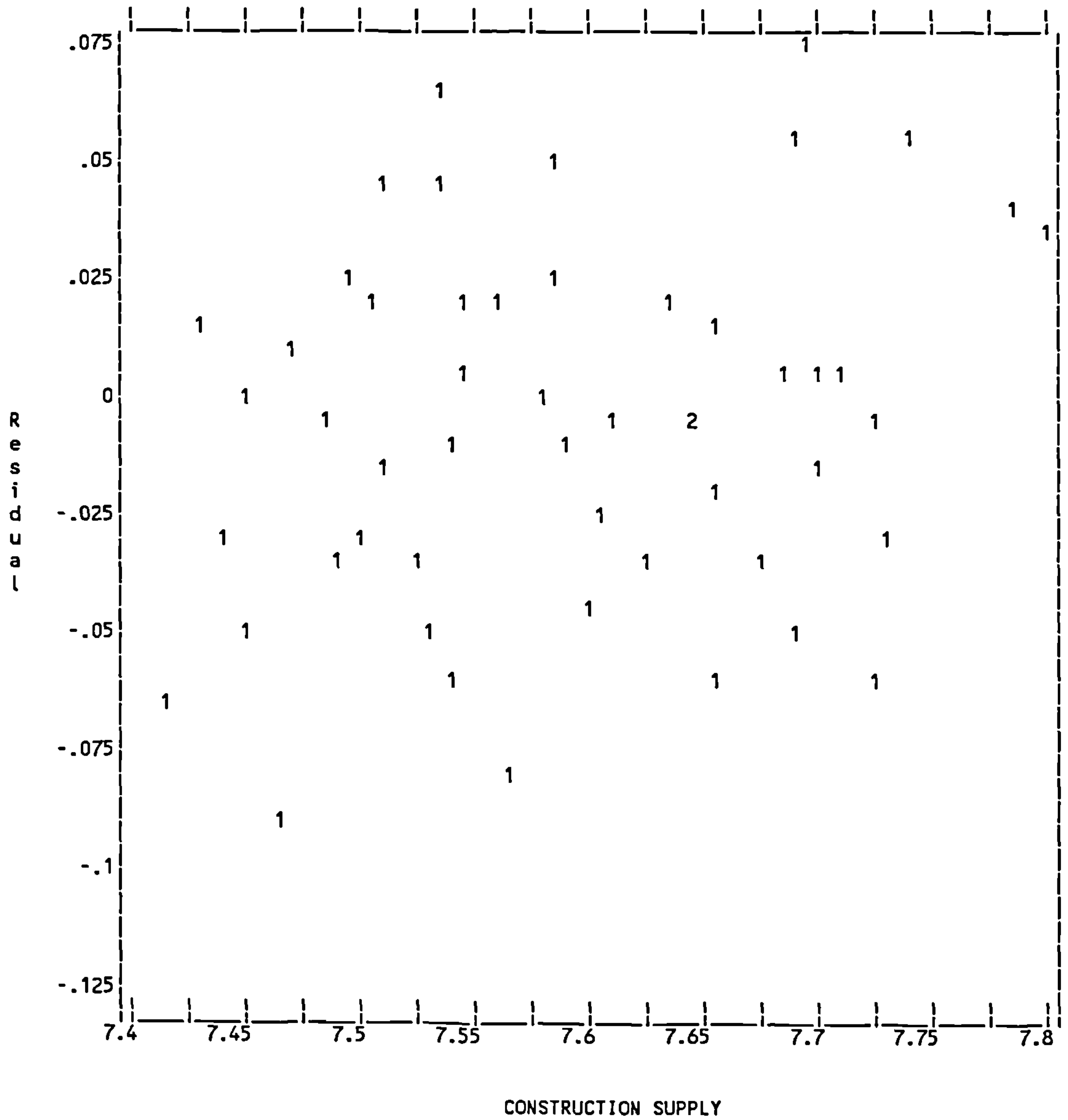

Figure 7.6 Analysis of Residuals: Plot of Residuals against Construction Supply

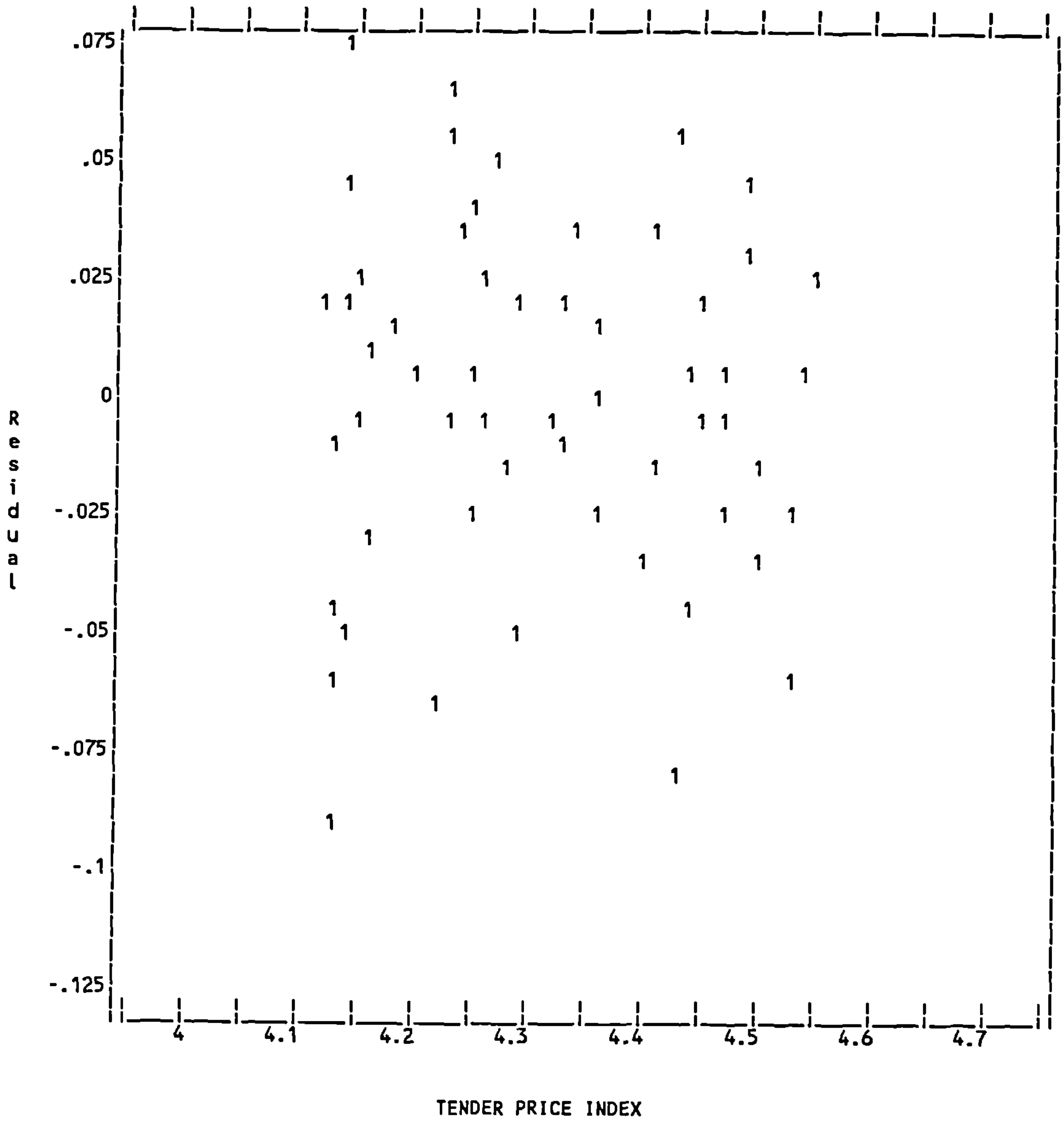

Figure 7.7 Analysis of Residuals: Plot of Residuals against Tender Price Index

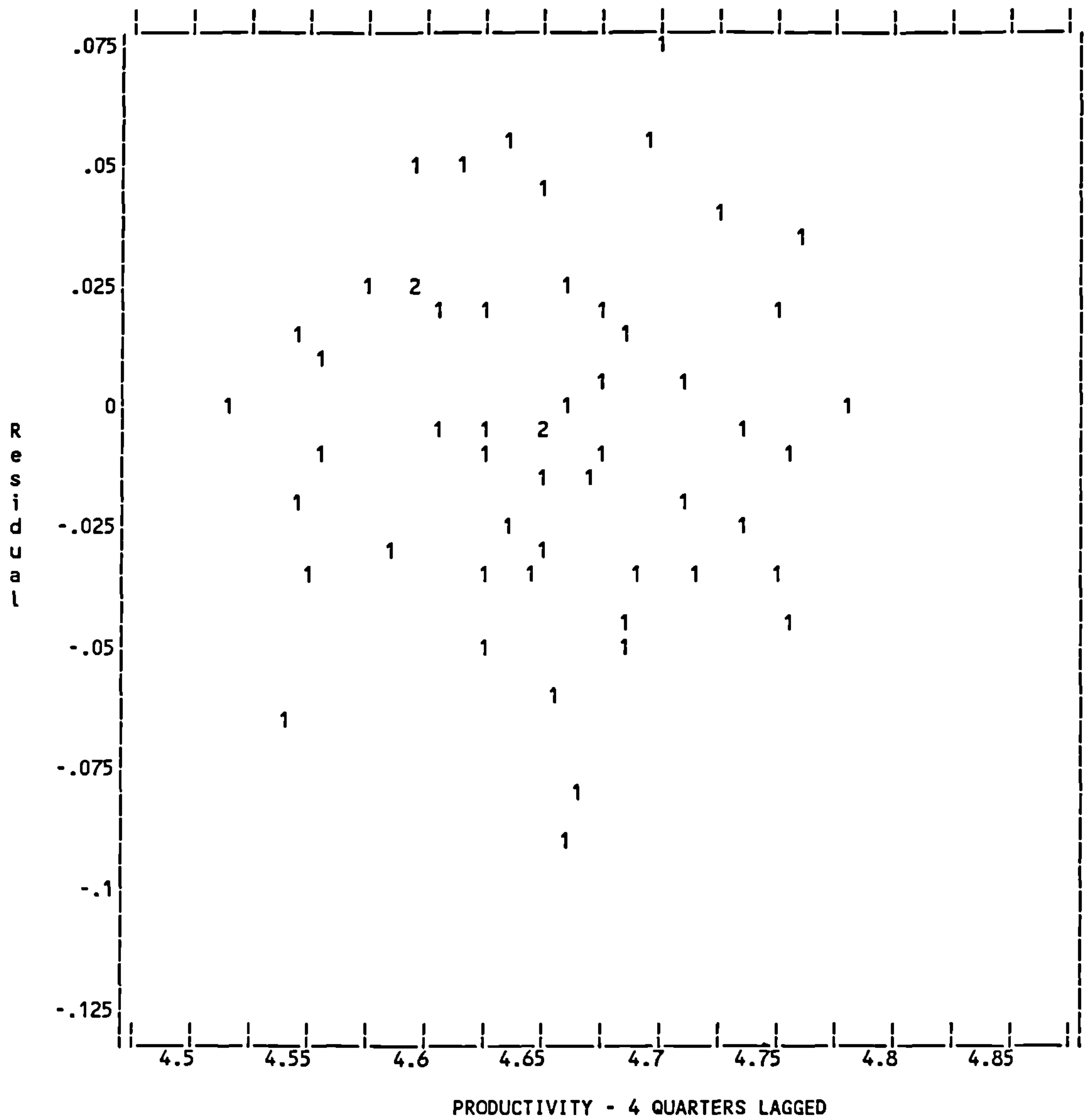

Figure 7.8 Analysis of Residuals: Plot of Residuals against Productivity

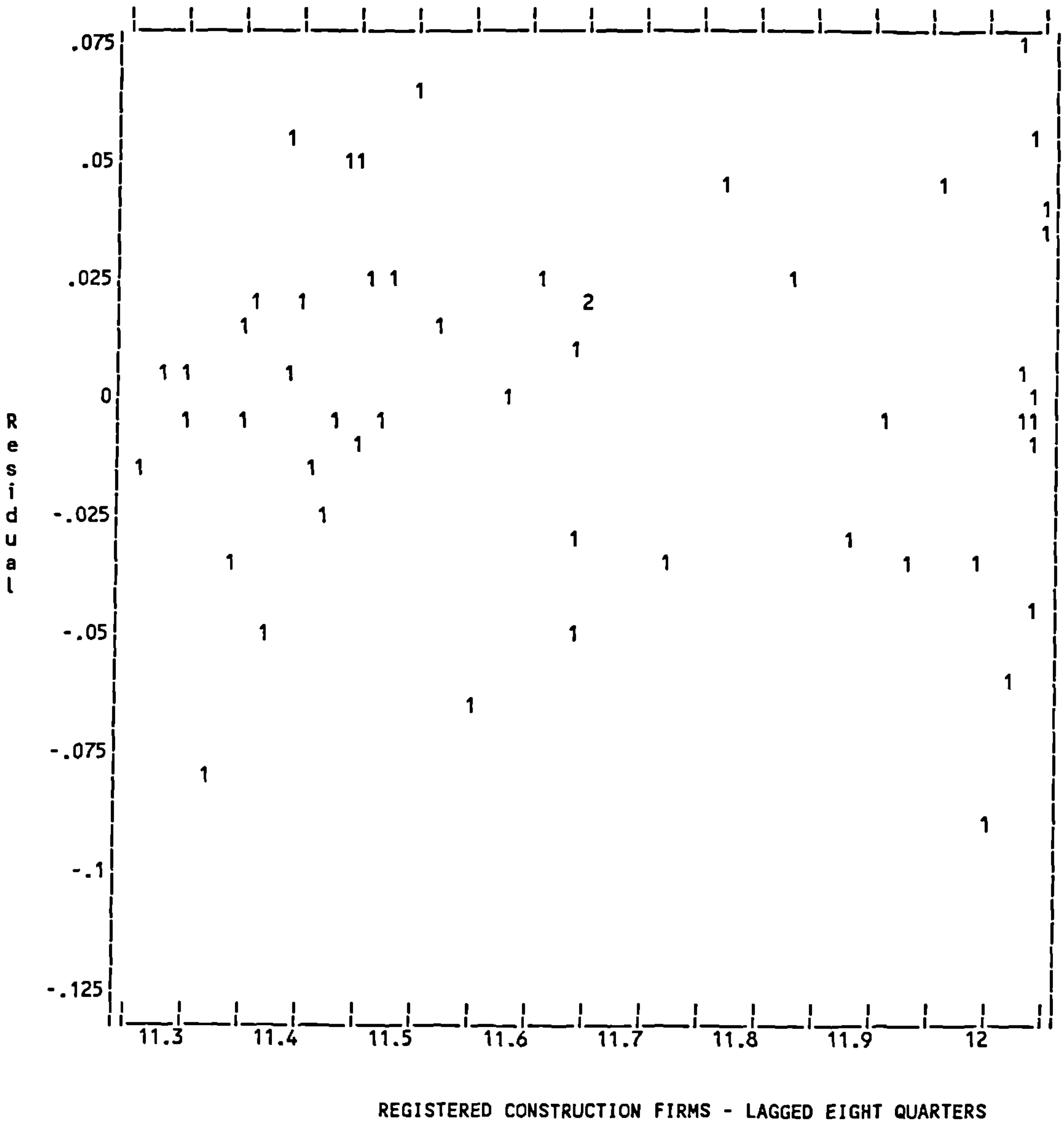

Figure 7.9 Analysis of Residuals: Plot of Residuals against Registered Construction Firms

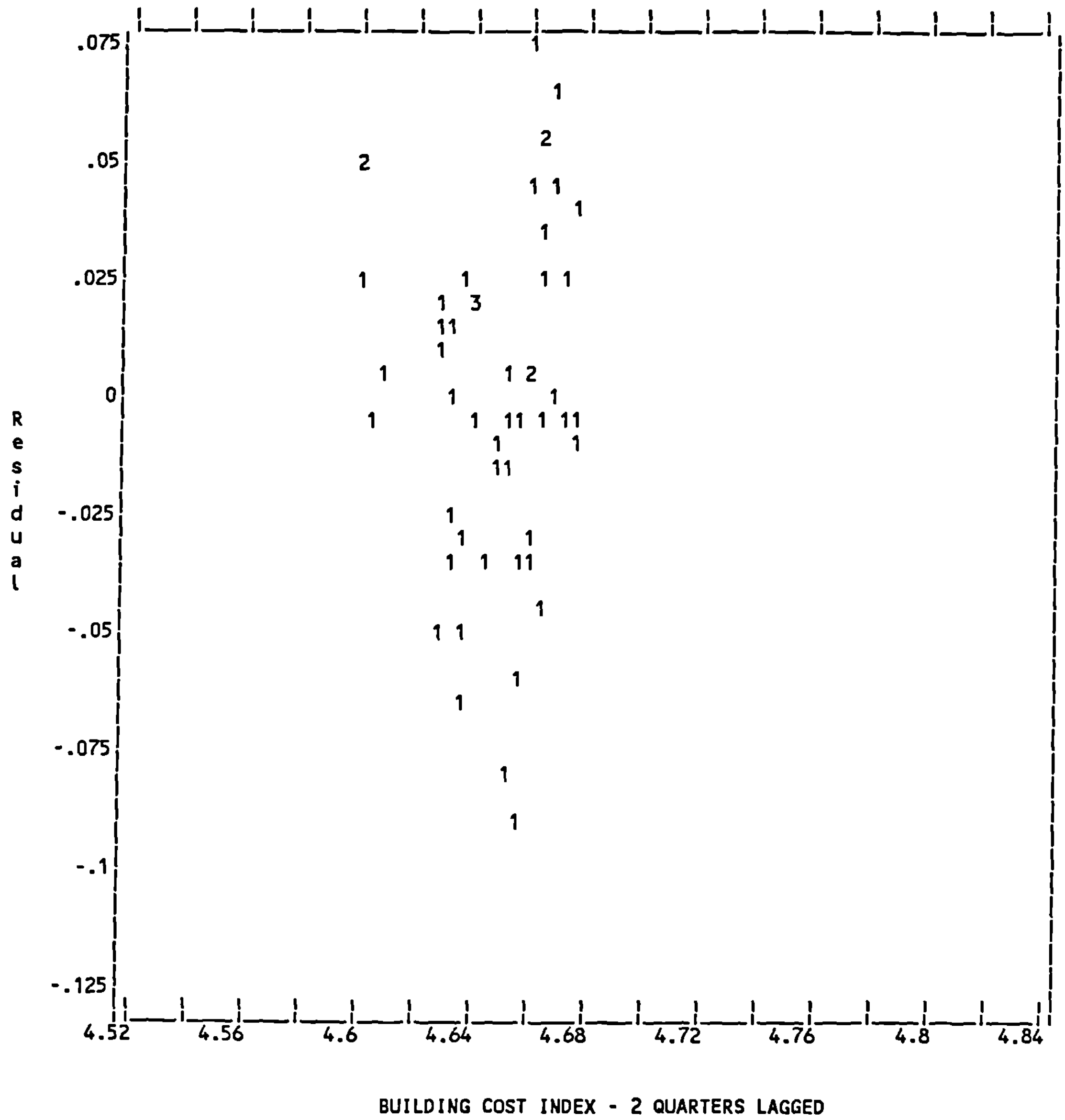

Figure 7.10 Analysis of Residuals: Plot of Residuals against Building Cost Index

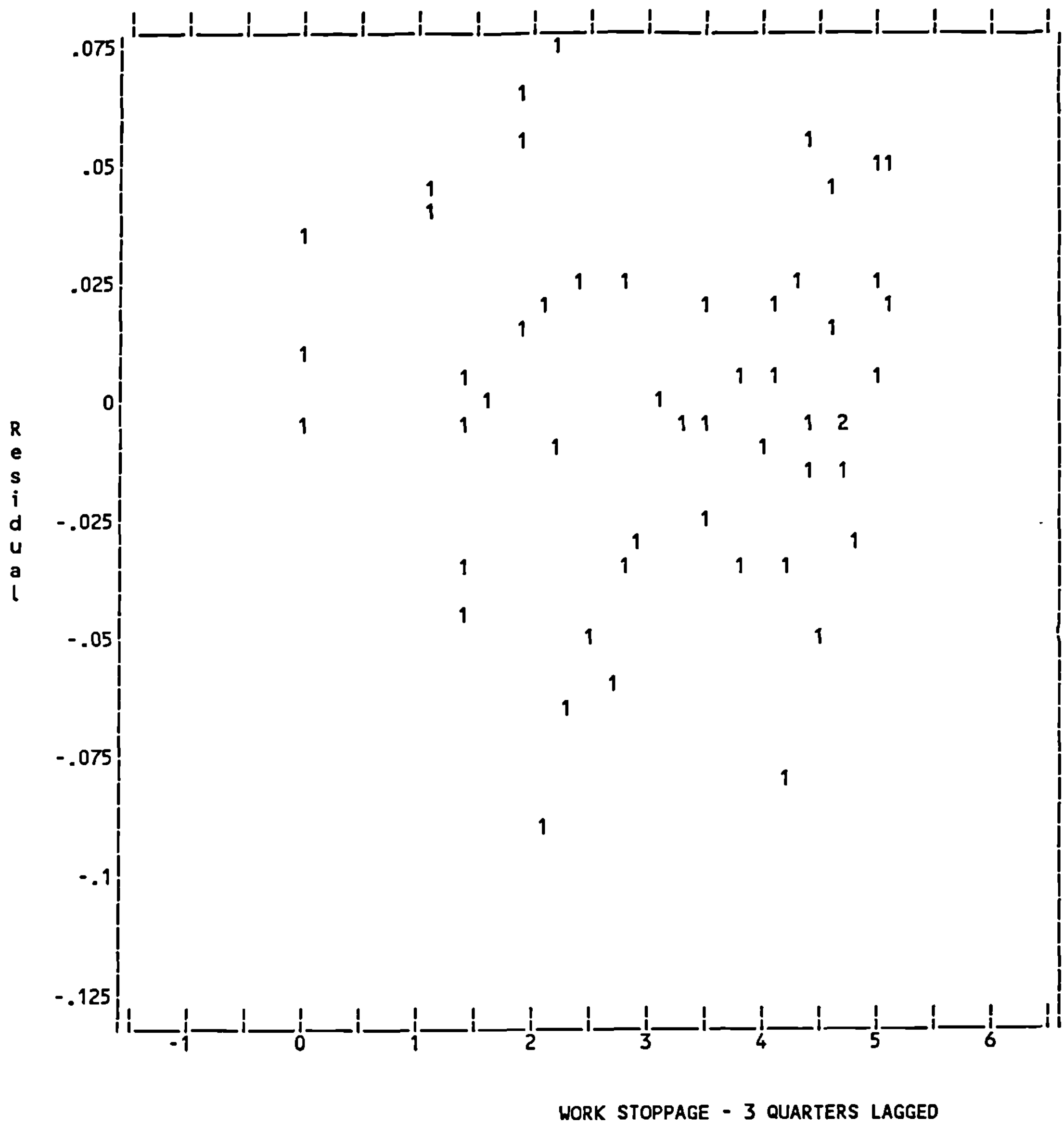

Figure 7.11 Analysis of Residuals: Plot of Residuals against Work Stoppages

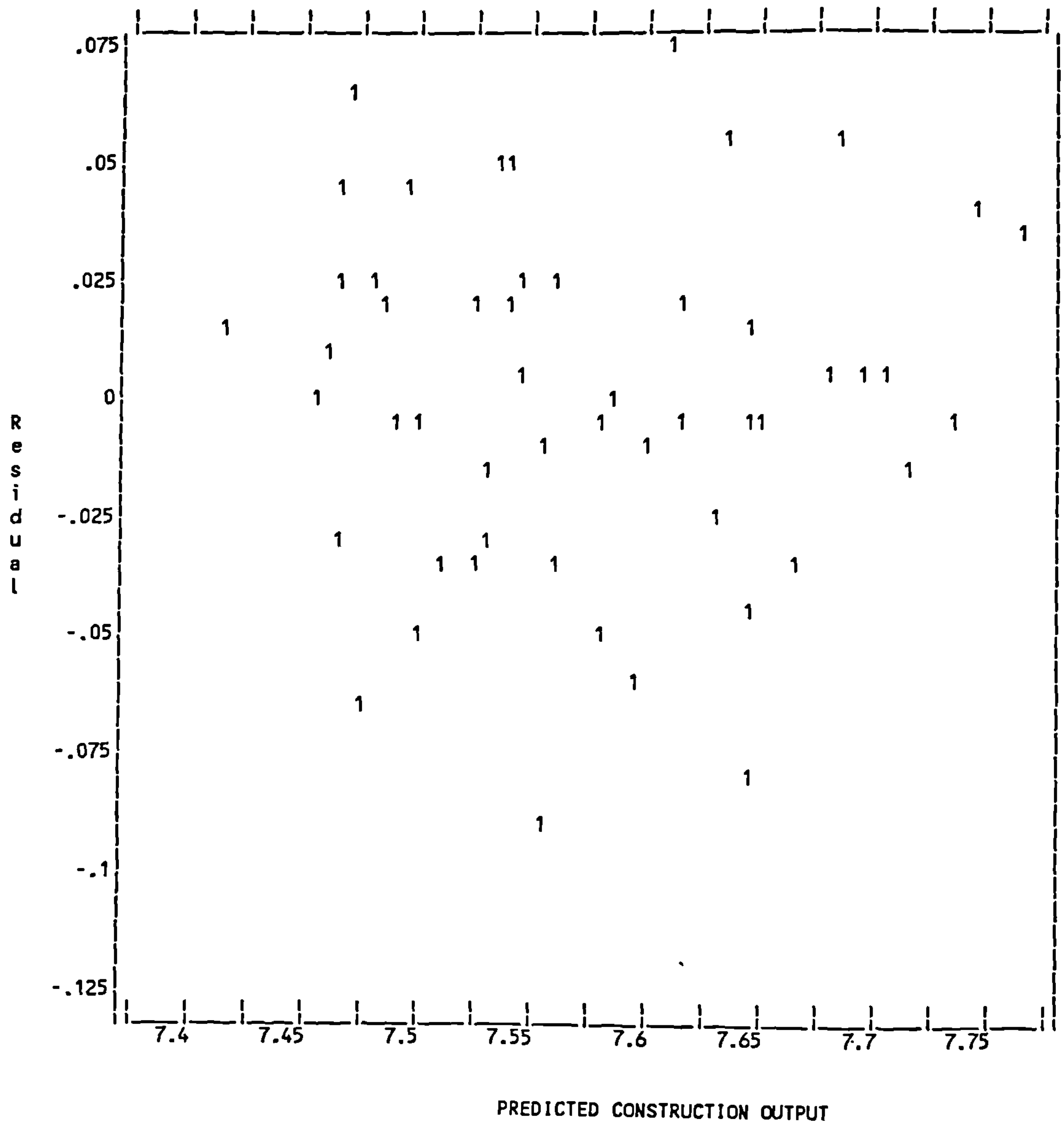

Figure 7.12 Analysis of Residuals: Plot of Residuals against Predicted Construction Supply

7.8 Conclusion

This chapter first reviewed the theory of supply at the micro and aggregated level. It was noticed that price of goods and service, input costs and productivity are relevant to firms' decisions as to what they are willing and able to offer for sales.

Construction literature on supply is scanty. This lack of relevant literature tends to corroborate Hillebrandt's1985) observations that we in the construction industry have failed to utilise the opportunities offered by economic theories. This chapter has adopted the principles offered by economic theories to identify the determinants of construction supply.

Construction output has been used as a proxy of construction supply against two backgrounds: (1) There appear to be no other better construction time series to be a reasonable proxy, and (2) This time series has relevance to what firms are willing or able to produce when construction price is put into consideration.

Using quarterly data, the construction supply equation has been estimated. It suggests that construction supply has an inelastic positive response with construction price and number of registered construction firms. It is negatively correlated with input costs and work stoppages. Productivity is positively correlated with construction supply and leads construction supply by four quarters. The adjusted r^2 values of 0.83 for the model is particularly encouraging for a deflated model of this kind. The analysis of the model's residuals suggests that the model is statistically stable with approximately normal distribution shape and lack of pattern in the plots of the residual values against the predicted values. The model, however, has failed to mimic "supply shocks". This tends to suggest that the revision of this model and/or any other models of construction supply should consider economic events that constitute shocks to construction supply. Examples in this case are the oil crisis and unusual construction investment such as the Channel Tunnel project.

Nonetheless, these findings may be useful to construction contractors in assessing their future construction supply in relation to macro-economic factors and can also assist in determining to what extent these affect tender price.

The following chapter considers the interactions of construction supply and demand as they help determine the construction price.

CHAPTER 8

Construction Price Determination - Interaction of Construction Demand and Supply

CONSTRUCTION PRICE DETERMINATION - INTERACTION OF CONSTRUCTION DEMAND AND SUPPLY

8.1 Introduction

The construction industry is regarded as highly competitive. According to the Bank of England, there are three different concept of competitiveness: price competitiveness, relative cost competitiveness and relative profitability. Though the three concepts of competitiveness are somehow interwoven, price competitiveness is of more relevance to construction industry because of its commercial activities. Price competitiveness is achieved through the process of tendering or bidding and its degree of competitiveness is predominantly determined by the market.

Skitmore (1987) described the construction market in terms of the demand and supply of construction works. Gaver and Zimermann (1977) assessed the price competitiveness and market condition in terms of building activity, the construction time, the number of competitors and the amount of cement shipped to a district. On the other hand Neufville, Hani and Lesage (1977) found a link between price competitiveness and economic conditions. Runeson and Bennett (1988) identified construction market condition and consequently price competitiveness in regression models in terms of unemployment, building approvals and value added. Earlier work by Runeson and Bennett (1983) and McCaffer et al (1983) examined and quantified the degree of price competitiveness of firms from both the demand and supply side.

The principle of price competitiveness supposes that a firm's product in terms of price, design, quality and other attributes matches those of other rivals. It also assumes that suppliers have freedom in setting price and satisfy whatever demand is generated at that price. This situation is well established in manufacturing sector and features in most manufacturing price equations (Eckstein and Framm, 1968; Ripley and Segal (1973).

In the construction sector, apart from theoretical work undertaken by Skitmore (1987), exponents have treated price competitiveness in relation to market condition either from demand or supply side. Little or no clear interaction between construction supply and demand has been identified. It seems difficult to measure and foresee the interaction of construction supply and demand. It is no surprise that the input cost (supply side) shows up more strongly in price equation than demand (Wilder, 1977).

Obviously, construction supply depends on construction demand(Butler, 1977, New Builder, 1990), and the two affect price. It is an established economic theory, that both demand and supply influence the equilibrium price and quantity. It can be said that an increase in construction demand cannot be satisfied without an increase in production, otherwise an increase in construction price will result. This situation may cease to be the case only when there is idle capacity in the construction industry.The consequence of increase in construction price is reduction in construction demand.

It becomes clear therefore that the estimates of the construction price equation based on only one of these construction activities (demand or supply) is most likely to be biased. Richardson (1974) suggests that estimates of demand price elasticities can be substantially different when supply relationships are explicitly accounted for.

This chapter reports an investigation that departs from earlier work. The chapter considers the price responsiveness of both construction demand and supply by adapting two methods: Single structural equation which, includes the construction demand and supply variables; and a simultaneous supply/demand estimation technique. The simultaneous equation technique is useful for separating demand and supply functions and provide consistent estimates of structural coefficients (Heathfield, 1976). These two approaches have different usefulness in econometric analysis. The simultaneous equation technique enables a reduced form equation for construction price to be derived. The reduced-form equation has better predictive and control performance than the single structural equations and worse structural analysis performance (Zellner and Palm, 1974). Since this research work is interested in both the structural analysis and prediction of construction prices it becomes necessary that these two equations are derived.

Apart from these, this chapter also reviews the theoretical framework for determining equilibrium price in economic theory.

8.2 Price determination mechanism: Demand, supply, market and equilibrium

Demand relates to the quantity of goods and services buyers (clients) wish to purchase (commission) at each conceivable price. Supply is the quantity of a good or services seller (contractors) wish to sell (produce) at conceivable price. A market is a set of arrangements (tendering process) by which buyers (clients) and sellers (contractors) are in contract to exchange goods or services (construction service).

The relationship between price and demand is negative holding other factors constant, while the relationship between price and supply is positive. Considering this the demand curves slope downward and the supply curves slopes upward for most goods and services.

Economic theory indicates that the market equilibrium is the intersection of the demand and supply curves and this point corresponds to equilibrium price.

The price determination mechanism implies that there will be excess supply at all prices above the equilibrium price and sellers may react to unsold stock by cutting prices until the equilibrium price is reached at which excess supply is eliminated. So also price below the equilibrium could lead to excess demand which, if not matched with instantaneous supply will push up the price. This bidding up of the price gradually eliminating excess demand until equilibrium point is reached. It becomes clear therefore, that at market equilibrium the buyers and sellers can trade as much as they wish at the equilibrium price providing there is no incentive for any further price changes.

A change in any of the factors determining the demand/supply of goods and services could lead to a shift in the demand/supply curve and consequently the equilibrium point. The determinants of construction demand and supply have been identified in chapters 6 and 7 respectively. Gross National Product is a determinant of construction demand. A lower demand for construction services due to lower income in real terms could shift the entire demand curve to the left since a lower quantity may be demanded at each price. This shift in demand curve leads to a new equilibrium price assuming the factors determining supply such as input costs, technology and government regulations are held constant. A change in any of these supply factors held constant will lead to a shift in supply curve and consequently a change in equilibrium price and quantity.

Simultaneous shifts in the demand and supply curves produce more complex price adjustment mechanism. In this case, the equilibrium price and quantity depend on the effects of both shifts.

8.3 Implications of price mechanism for construction price determination

Does the neo-classical economic theories of price determination have any application to construction price determination? The construction industry lack relevant literature that could be useful to give a straightforward answer to this question. The activities of the industry however points to the possible relevance of economic theory in construction price determination.

Construction price is mainly determined through a process of contract bidding. At the micro level, construction price may responds to the aggregate demand and supply for construction. A construction firm's workload is correlated with the general construction demand. Conversely, the price at which firms bid may depend on the current and the expected workloads. Clients have tendencies to increase construction investment in times of low price and the construction industry, probably, will respond to this excess demand by increasing the bidding price. Higher construction prices may encourage firms to increase production possibly to improve profitability. Idle capacities in firms may be utilized, additional organisational structures created and resources expanded to buffer up production. That most construction firms have tendencies to increase supply in times of higher construction price has implication at the macro level. At the macro level, excess supply capability is probably created over time. In theory, construction firms should respond to excess supply by bringing down the price as production capacity becomes more than the available construction demand.

This illustration tends to show that the construction industry price determination have resemblance to the classical economic theory of price. However, the relationship between the construction demand, supply and price have time lag constraints.

8.4 Causal relationship: construction demand, supply and price

The relationship between demand, supply, price and market is an established neo-classical economic theory. Free market condition allows prices to be determined purely by the forces of supply and demand.

Construction price being determined on contract bidding basis qualifies the industry's commercial activity as a free market, considering that there is little or no barrier to entry. The industry has low fixed assets and positive capital flow (Hillebrandt, 1990), hence, what could constitute barrier to entry into the industry is the ability to bid and win contracts. Operation of free market within the industry makes construction price vulnerable to the forces of construction demand and supply. Construction supply and demand influence the construction price and *vice versa*. Figure 8.1 illustrates the causal relationships between construction demand, supply and price.

This principle of price determination is not peculiar. The notions that underlie the model development are consistent with supply and demand concepts adopted as a basis for modelling production inventory problem (Sethi and Thompson, 1980). Sethi and Thompson described, heuristically, cause-and-effect models in the field of finance, marketing, maintenance and replacement, and production inventory system using the notions of supply and demand concepts.

8.5 Structural Equations of Construction Price

The structural analysis of the construction price equation consists of the following:

1. Methodology
2. Presentation of estimated equation and summary statistics
3. Analysis of construction price equation
4. Contributions of variables to construction price equation
5. Analysis of stability properties
6. Analysis of the equation residuals

8.5.1 Methodology

The analysis adopted was via the multiple regression program devised by Akintoye and Skitmore (1990). The structural equation employed explanatory variables comprising the determinants of construction demand (see chapter 6) and supply (see chapter 7). Using this method each of the determinants is given equal opportunity in the construction price equations. The intention here is that any explanatory variable that produces an insignificant coefficient probably due to auto-correlation with another variable could be dropped and the equation re-estimated.

The aim at this stage being the development of the lead relationships of the independent variables in relation to construction price. These are estimated using a multiple regression program (Appendix B).

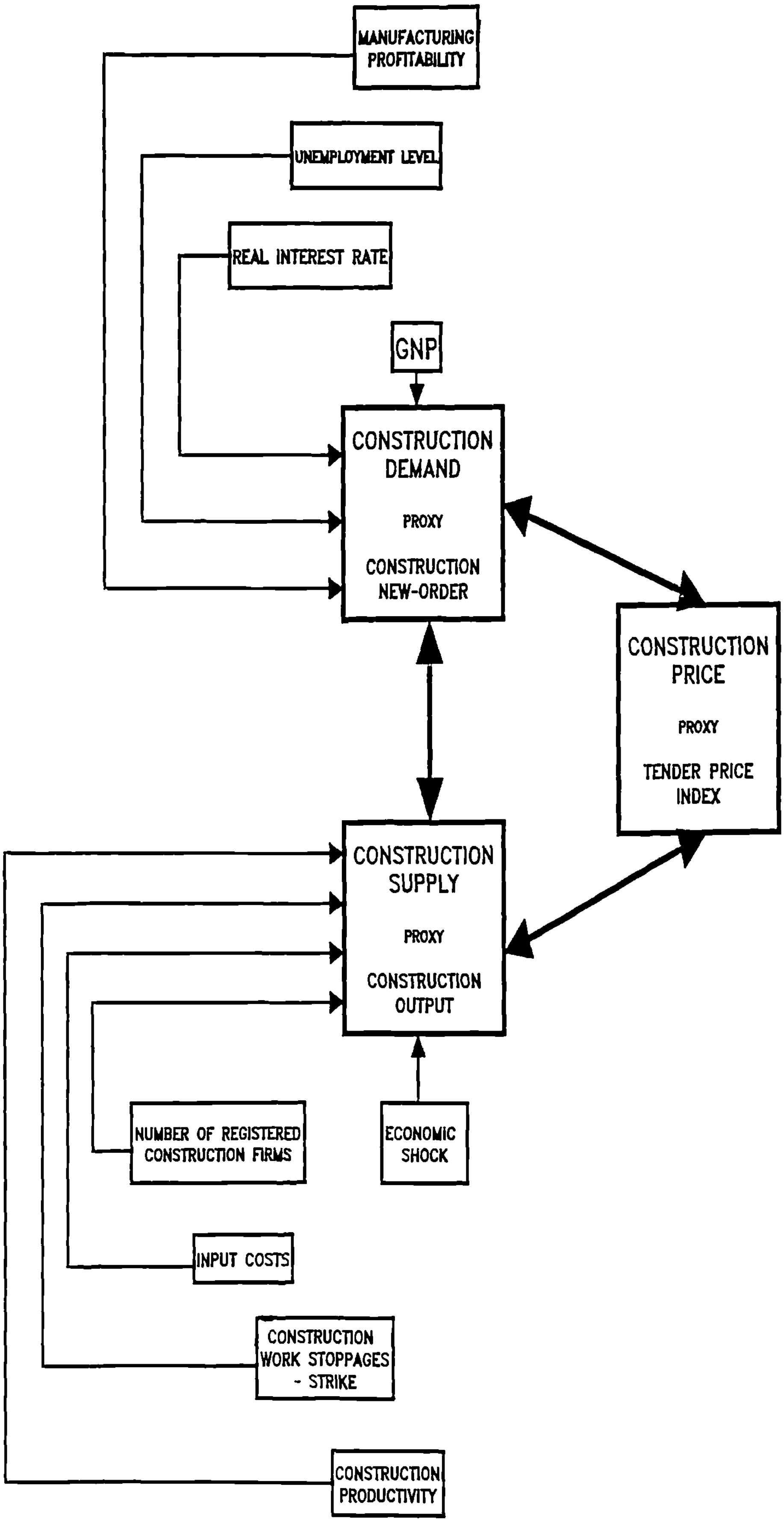

Figure 8.1 Construction price causal model

The univariate analysis in chapter 5 (see section 5.6) shows the probabilities of correlations between construction price and some listed indicators. This produces an initial impression of possible lead relationships between these construction demand and supply determinants; and construction price. Tables 5.2 to 5.5 give the probabilities that the relevant variable could be excluded from the construction price prediction equation. Low probability in that table implies strong marginal prediction power and vice versa. Variables with strong predictive power are taken as having not more than a probability value of 0.0500, which means that there is 500 chance out of 10,000 (5% chance) that the particular lead of a listed variable does not belong in that prediction equation. Hence, lead of a listed variable must have points of between 5 and 3 to be regarded as significant in construction price equation (see section 5.6.1).

Table 8.1 shows the significant lead relationships between construction price and the determinants of construction demand and supply using the analysis presented in Tables 5.2 to 5.5.

Table 8.1 Construction demand and supply determinants lead relationships with TPI

Significant lead relationships are established with construction price at the following lead (Significant level being 95% which correspond to probability value more than 3 points - see section 5.6.1)

Construction Demand and supply Determinants	Aggregated Analysis Table 5.2 1974 - 1986 52 Quarters	Disaggregated Analysis Table 5.3 1974 - 1979 24 Quarters	Table 5.4 1980 - 1985 24 Quarters	Table 5.5 1986 - 1990 18 Quarters	Choice of optimum Lead based on consistency of leads in both aggregated and disaggregated analysis
MAN (M^p)	1 - 7	5, 6	6, 7, 8	5, 6	Inconclusive
EMP (U^e)	0 - 3	0, 1, 2, 5	1, 2, 5, 6, 7	3, 4	Inconclusive
GNP (Y^d)	0	0, 1	0, 4, 5	0	0
FRM (F^r)	5	0	7	0 - 7	Inconclusive
BCI (C^p)	0, 1	0	-	0, 2, 4	0
STR (S^T)	0, 5	-	7	-	Inconclusive
PRO (P^r)	2, 5, 6	2	2	-	2
RIR (r)	5 - 7	-	-	2, 3	Inconclusive

From Table 8.1 the leads for Y^d, C^p, and P^r are established at 0, 0 and 2 respectively. However, the leads in respects of M^p, U^e, F^r, S^T, and r are inconclusive. These information are incorporated into the multiple regression program such that Y^d, C^p, and P^r are fixed at leads 0, 0 and 2 respectively while M^p, U^e, F^t, S^T, and r having an integer range of 0 to 8 possible lead periods (see Appendix B). This method of analysis is not unusual in economic modelling. Burridge *et al* (1991) support this stance that it is commonplace to suggest that economic theory has most to say about the specification of economic relationships and that the precise specification of lag distributions is best left to the data.

The multiple regression program produced a total of 59049 separate regression models at a complete run of the program. A test run in which each of the nine variables takes an integer 0 to 8 possible lead periods is preferred and would have produced 43 million separate regression models at a complete run of the program. This is not practicable as the test run would have taken about 175 days to complete a run on the University of Salford Prime Mainframe. Table 8.2 presents the construction price multiple regression program output. The criteria for the choice of best model for further analysis is discussed in Appendix B. The asterisked (*) model in Table 8.2 which produced the least Mean Squared Error is the choice of model for further analysis. The rest of this section reports the results of the estimated equation and summary statistics. This analysis employed SPSSX statistics package on the University of Salford Prime Network.

8.5.2 Presentation of estimated equation and summary statistics

The structural form of equation of construction price is presented in Equation 8.1 using the quarterly data from the first quarter 1974 to the fourth quarter 1988 (Appendix 8.1 shows the full statistics in respect of this equation). The equation is expressed in double-log except for real interest rate variable. The raw real interest rate is used due to the presence of negative values. This shows that the coefficients of the variables expressed as log-linear could be interpreted as the elasticities of construction price.

$$\ln P_t = -3.614 + 0.807 \ln C^P_t + 0.009 \ln S^T_{t-4} - 0.296 \ln P^r_{t-2} - 0.258 \ln F^r_{t-5}$$
$$+ 0.003\, r_{t-3} + 0.542 \ln M^P_{t-7} - 0.136 \ln U^e_{t-2} + 0.606 \ln Y^d + 0.061\, O^L_{t-1}$$

R = 0.986 Adjusted R^2 = 0.966 SEE = 0.020

DW = 2.172 F-value = 164 D.F. = 9,43

Eqn. 8.1

Table 8.2 Construction price multiple regression program output

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PROGRAM ENTERED

DATA IN

BC	ST	PR	FM	MA	BB	EM	GP	OL	SEE	Const.	C^P	S^T	P^r	F^r	M^P	r	U^e	Y^d	O^L	Cases
0	0	2	0	0	0	0	0	1	0.00102	-1.297	0.934	-0.001	-0.397	-0.166	-0.592	0.002	-0.229	0.788	0.091	58
0	0	2	0	0	0	1	0	1	0.00098	-0.529	0.543	0.001	-0.282	-0.159	-0.533	0.005	-0.243	0.802	0.089	58
0	0	2	0	0	1	0	0	1	0.00092	0.006	0.728	-0.001	-0.291	-0.178	-0.701	0.004	-0.231	0.769	0.093	58
0	0	2	0	0	1	1	0	1	0.00083	1.043	0.242	0.001	-0.145	-0.179	-0.695	0.006	-0.238	0.820	0.091	58
0	0	2	0	0	2	1	0	1	0.00074	0.495	0.281	0.004	-0.237	-0.226	-0.719	0.006	-0.221	0.964	0.074	58
0	0	2	0	0	3	1	0	1	0.00070	0.465	0.240	0.006	-0.164	-0.293	-0.910	0.005	-0.183	1.114	0.067	57
0	0	2	1	0	2	1	0	1	0.00066	0.327	0.295	0.004	-0.239	-0.223	-0.684	0.006	-0.223	0.955	0.071	58
0	0	2	1	0	3	1	0	1	0.00061	0.334	0.248	0.005	-0.161	-0.285	-0.865	0.005	-0.188	1.093	0.062	57
0	0	2	1	0	3	2	0	1	0.00059	-0.437	0.328	0.005	-0.158	-0.312	-0.730	0.006	-0.178	1.099	0.063	57
0	0	2	2	0	3	1	0	1	0.00057	0.151	0.277	0.005	-0.162	-0.268	-0.778	0.005	-0.195	1.039	0.061	57
0	0	2	2	0	3	2	0	1	0.00054	-0.668	0.361	0.005	-0.160	-0.295	-0.631	0.006	-0.185	1.043	0.061	57
0	0	2	3	0	3	2	0	1	0.00052	-0.980	0.390	0.005	-0.170	-0.277	-0.522	0.005	-0.191	0.995	0.061	57
0	0	2	3	7	3	2	0	1	0.00051	-3.196	0.876	0.005	-0.410	-0.265	0.637	0.005	-0.144	0.552	0.058	53
0	0	2	4	6	2	3	0	1	0.00049	-1.733	0.432	0.005	-0.277	-0.249	0.761	0.005	-0.128	0.473	0.089	54
0	0	2	4	6	3	2	0	1	0.00048	-2.179	0.644	0.005	-0.374	-0.260	0.628	0.004	-0.134	0.539	0.074	54
0	0	2	4	7	3	2	0	1	0.00045	-3.057	0.772	0.006	-0.366	-0.266	0.687	0.004	-0.135	0.543	0.058	53
0	0	2	5	7	3	2	0	1	0.00045	-3.054	0.757	0.004	-0.288	-0.259	0.735	0.004	-0.132	0.483	0.056	53
0	1	2	4	7	3	2	0	1	0.00044	-2.634	0.623	0.007	-0.387	-0.263	0.581	0.004	-0.145	0.625	0.059	53
0	1	2	5	7	3	2	0	1	0.00043	-2.610	0.573	0.007	-0.316	-0.258	0.635	0.004	-0.139	0.582	0.057	53
0	4	2	3	0	3	2	0	1	0.00042	-1.897	0.488	0.010	-0.150	-0.280	-0.540	0.004	-0.171	1.040	0.065	56
0	4	2	4	0	3	1	0	1	0.00042	-1.681	0.469	0.013	-0.188	-0.234	-0.545	0.003	-0.188	0.994	0.063	56
0	4	2	4	0	3	2	0	1	0.00041	-2.429	0.555	0.011	-0.179	-0.265	-0.394	0.003	-0.174	0.990	0.066	56
0	4	2	5	5	3	2	0	1	0.00041	-2.699	0.583	0.011	-0.364	-0.256	0.447	0.003	-0.136	0.690	0.080	55
* 0	4	2	5	7	3	2	0	1	**0.00040**	**-3.614**	**0.807**	**0.009**	**-0.296**	**-0.258**	**0.542**	**0.003**	**-0.136**	**0.606**	**0.061**	53

OK,

8.5.3 Analysis of the construction price equation

All the variables have the expected theoretical signs.

Adjusted R^2 of the equation, (adjusted coefficient of determination) indicates excellent fit with 97 per cent of the variance in the construction price being explained by the equations. Since the equation is log-linear, the standard error of the estimate implies an average within-sample prediction error of 2 per cent. DW shows no problem with first-order autocorrelation of the residuals since the DW statistics is comfortably near 2.0 (by Stewart criteria).

Theoretical expectation is that growth in general economic condition induces construction demand and consequently an increase in construction price. The positive relationship between construction price and GNP is preferred.

Estimating folklore would have the bid price as a product of input costs and mark-up, which implies that increases in costs will result in increases in prices. The positive relationship found between these two variables, even in partial correlations, satisfies this preconception.

Work stoppages in the construction industry have a positive relationship with construction price. This variable reduces construction supply and consequently increase the price.

The number of private construction firms registered is related to the intensity of competition (Skitmore, 1987) and affects construction supply. The greater the number of firms, the greater the potential number of contractors expected to bid for a contract, which increase the actual and perceived intensity of competition, The higher the intensity of competition the lower, will be the price (McCaffer, 1976; Neufville, 1977), and hence the negative sign of this variable coefficient accord with *a priori* beliefs.

Productivity is expected to have a negative relationship with price, in which case the higher the productivity, the lower the unit cost that may be expected and consequently a lower price of construction. Its negative relationship at lead of two quarters in the equation is theoretically reasonable. Firms with high productivity are expected to have lower price level to improve the chances of winning more contracts. Another study by Akintoye and Skitmore (1990) indicates a significant negative relationship between construction price and the future or expected productivity. These results suggest that the industry is interested in both future level of productivity and historical productivity level as they affect construction price.

Manufacturing profitability has an impact on the demand side of construction price. This has positive inelastic relationship with construction price.

Unemployment has a negative inelastic relationship with construction price with a lead of 2 quarters. A likely interpretation of this centres around the notion than an increase in unemployment rate creates financial hardship and uncertainty. This uncertainty causes many potential clients of the construction industry to postpone initiating new construction works. This results in total decrease in the volume of construction available for construction contractors. A decrease in the construction volume is expected to result to a decrease in construction price as there will be more contractors chasing few works.

The dummy variable for the oil crisis has a positive and lead of 1 quarter with construction price. This has a coefficient of 0.061.

8.5.4 Contributions of variables to construction price equation

Table 8.2 presents the unsigned beta coefficient contributions of variables to variability in construction price equation expressed in percentage ranked in order of magnitude. The factors influencing the demand side of construction price trend included in the equations are GNP (Y^d), manufacturing profitability (M^p), real interest rate (r) and unemployment (U^e). The proxy for intensity of competition is number of construction companies (F^r). The factors that may influence the unit cost of construction are input costs level denoted by Building Price Index (C^p), Productivity (P^r) and Energy cost (O^L).

Oil Crisis, Productivity and Building Cost index ranked 6th, 7th and 8th respectively with a total contribution of 16.8% to the construction price equation. Intensity of competition and demand factors occupy the first five positions in the table with a total contribution of 75.8%.

Table 8.3 Absolute beta coefficient contributions of variables (in per cent) to variability in construction price equation

Variables		Contributions (per cent)
FRM	(F^r)	25.78
EMP	(U^e)	20.08
GNP	(Y^d)	17.32
RIR	(r)	6.47
MAN	(M^p)	6.11
OIL	(O^L)	5.63
PRO	(P^r)	5.62
BCI	(C^p)	5.53
STR	(S^T)	4.05
Unexplained		3.41

8.5.5 Stability of construction price equation

The stability of construction price equation was investigated by determining 'rolling regression' of the dependent variable (after McNees, 1989). Using this process, the construction price equation was re-estimated each quarter using information (dependent and independent values) only up to the start of the relevant period.

Table 8.4 presents the re-estimated construction price equations up to the start of the quarter from 1983 first quarter (1983:1) to 1990 second quarter (1990:2) using quarterly data from 1974:1. This produced 30 estimated equations of construction price. The relevant statistics are also presented. The first quarter of 1983 was chosen as the starting period to have a reliable degree of freedom.

The table enables the coefficients for each variable to be compared over time. Also the table produces summary analyses in form of arithmetic mean, standard deviation and coefficient of variation (standard deviation expressed as percentage of the arithmetic mean) for each of the variables and statistics to determine their variabilities. All are shown in Tables 8.4.

This table shows that the coefficient of variation of regression coefficients of variables fall within 3 and 20%. The only exception is S^T regression coefficients. The R and Adjusted R^2 statistics are very stable with less than 1 per cent variability.

8.5.6 Analysis of Residuals of construction price equation

Appendix 8.1 includes the results on the analysis of residuals of the construction price equations (Eqn. 8.1).

The residual of this model is random and normally distributed. This is shown by the expected values of the residuals and standardized residuals equal zero with standard deviations equal 0.0182 and 0.9094 respectively. The mean of leverage value is 0.1698 (standard deviation= 0.0927). Only one case (case 8) has leverage value above the critical value (critical value = 0.3396). The outliers are not patterned and only two case from the 60 cases (case 16=-2.63 and case 32=-2.04) have standardized value greater than 2 or less than -2 which, is less than the 5 per cent one would expect by chance.

The frequency distribution of the standardized residuals is approximately bell shaped which, supports normal distribution. The normal probability plot shows that the residuals for all cases fall near the diagonal which, also confirms that the residuals are normally distributed.

The visual examination of the residuals plot against the observed and estimated construction price show that the plots are randomly scattered without any specific pattern.

Table 8.4 Construction price models showing stability of Eqn 8.1

	Const.	C^P	S^T	P^r	F^r	M^P	r	U^e	Y^d	O^L	R	Adj. R^2	SEE	D-W	F-Value	D.F	Data (Qrts)
1983 1	-5.236	0.604	0.005	-0.174	-0.240	0.882	0.003	-0.126	0.690	0.051	0.982	0.949	0.023	2.223	61.0	9,20	37
2	5.245	0.605	0.006	-0.155	-0.227	0.891	0.003	-0.126	0.696	0.050	0.984	0.954	0.022	2.292	70.1	9,21	38
3	-5.125	0.582	0.005	-0.195	-0.256	0.883	0.003	-0.122	0.679	0.053	0.985	0.958	0.022	2.307	79.6	9,22	39
4	-5.110	0.590	0.004	-0.182	-0.247	0.892	0.003	-0.126	0.681	0.051	0.986	0.961	0.021	2.322	88.5	9,23	40
1984 1	-5.187	0.592	0.004	-0.203	-0.241	0.903	0.003	-0.126	0.683	0.051	0.986	0.963	0.021	2.317	96.8	9,24	41
2	-5.096	0.585	0.004	-0.207	-0.258	0.821	0.003	-0.130	0.699	0.053	0.987	0.965	0.021	2.336	105.6	9,25	42
3	-5.027	0.596	0.004	-0.203	-0.254	0.824	0.003	-0.130	0.699	0.053	0.988	0.967	0.020	2.336	115.1	9,26	43
4	-4.983	0.562	0.004	-0.200	-0.240	0.873	0.003	-0.130	0.722	0.051	0.988	0.967	0.020	2.306	119.3	9,27	44
1985 1	-4.820	0.583	0.003	-0.203	-0.255	0.805	0.003	-0.134	0.704	0.053	0.988	0.967	0.020	2.251	122.9	9,28	45
2	-4.817	0.530	0.004	-0.207	-0.248	0.806	0.003	-0.129	0.707	0.052	0.988	0.967	0.020	2.202	127.9	9,29	46
3	-4.865	0.541	0.003	-0.204	-0.252	0.809	0.003	-0.134	0.718	0.053	0.988	0.969	0.020	2.241	134.9	9,30	47
4	-4.850	0.535	0.003	-0.202	-0.251	0.809	0.003	-0.134	0.718	0.053	0.988	0.969	0.020	2.262	142.1	9,31	48
1986 1	-4.760	0.619	0.004	-0.213	-0.258	0.768	0.003	-0.133	0.667	0.054	0.988	0.968	0.020	2.184	140.4	9,32	49
2	-4.687	0.638	0.004	-0.219	-0.259	0.758	0.003	-0.133	0.659	0.055	0.988	0.970	0.020	2.210	149.0	9,33	50
3	-4.805	0.634	0.004	-0.217	-0.257	0.760	0.003	-0.135	0.670	0.054	0.988	0.970	0.020	2.222	155.6	9,34	51
4	-4.539	0.679	0.005	-0.225	-0.260	0.768	0.003	-0.129	0.624	0.055	0.988	0.970	0.020	2.195	156.5	9,35	52
1987 1	-4.385	0.708	0.005	-0.235	-0.260	0.738	0.003	-0.130	0.614	0.056	0.988	0.970	0.020	2.273	160.9	9,36	53
2	-4.041	0.793	0.006	-0.271	-0.259	0.627	0.003	-0.137	0.606	0.058	0.987	0.967	0.021	2.242	151.2	9,37	54
3	-3.664	0.800	0.009	-0.299	-0.258	0.534	0.003	-0.137	0.609	0.061	0.986	0.965	0.021	2.123	144.9	9,38	55
4	-3.637	0.803	0.009	-0.299	-0.258	0.533	0.003	-0.137	0.605	0.061	0.986	0.965	0.021	2.170	149.3	9,39	56
1988 1	-3.629	0.803	0.009	-0.299	-0.258	0.532	0.003	-0.137	0.605	0.061	0.986	0.965	0.021	2.170	153.2	9.40	57
2	-3.643	0.802	0.009	-0.298	-0.258	0.538	0.003	-0.136	0.604	0.061	0.986	0.966	0.021	2.167	157.1	9,41	58
3	-3.620	0.800	0.009	-0.297	-0.258	0.537	0.003	-0.137	0.613	0.061	0.986	0.966	0.020	2.170	160.6	9,42	59
4	-3.614	0.807	0.009	-0.296	-0.258	0.542	0.003	-0.136	0.606	0.061	0.986	0.966	0.020	2.172	164.3	9,43	60
1989 1	-3.605	0.810	0.009	-0.295	-0.258	0.542	0.003	-0.135	0.603	0.061	0.986	0.966	0.020	2.172	168.3	9,44	61
2	-3.658	0.817	0.009	-0.294	-0.262	0.553	0.003	-0.130	0.590	0.062	0.986	0.965	0.020	2.162	168.8	9,45	62
3	-3.648	0.813	0.009	-0.295	-0.263	0.552	0.003	-0.129	0.593	0.062	0.986	0.966	0.020	2.172	172.5	9,46	63
4	-3.743	0.815	0.011	-0.299	-0.275	0.592	0.003	-0.122	0.592	0.065	0.984	0.962	0.021	2.095	157.0	9,47	64
1990 1	-3.848	0.813	0.009	-0.283	-0.291	0.776	0.002	-0.124	0.578	0.064	0.981	0.955	0.022	1.757	134.6	9,48	65
2	-4.444	0.817	0.007	-0.284	-0.311	0.837	0.002	-0.118	0.542	0.065	0.976	0.944	0.025	1.525	110.6	9,49	66
Mean	-4.414	0.689	0.242	-0.242	-0.258	0.723	0.003	-0.131	0.646	0.057	0.986	0.964	0.021	2.185	133.9		
Std	0.624	0.109	0.002	0.047	0.015	0.137	0.000	0.005	0.051	0.005	0.003	0.006	0.001	0.161	30.3		
CV(%)	14.125	15.802	39.690	19.563	5.699	18.912	8.504	3.930	7.823	8.386	0.259	0.640	5.374	7.369	22.6		
Excluding 1983 regression coefficients and statistics																	
Mean	-4.297	0.704	0.006	-0.252	-0.260	0.698	0.003	-0.132	0.640	0.058	0.986	0.965	0.021	2.170	143.1		
Std	0.587	0.110	0.003	0.042	0.014	0.130	0.000	0.005	0.051	0.005	0.003	0.005	0.001	0.167	20.5		
CV(%)	13.655	15.636	40.751	16.822	5.311	18.567	9.116	3.735	8.042	7.894	0.262	0.545	7.074	7.698	14.3		

* underlined regression coefficients are insignificant at 5% confidence level

8.6 The simultaneous model

8.6.1 Construction supply and demand

The construction industry is composed of several markets in terms of geographical location of projects, types of project and the overall state of the industry (MacCaffer, 1979). The market could be broadly classified as perfect competitive and imperfect competitive. The imperfect competitive includes monopoly market and to some extent the oligopoly market. We are focusing on the interactions of construction demand and supply in relation to construction price. Therefore it is necessary to assume that the firms in the construction industry are endowed with the same current and past price level and quantity information (though this could be imperfect sometimes) about the construction market. This sounds reasonable in the sense that firms are formally or informally conscious of the general movements in economic conditions and general price level. All of these have direct effects on the construction price and quantities. Apart from this, organisations (private and public) abound that prepare information on the activities of the construction industry. Accepting this presumption indicates that the construction market is perfect to some extent.
Hillebrandt's (1982) comment supports that no categorical statement can be made of the extent of competition in the construction industry that could be true of all type of markets in the industry. The classification of markets in respect of the construction industry seems inconclusive. Exponents have suggested oligopolistic market but evidences on the operation of markets in the industry may not fully support this. Oligopoly demands restrictions on entry into an industry. Entry into the construction industry seems free and easy, which is one of the assumptions of perfect competition.

Ultra free entry into and exist out of an industry are issues addressed by contestable market. Shepherd (1984) argued that if entry is sufficiently trivial it may indeed avoid a response from the existing member of an industry. This corroborate Baumol *et al* (1982) that if an entrants output is small relative to that of the industry, the magnitude of the required adjustment to the activity of the industry may be small. In essence, for free entry and exist to have impact, their influence must be significant.

It will appear that the concept of contestable market will more relevant to the 'sub-markets' that exist within the construction industry in view of diversity of markets in the industry that are probably not well defined.

Another assumption of perfect competition applicable to the industry relates to mobility of the factors of production. It is somehow free to move resources like labour from one firm to another particularly during a period of boom. Perfect competition assumes a large number of sellers and buyers and oligopoly assumes a small number of firms so that sellers are conscious of their interdependence. It is hard to believe that construction sellers can influence construction demand as there are many buyers of construction works. This suggests that oligopoly does not have much influence on construction demand. The construction industry supports a large number of firms, only that the number reduced drastically on large and specialised construction works and/or where selective tendering procedure is employed. Nonetheless, the notion of 'merging' that currently characterizes the industry does suggest that a small or medium firm can indeed undertake a large and specialised jobs if merged with a large firm from where it derives technical support. Oligopoly demands that rival firms reactions are known to each other and firms must be capable of 'guessing' and taking accounts of each other reactions. This assumption may break down in the UK construction industry with large number of big contractors.

Apart from this inconclusive market classification of the construction industry, it is not unusual to make assumptions in economic modelling depending on the objective of the modelling particularly when supported by empirical data. Koutsoyiannis's (1987) identification of several criteria to validate a model include predictive power, consistency and realism of its assumptions, the extent of information it provides, its generality and simplicity. Friedman's (1953) position on this showed the most important criterion of the validity of model is its predictive performance. Though their are contrary opinions on this, Koutsoyiannis expressed the position of most economists that the most important attribute of a model depends on its purpose.

A recent report by the Oxford Economic Forecasting Group supports this stance (Burridge et al, 1991). Among the models prepared by this group is supply issue in the manufacturing sector. The model was initially developed based on the conventional model of profit maximization under imperfect competition conditioned on the capital stock in a forward looking framework. This model produced unsatisfactory results in terms of noticeable big standard error. A final equation having properties that are consistent with theoretical model in equilibrium but whose dynamic properties are more data based is empirically preferable than the former.

Considering these arguments, it may be possible to make assumption of 'approaching perfect competition' in this analysis with respect to construction market, bearing in mind that the ultimate objective of this model is its application in predicting the trend in construction price level. This being the case, the economic theory of price mechanism could have application for determining the trend in construction market.

Construction production takes some time. The supplier of construction has to decide today how much output they will put on the market in the next periods. The output decisions are made based on what are believed to constitute the explanatory variables of construction supply.

More precisely supply of construction is given by the equation (see chapter 7):

$$\ln Q^{s*}_t = a_0 + a_1 \ln P_t + a_2 \ln P^R_t + a_3 \ln C^P_t + a_4 \ln S^T_t + a_5 \ln F^r_t + V_t$$

Eqn 8.2

Where Q^s is the logarithm of construction supply at time t. a_1, a_2, a_3, a_4, and a_5 are elasticities with respect to price, productivity, input cost, strike and registered private construction firms; and V is a random shock to production of construction output whose first difference is normally distributed with mean zero and constant variance which, are serially and mutually uncorrelated.

Demand for construction at time t (see chapter 6) is given by:

$$\ln Q^d_t = b_0 + b_1 \ln P_t + b_2 \ln Y^d_t + b_3 r_t + b_4 \ln U^e_t + b_5 \ln M^P_t + U_t$$

Eqn 8.3

Where Q^d is the logarithm of demand for construction at the time t. b_1, b_2, b_4, and b_5 are the elasticities of price, GNP, unemployment and manufacturing profitability; b_3 is the coefficient of real interest rate and U is a random shock to construction demand whose first difference is normally distributed with mean zero and constant variance which, are serially and mutually uncorrelated.

The equations (Eqn. 8.2 and 8.3) have been estimated in chapters 7 and 6 respectively as shown:

$$\ln Q^{S*}_t = 1.104 + 0.846 \ln P_t + 0.773 \ln P^R_{t-4} - 0.558 \ln C^P_{t-2} - 0.0225 \ln S^T_{t-3} + 0.180 \ln F^r_{t-8}$$

Eqn 8.4

$$\ln Q^d_t = -14.051 - 0.766 \ln P_{t-3} + 1.632 \ln Y^d_t - 0.011\, r_{t-1} - 0.249 \ln U^e_{t-4} + 1.764 \ln M^P_{t-4}$$

Eqn 8.5

8.6.1.1 Impact of economic shock on the construction supply model

The need to allow for economic shocks in construction supply equation has been clarified in chapter 7. Relevant shock in this respect includes the oil crisis and impact of sporadic increase in the construction investment. In the construction supply equation only the oil crisis has been considered. There is a need to include the oil crisis in construction supply equation. Corroborative of this stance Fieleke (1990) identified the consequences of the oil crisis particularly the first oil crisis of 1973/74 (due to Arab oil embargo) and the second oil crisis of 1978-1980 (mainly due to political turmoil in Iran).

The oil crisis means that industrial countries have to give up some quantity of goods being produced in exchange for real price increase for a barrel of oil. This had contractionary as well as inflationary influence on the economy. This was consensus about the effects of oil crisis on output and inflation in the industrial countries. Within the industrial countries an average of 10 per cent rise in world oil prices is believed to lower real gross national product by about 0.2 per cent and to raise consumer prices by perhaps 0.3 per cent.

Considering this effect on the output and the deficiency of the estimated construction supply equation in chapter 7 the construction supply equation has been re-estimated taking into consideration the oil crisis at the relevant periods. The relevant periods associated with the oil crisis have been represented by dummy variable such that this equals 1 in relevant quarters and zero otherwise (Takacs and Tanzer, 1986)

8.6.1.2 Re-estimation of construction supply equation

In the construction supply equation (Eqn 8.4), the construction price is an endogenous variable which shows that P_t is related to error term V_t (Eqn 8.2). This being the case, P_t is biased (Thomas, 1985). In other words this OLS estimation (Eqn 8.4) is a biased and inconsistent estimator of construction supply equation parameter. This is a problem of simultaneous equation bias (Neal and Shone, 1976). However, Thomas (1985) has offered a solution to resolve this problem in form of Two- stage least square (TSLS) analysis.

The first stage of the TSLS analysis is the regression of the endogenous variable against other likely explanatory variables. The aim is to derive the estimated dependent variable values of the endogenous variable such that these values can replace the observed values of the endogenous variable in the original equation. Estimated values of P_t are derived, therefore, by regressing construction price against unemployment, GNP, interest rate and input costs.

The second stage of the TSLS analysis is the estimation of the construction supply equation using the estimated values of P. These are the values derived in the first stage of TSLS and the other explanatory variables in Eqn 8.2. Added to Eqn 8.2 is a dummy variable for oil crisis.

The TSLS equation of construction supply is given by:

$$Q^{st} = 1.049 + 0.970 \ln P_t + 0.628 \ln P^r_{t-4} - 0.695 \ln C^P_{t-2} - 0.019 \ln S^T_{t-3} + 0.239 \ln F^r_{t-8} - 0.093G^L_{t-1}$$

$R = 0.927$ R^2 Adjusted $= 0.843$ $DW = 1.706$

Eqn 8.6

8.6.2 Equilibrium

Construction output decisions depend on a firm's knowledge of the movements of relevant explanatory variables. Decisions on construction output and the construction demand movements/shocks determine the equilibrium price of construction at time t. Formally, the equilibrium price may be obtained by equating Eqn 8.2 and 8.3 and solve for P_t.

That is

$$Q^s_t = Q^d_t$$ Eqn. 8.7

The activity of construction industry does not suggest that the construction supply and construction demand equals at time t. Rather, the construction demand at time t continues to filter into construction supply in the following periods (Butler, 1977; New Builder, 1990). However, the greater the construction demand at time t, the greater the construction supply expected from time t to the following quarters. In other words, construction demand is a leading indicator of construction supply.

More precisely supply of construction in relation to construction demand can be given by:

$$Q^s_t = f(Q^d_t, Q^d_{t-1}, Q^d_{t-2}, ..., Q^d_{t-m}) \qquad \text{Eqn. 8.8}$$

Equation 8.8 is in distributed lag form.

Considering this addition, the construction price is obtained by equating Eqn 8.2 (estimated as Eqn. 8.6) and Eqn 8.3 (estimated as Eqn 8.5) using Eqn. 8.8 and solve for P_t. The equation of P_t derived by solving the simultaneous equation is regarded as the reduced-form equation of construction price.

8.6.2.1 Construction supply - demand distributed lag estimation

The *a priori* assumption is that the current value of construction supply depends not only on the current value of construction demand but also on lags of construction demand. That is:

$$Q^s_t = \alpha + \beta_0 Q^d_t + \beta_1 Q^d_{t-1} + \beta_2 Q^d_{t-2} + ...+ \quad \beta_m Q^d_{t-m} + U_t \qquad \text{Eqn. 8.9}$$

In a general distributed lag formation, number of lags (m) may be either infinite or finite depending on the expected relationship between the dependent and the lagged explanatory variables. For the construction supply-demand relationship a finite lag distribution is expected in line with the activities of the construction industry. Hence, the *a priori* assumption is that within a specific lag period the current construction demand should have completely or to greater extent have filtered into construction supply.

In econometric studies, different methods of distributed lag relationships are available (Stewart and Mark, 1981; Thomas, 1985; Stewart, 1986). Thomas (1985) classified some of these as follows:

a. Geometric lag distributions - Example of this is Koyck geometric lag model that assumes that the coefficients of the lags decline geometrically indefinitely into the past.

b. OLS estimated lag distribution

c. Almon polynomial lag (a generalised Leeuw's inverted 'V' distribution approach)

To establish the distributed lag relationship between construction supply and construction demand methods (b) and (c) have been adopted based on the *a priori* assumption of finite relationship. The geometric lag distribution is considered inappropriate for this relationship.

8.6.2.1.1 OLS estimated distributed lag relationship

Using the SPSSX OLS multiple regression analysis, 13 explanatory variables based on the lagged Q^d were created (Q^d_t, Q^d_{t-1}, Q^d_{t-2}, ... Q^d_{t-12}). The construction supply Q^s was then regressed against these lagged Q^d using a Stepwise Method of regression analysis, such that each of the explanatory variables enters the models one after the other. The variables that are eventually retained in the models were the ones that passed the necessary tolerance tests. The final equation derived through this procedure is shown as follows:

$$Q^s_t = 3.436 + 0.198Q^d_t + 0.181Q^d_{t-1} + 0.118Q^d_{t-2} - 0.066Q^d_{t-3} + 0.028Q^d_{t-4} + 0.135Q^d_{t-5}$$

$$R^2 = 0.881 \qquad \text{Adjusted } R^2 = 0.747$$

Eqn 8.10

Using this method the sum of the coefficients weighting in Eqn 8.10 is 0.594 (ie 0.198 + 0.181 + 0.118 - 0.066 + 0.028 + 0.135), whereas a unity is expected if construction demand is totally converted into construction supply (after Thomas, 1985), or in a situation where construction supply is predominantly an outcome of the construction demand only.

The DoE definition of construction output (used as proxy for construction supply) and construction neworder (proxy for construction demand) shows that some items of work included in construction output are not considered in the definition of construction neworder as highlighted below. On the other hand, the long run interpretation of the result shows that the recorded construction neworder only constitute 60% of the construction output.

This OLS method of distributed lag estimation has, however, being criticised as been faulted with problems of multicollinearity of the lagged explanatory variables with one another. It is expected that the coefficients of the explanatory variables based on this method will have large standard error such that it becomes extremely difficult to separate out the effect of the different lags (Stewart and Walls, 1981).

8.6.2.1.2 Almon Polynomial Distributed Lag method

Basic principles of Almon Polynomial Lag are explained by Stewart and Walls (1981), Thomas (1985) and Stewart (1986).

Rather than assuming that the weighting of the coefficients declines geometrically as the case in the Koyck geometric lag distribution, Almon Polynomial lag distribution imposes some form of polynomial on the coefficients β_i (Eqn 8.9), that is the relationship between the β_i can be approximated by some polynomial. The type of the polynomial may be such that the coefficients weighting increases until it reaches a peak and then decline (2nd degree polynomial - with one turning point). Alternatively, the coefficients weighting increase until it reaches a peak, then decline only to peak up again (3rd degree polynomial - with two turning point) or any other forms of polynomial.

The Almon polynomial lag assumes a finite lag length relationship between the dependent and the lagged explanatory variables. So also, the degree of the polynomial has to be at least one more than the number of the turning points in the curve. The degree of the polynomial to use may depend on the lag length particularly where the lower degree polynomial will not give a true relationship between the β_i.

With the quarterly data of construction supply and construction demand, alternative relationships between the β_i have been considered. This varies for the finite lag length between 3 and 8 different maximum lag lengths, that is, s=3,4,5,6,7 and 8; and two to seven degree polynomial.

For example in case of Poly32, (Poly32 has three quarter lag length and second degree polynomial relationship between construction supply and the construction demand.) the following indicates the process of arriving at the β_i relationship.

$$Q^s_t = \alpha + \beta_0 Q^d_t + \beta_1 Q^d_{t-1} + \beta_2 Q^d_{t-2} + \beta_3 Q^d_{t-3} + U_t \qquad \text{Eqn 8.11}$$

Hence

$$\beta_i = \phi_0 + \phi_1 i + \ldots\ldots\ldots \phi_s i^s \qquad \text{Eqn 8.12}$$

However, s=3 in this case. We use second degree polynomial

$$b = \phi_0 + \phi_1 i + \phi_2 i^2 \qquad \text{Eqn 8.13}$$

which passes through the four points corresponding to the values β_0, β_1, β_2, and β_3.

Using Eqn 8.11 and Eqn 8.12, we have

$$\begin{aligned}
\beta_0 &= \phi_0 \\
\beta_1 &= \phi_0 + \phi_1 + \phi_2 \\
\beta_2 &= \phi_0 + 2\phi_1 + 4\phi_2 \\
\beta_3 &= \phi_0 + 3\phi_1 + 9\phi_2
\end{aligned}$$

Eqn. 8.14

Eqn. 8.11 becomes

$$Q^s_t = \alpha + \phi_0 Q^d_t + (\phi_0 + \phi_1 + \phi_2)Q^d_{t-1} + (\phi_0 + 2\phi_1 + 4\phi_2)Q^d_{t-2} + (\phi_0 + 3\phi_1 + 9\phi_2)Q^d_{t-3} + U_t \qquad \text{Eqn 8.15}$$

Rearranging Eqn 8.15 we have

$$\begin{aligned} Q^s_t = {} & \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3}) \\ & + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3}) \\ & + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3}) \end{aligned}$$

Eqn 8.16

Using Eqn 8.16 the parameters ϕ_0, ϕ_1 and ϕ_2 are then estimated using OLS regression analysis. Having obtained these, β_0, β_1, β_2, and β_3 can be calculated using Eqn. 8.14.

The same principle is adopted for the alternative β_i relationships considered in this work for maximum lag lengths 3,4,5,6,7 and 8; and polynomial degrees 3,4,5,6 and 7. The results showed that the estimation of parameters ϕ_i based on more than third degree polynomial and lag length more than 7 quarters are insignificant and failed to pass the tolerance test based on the OLS regression analysis - Stepwise Method. Hence, the results in this report only discuss the β_i relationships up to 7 lag length and third degree polynomial.

The estimation of ϕ_i carried out are recognised as follows: Poly31, Poly32, Poly43, Poly53, Poly63, and Poly73. Appendix 8.2 presents the full descriptions of the Polys.

The results of the OLS estimation for ϕ_i are shown in Table 8.5 The standard error of ϕ_is are shown in parentheses.

Using the values of ϕ_i (where i = 0, 1, 2, 3) in Table 8.5 and based on Eqn 8.14, the β_i relationship for each of the Poly-models is derived as shown in Table 8.6.

Table 8.5 ϕ_i and statistics

	α	ϕ_0	ϕ_1	ϕ_2	ϕ_3	r^2	adj	RMSE	F value	D.F	DW
Poly31	3.568	0.218	-0.049			0.86	0.736	0.050	78.99	2,54	0.87
	(0.325)	(0.044)	(-0.028)								
Poly32	3.596	0.148	0.156	-0.068		0.87	0.746	0.049	55.94	3,53	0.83
	(0.319)	(0.057)	(0.117)	(0.038)							
Poly43	3.410	0.110	0.392	0.278	0.045	0.88	0.751	0.049	42.40	4,51	0.78
	(0.335)	(0.063)	(0.205)	(0.132)	(0.218)						
Poly53	3.468	0.153	0.169	-0.132	0.020	0.89	0.756	0.046	42.77	4,50	0.508
	(0.334)	(0.054)	(0.122)	(0.060)	(0.008)						
Poly63	3.281	0.197	-0.0267	-0.0144	0.0025	0.86	0.720	0.049	35.14	4,49	0.669
	(0.397)	(0.064)	(0.011)	(0.043)	(0.005)						
Poly73	3.591	0.141	-0.071	0.034	-0.004	0.88	0.748	0.047	39.56	4,48	0.670
	(0.421)	(0.063)	(0.101)	(0.035)	(0.003)						

Table 8.6 Coefficients weighting in relation to Polys'

	α	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	Total
Poly31	3.568	0.218	0.169	0.119	0.070					0.576
Poly32	3.596	0.148	0.241	0.188	0.004					0.581
Poly43	3.410	0.110	0.269	0.138	-0.012	0.084				0.589
Poly53	3.468	0.153	0.210	0.120	0.001	-0.029	0.148			0.603
Poly63	3.281	0.197	0.158	0.106	0.055	0.020	0.016	0.058		0.610
Poly73	3.591	0.141	0.100	0.102	0.120	0.129	0.103	0.016	-0.157	0.554

The sums of weighting of β_i in Table 8.6 which, ranged between 0.554 and 0.610 compared favourably with 0.594 got using the OLS method of distributed lags estimation. This Almon polynomial lag analysis assured us of one of two things: (1) the construction neworder (demand) can only account for about 60% of the construction output (supply), or (2) only 60% of the construction demand are converted to construction supply.

Using the maximum total weighting of β_i as the criteria for the choice of the β_i relationship Poly63 appeared to be favoured (see Figure 8.2). The positive sign of all the coefficients is also favoured in terms of the lag structure and the *a priori* expectation based on the activity of the construction industry.

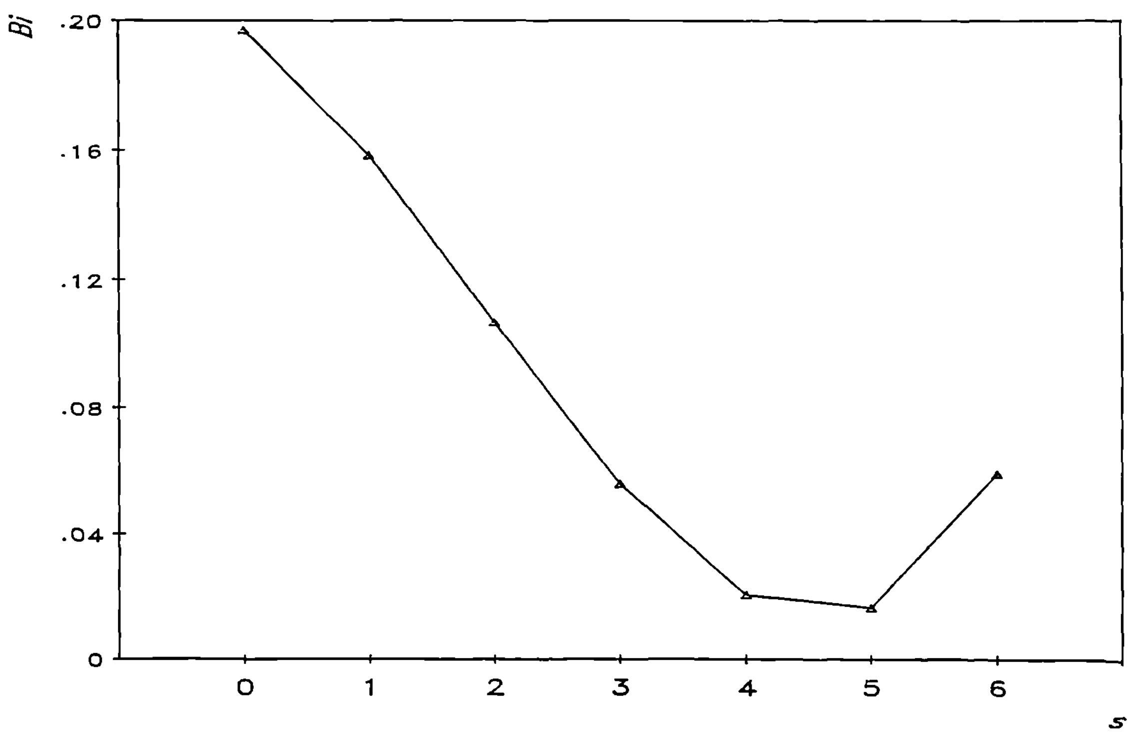


Figure 8.2 Almon polynomial lag distribution of construction demand and supply

This shows that the level construction demand has an instant impact on the construction supply of construction firms. This then tails off until five quarters later with a little rise noticed at the sixth quarter. This sound reasonable in the sense that contractors are most likely to increase construction output in the times of construction boom to make instant profit. As the boom starts declining firms are also likely to support a declining output. This is not only to keep the key workforce occupied but also to ensure that the firms continue to survive until the construction demand peaks up again.

Hence,

$$Q^s_t = 3.281 + 0.197Q^d_t + 0.158Q^d_{t-1} + 0.106Q^d_{t-2} + 0.055Q^d_{t-3} + 0.02Q^d_{t-4} + 0.016Q^d_{t-5} + 0.058Q^d_{t-6} \qquad \text{Eqn. 8.17}$$

8.6.3 Reduced-form of the equation of construction price

The simultaneous equations are as follows (Eqn. 8.5, 8.6 and 8.17). Figures 8.3 and 8.4 present construction demand and supply models respectively.

$$Q^d_t = -14.051 - 0.766P_{t-3} - 0.249U^E_{t-5} + 1.764M^P_{t-4} - 0.011R^r_{t-1} + 1.632Y^d$$

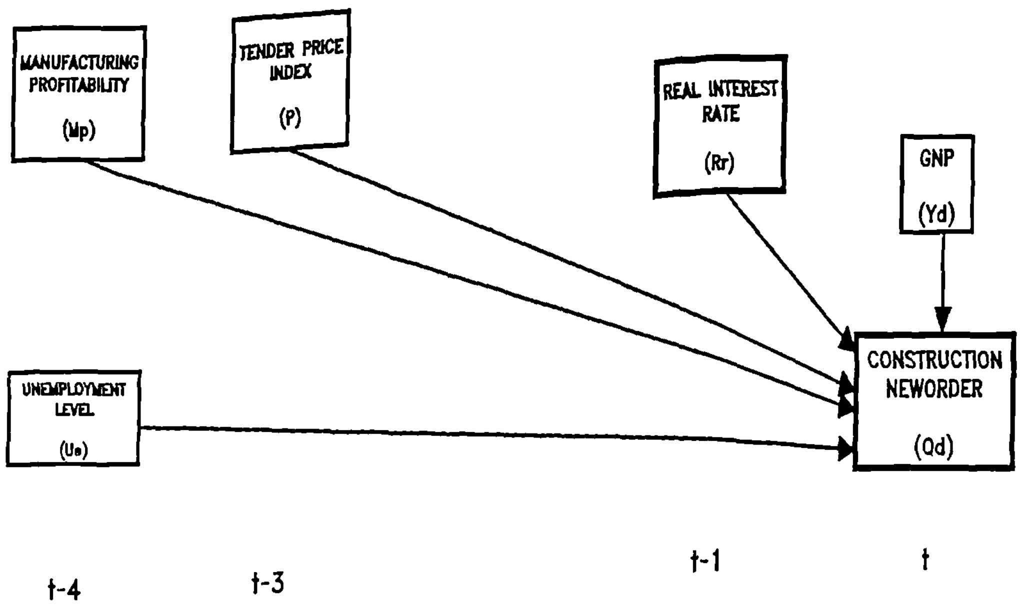
Demand equation Eqn 8.5A

$$Q^s_t = 1.049 + 0.970P_t + 0.628P^r_{t-4} - 0.695C^P_{t-2} - 0.019S^T_{t-3} + 0.239F^r_{t-8} - 0.093O^L_{t-1}$$

Supply equation Eqn 8.6A

$$Q^s_t = 3.281 + 0.197Q^d_t + 0.158Q^d_{t-1} + 0.106Q^d_{t-2} + 0.055Q^d_{t-3} + 0.02Q^d_{t-4} + 0.016Q^d_{t-5} + 0.058Q^d_{t-6}$$

Equilibrium equation Eqn 8.17A



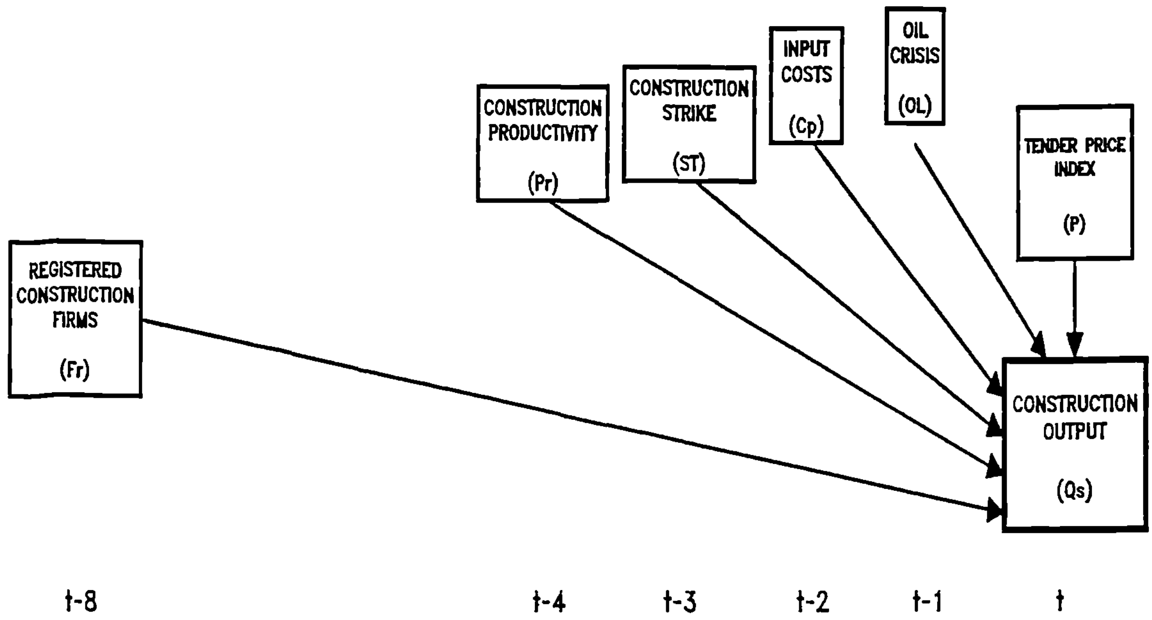
Qd = -14.051 - 0.766P + 1.632Yd - 0.011Rr - 0.249Ue + 1.764Mp

All independent variables are significant

R = 0.913
R2 Adj. = 0.817
D.F. = 5, 50
DW = 1.917

All variables are expressed in natural logarithm with the exception of real interest rate.

Figure 8.3 Construction demand model and statistics



Qs = 1.049 + 0.970P + 0.628Pr - 0.695Cp - 0.019ST + 0.239Fr - 0.093OL

All independent variables are significant

R = 0.912
R2 Adj. = 0.827
D.F. = 6,45
DW = 1.714

All variables are expressed in natural logarithm with the exception of oil crisis (dummy variable)

Figure 8.4 Construction supply model and statistics

P (tender price level) in these equations is an endogenous variable. This being the case P's relationship with other endogenous/exogenous variables can be derived by the **reduced form** of equations as follows:

By substituting Eqn 8.5A into Eqn 8.17A we have

$$
\begin{aligned}
Q^{s} = -5.182 &- (0.151P_{t-3} + 0.121P_{t-4} + 0.081P_{t-5} + 0.042P_{t-6} + 0.015P_{t-7} + 0.012P_{t-8} + 0.044P_{t-9}) \\
&- (0.049U^{E}_{t-4} + 0.039U^{E}_{t-5} + 0.026U^{E}_{t-6} + 0.014U^{E}_{t-7} + 0.005U^{E}_{t-8} + 0.004U^{E}_{t-9} + 0.014U^{E}_{t-10}) \\
&+ (0.345M^{P}_{t-4} + 0.279M^{P}_{t-5} + 0.186M^{P}_{t-6} + 0.096M^{P}_{t-7} + 0.034M^{P}_{t-8} + 0.027M^{P}_{t-9} + 0.102M^{P}_{t-10}) \\
&- (0.002R^{r}_{t-1} + 0.002R^{r}_{t-2} + 0.001R^{r}_{t-3} + 0.0006R^{r}_{t-4} + 0.0002R^{r}_{t-5} + 0.0002R^{r}_{t-6} + \\
&\quad 0.0006R^{r}_{t-7}) \\
&+ (0.321Y^{d} + 0.258Y^{d}_{t-1} + 0.172Y^{d}_{t-2} + 0.089Y^{d}_{t-3} + 0.032Y^{d}_{t-4} + 0.025Y^{d}_{t-5} + 0.095Y^{d}_{t-6})
\end{aligned}
$$

Eqn 8.18

Eqn 8.6A equals Eqn 8.18 that is:

$$
\begin{aligned}
&1.049 + 0.970P + 0.628P^{r}_{t-4} - 0.695C^{P}_{t-2} - 0.019S^{T}_{t-3} + 0.239F^{r}_{t-8} - 0.093O^{L}_{t-1} \\
&= \\
&-5.182 - (0.151P_{t-3} + 0.121P_{t-4} + 0.081P_{t-5} + 0.042P_{t-6} + 0.015P_{t-7} + 0.012P_{t-8} + 0.044P_{t-9}) \\
&\quad - (0.049U^{E}_{t-4} + 0.039U^{E}_{t-5} + 0.026U^{E}_{t-6} + 0.014U^{E}_{t-7} + 0.005U^{E}_{t-8} + 0.004U^{E}_{t-9} + 0.014U^{E}_{t-10}) \\
&\quad + (0.345M^{P}_{t-4} + 0.279M^{P}_{t-5} + 0.186M^{P}_{t-6} + 0.096M^{P}_{t-7} + 0.034M^{P}_{t-8} + 0.027M^{P}_{t-9} + 0.102M^{P}_{t-10}) \\
&\quad - (0.002R^{r}_{t-1} + 0.002R^{r}_{t-2} + 0.001R^{r}_{t-3} + 0.0006R^{r}_{t-4} + 0.0002R^{r}_{t-5} + 0.0002R^{r}_{t-6} + \\
&\qquad 0.0006R^{r}_{t-7}) \\
&\quad + (0.321Y^{d} + 0.258Y^{d}_{t-1} + 0.172Y^{d}_{t-2} + 0.089Y^{d}_{t-3} + 0.032Y^{d}_{t-4} + 0.025Y^{d}_{t-5} + 0.095Y^{d}_{t-6})
\end{aligned}
$$

Eqn 8.19

Hence P can be derived as follows:

$$
\begin{aligned}
P = -6.424 &- 0.647P^{r}_{t-4} + 0.716C^{P}_{t-2} + 0.0196S^{T}_{t-3} - 0.246F^{r}_{t-8} + 0.096O^{L}_{t-1} \\
&- (0.155P_{t-3} + 0.125P_{t-4} + 0.083P_{t-5} + 0.043P_{t-6} + 0.015P_{t-7} + 0.012P_{t-8} + 0.046P_{t-9}) \\
&- (0.050U^{E}_{t-4} + 0.041U^{E}_{t-5} + 0.027U^{E}_{t-6} + 0.014U^{E}_{t-7} + 0.005U^{E}_{t-8} + 0.004U^{E}_{t-9} + 0.015U^{E}_{t-10}) \\
&+ (0.357M^{P}_{t-4} + 0.287M^{P}_{t-5} + 0.192M^{P}_{t-6} + 0.099M^{P}_{t-7} + 0.035M^{P}_{t-8} + 0.028M^{P}_{t-9} + 0.105M^{P}_{t-10}) \\
&- (0.002R^{r}_{t-1} + 0.002R^{r}_{t-2} + 0.001R^{r}_{t-3} + 0.0006R^{r}_{t-4} + 0.0002R^{r}_{t-5} + 0.0002R^{r}_{t-6} + \\
&\quad 0.0006R^{r}_{t-7}) \\
&+ (0.331Y^{d} + 0.266Y^{d}_{t-1} + 0.178Y^{d}_{t-2} + 0.091Y^{d}_{t-3} + 0.032Y^{d}_{t-4} + 0.026Y^{d}_{t-5} + 0.097Y^{d}_{t-6})
\end{aligned}
$$

Eqn 8.20

Eqn 8.20 is the reduced-form equation for construction price. The coefficients in the reduced-form equation are called reduced-form coefficients. These are functions of the structural coefficients, that is, the parameters of the reduced-form equations are themselves functions of the parameters of the underlying structural system. The reduced-form models have neither direct nor unique economic interpretation. Reduced-form models predict what will happen when one or more exogenous variables change, and they do not necessarily produce a particular explanation of how or why. In essence, the reduced-form equations, apart from being consistent estimates of structural coefficients, are used for forecasting macroeconomic variables.

8.7 Conclusion

This chapter has examined in some detail the construction price equations using two systems of equations: single structural form of equation and the simultaneous supply/demand estimation technique. The chapter started with a review of price determination mechanism under the forces of market in a free economy. The question of how demand and supply combines to influence prices was considered.

Single structural form of construction price equation was estimated. The model seems to be satisfactory in several counts, (1) it is statistically significant, (2) it has some theoretical basis. The model has R^2 adjusted value 0.97 for the deflated data with acceptable Durbin-Watson statistics. The independent variables have inelastic relationships with construction price.

The stability of the model was investigated by producing 'rolling regression' of the dependent variable. Using this process, construction price equation was re-estimated each quarter using only information from 1974 first quarter up to the start of the quarter being considered. Coefficient of variation of the regression coefficients for each independent variables was derived to determine the stability of the equation.

Analysis of residuals of the equation was undertaken. The results of the analysis show that the equation has random residuals with standardized mean of zero and constant variance. The plots of the residuals against observed and estimated values of construction price show a random scatter of points (that is, have no special pattern). Thus the model fitted correctly.

The reduced-form equation of construction price was derived from the simultaneous construction supply, demand and equilibrium equations. The equilibrium relationship between construction supply and demand is of distributed lag with construction demand responsible for 60 per cent values of construction supply though 100 per cent is expected.

The following chapter considers the forecasting behaviour of these models in comparison with the construction price forecast produced by some establishments in U.K.

CHAPTER 9

Construction Price Model Testing and Accuracy

CONSTRUCTION PRICE MODEL TESTING AND ACCURACY

9.1 Introduction

In previous chapters models of construction price based on single structural and simultaneous equation techniques were developed. The model of construction price based on the simultaneous equation technique was of reduced-form. The single structural model which, was based on economic theory explained structural movements in TPI. It however has an inferior predictive power to the reduced-form equation (Kane, 1968; Neal and Shone 1976). In this chapter attention is focused on the reliability and the forecasting behaviour of the (reduced form) equation of construction price. The motivation for investigating forecasting behaviour is that if a model could be developed to estimate the relationship between construction price and exogenous variables that is theoretically acceptable, the model could also be used to forecast future construction price level.

The reliability of this model in comparison with two leading forecasts by Building Cost Information Service; and Davis, Langdon & Everest are undertaken in this chapter. Apart from PSA Specialist Services (Directorate of Building Surveying Services) these two are the leading organisations in forecasting construction price movements dated back to 1980 and 1976 respectively. The choice of these two organisations' forecasts suits our purpose: the organisations are sponsored by private sector; the movements in tender price and forecasts produced by them relate to both public and private construction works; and these tender price movements give us more confidence on the competitive situation in the construction industry.

Appendix 9.1 reviews the state of art of forecasting

9.2 Models, Forecasting and Errors

Models may be used in two contexts, (1) to **explain** past movements and (2) to **forecast** future events. Bowerman and O'Connell (1987) defined forecast in terms of predictions of future events and conditions, while the act of making such predictions is forecasting. Predictions, provided by the various forecasting methods, are used as input in the majority of decision-making activities. The various forecast can be obtained by purely judgemental or intuitive approaches; causal or explanatory methods (regression or econometric models); time series (extrapolative) methods; and combination of these approaches (Makridakis, 1983). These forecasting methods can be classified into two: qualitative forecasting methods (judgemental or intuitive approaches which, generally use the opinions of experts to predict future events) and quantitative forecasting method (involving analysis of historical data in an attempt to predict future values of variable of interest). The quantitative forecasting methods comprise of univariate models or causal models.

The reduced model of construction price derived in chapter 8 is an example of causal quantitative forecasting model which, involved the identification of other variables that are related to construction price.

Errors produced by forecasting models are not unusual and inevitable due to uncertainty. However, because decisions are made based on the outcome of forecast produced from forecasting models some discontent arise when forecasting error produced by models are large. Bowerman and O'Connel (1987) have associated the errors produced by forecasting models with the combined effects of the irregular component and the accuracy with which the forecasting technique can predict trend, seasonal, or cyclical patterns.

9.2.1 Types of economic forecasts

Pindyck and Rubinfeld (1976) have classified economic forecasts into three types as follows: (1) *ex post* simulation or "historical" simulation by which the values of dependent variables are simulated over the period in which the model was estimated, that is the in-sample period; (2) *ex post* forecasting, in which the model is simulated beyond the estimation period, but not further than the last date for which the data is available; and (3) *ex ante* forecasting, by which forecasts are made beyond the last date for which data is available into the future. These three periods are illustrated in Figure 9.1

Ex post forecasting and *ex ante* forecasting are regarded as out-of-sample period forecasting. In *ex post* simulation and forecasting, a comparison can be made between the actual values and predicted values of the dependent variable to determine the forecasting accuracy of the model(s). Most often the closest fit comes from the *ex post* simulation period. This is followed by the *ex post* forecast period, with the poorest fit coming from the *ex ante* forecast period. (Dhrymes et al, 1972, have shown that in the single equation case, the root mean squared error of the post-sample period should be expected to exceed the standard error of the fitted equation).

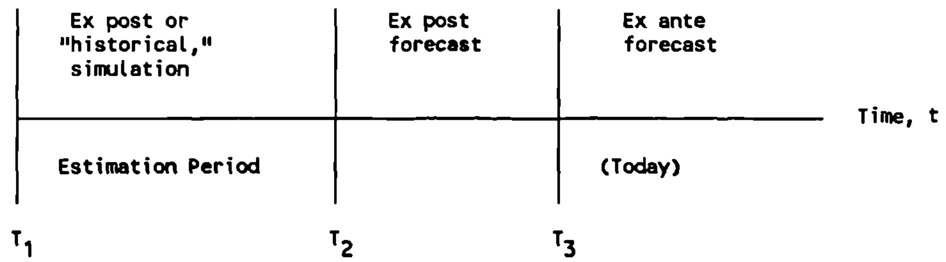


Figure 9.1 Types of economic forecast

Source: Robert S. Pindyck and D.L. Rubinfeld, *Econometric Models and Economic Forecasts* (New York: McGraw-Hill, 1976), pp.313.

9.2.2 Factors in forecasting

There are some factors that have impact on the choice of forecasting techniques (O'Donovan, 1983; Bowerman and O'Connell, 1987) and these factors also have tremendous influence on the forecasting accuracy desired and achievable. The factors include:

1. The forecast form

Two forms of forecast are point forecast and prediction interval forecast. The point forecast is a single number that represents the best prediction of the actual value of a variable being forecasted. Prediction interval forecast is an interval or range that is calculated so that the actual value will be contained (say at 95% confidence level).

2. The time frame or time horizon

This is usually categorised as:

Immediate: less than one month
Short term: one to three months
Medium: more than three months to less than two years
Long term: two years or more

3. Availability of data

This relates to the accuracy and timeliness of the required historical data. The value of economic data for economic decisions depends on both their reliability and their timeliness (McNees, 1986). Also important in this respect is the level of information (Skitmore, 1990).

4. The accuracy desired

The desired accuracy of a forecast will depend on the use for the forecast, forecast form, time horizon etc. For example, Ashworth and Skitmore (1983, 1986) have indicated a standard deviation of 15 to 20 per cent to be appropriate for early stage estimates (conceptual estimate) of construction price reducing to 13 to 18 per cent for later stage estimate. These accuracy levels incorporate the use, time horizon and a prediction interval forecast.

9.3 Accuracy of Building Cost Information Service (BCIS) Tender Price Index Forecasts

9.3.1 Preamble

BCIS is a self financing non-profit making organisation with two main objectives: "(1) to provide for cost information needs of the Quantity Surveying Division of Royal Institution of Chartered Surveyors (RICS) and (2) to assist in confirming the Chartered Quantity Surveyor's pre-eminence in the field of building economics and cost advice and make this expertise and statues more generally known" (BCIS NEWS, 1987).

BCIS has been involved in monitoring building price since 1961. The cost analyses from this organisation was published in the first BCIS bulletins in May 1962. However it was not until June, 1980 that the first "24 month forecast of tender price index" was published by this organisation. The forecast of TPI produced and published by BCIS is an example of point forecast.

9.3.2 BCIS TPI forecasting model and activities

The organisation has a linear regression model that provides guidance for TPI forecast. This model was instigated by research work into computer aided tender price prediction done in late 1970's at Loughborough University by McCaffer and

McCaffery. The variable inputs into the BCIS tender price index model are building cost trends, construction output and construction neworder. However this organisation considers building cost trends as having low significance in tender price index forecast. The most important factor considered to have major impact on this forecast relates to market condition which is predominantly construction demand (neworder).

The forecast produced from the BCIS models is substantially judgemental adjustment based using the organisation's experts judgement. Though BCIS claims to monitor the accuracy of its published forecasts sometimes, it is not sure of the impact of the judgemental adjustment on the accuracy of the published forecast. Some factors have been identified as responsible for problems in forecasting TPI by this organisation: the unpredictable reaction of contractors to changes and the speed of change in construction demand.

9.3.3 TPI forecast accuracy

The forecast accuracy of TPI has been investigated using both graphical presentation and non-parametric test of accuracy. The forecast period covers the eleven years from 1980:2 through 1990:4. The forecast horizon (quarters ahead) covers eight quarters (0, 1, 3,....., 8 quarters ahead). Thus, there are 43 zero-quarters-ahead forecasts, 42 one-quarter-ahead forecast, 41 two-quarter-ahead forecast, and 35 eight-quarter-ahead forecast. The 35 eight-quarter-ahead forecast is long enough for one to be able to draw a generalised long-term performance of TPI forecast produced by BCIS

Earlier studies on non-parametric analysis of TPI forecast accuracy were produced by McCaffer et al., (1983) and Fellows (1988). Fellows (1988) produced BCIS forecasts' mean percentage errors of all-in TPI using published forecasts between 1980 June and November, 1983. This study also developed a TPI regression adjustment model excluding and including 1980 forecasts using number of quarters ahead as variables. This model, excluding 1980 forecasts was found to perform better than BCIS forecasts when validated against 1984 BCIS forecasts. This model, though based on few observations, (11 Quarters) tends to suggest that BCIS forecasting accuracy could be improved using simple regression model.

9.3.3.1 Graphical presentation of forecast accuracy

Figure 9.2 presents the plots of actual and predicted values of tender price index. The plots presented in the figure relate to values from 1982:1 through 1990:4 to allow for standardized comparison of performances across forecast horizon. The plots on the predicted values cover the eight quarters forecast horizon. The plots present a clear picture of the performance of BCIS forecast of TPI. Visual observations of these plots show that the forecasts of TPI generally track the actual levels up to two quarters ahead. Forecast above two quarters ahead are not very encouraging. The forecasts failed to catch the turning points in actual levels. Forecasts for 1988:4 through 1990:4 were specifically different from actual value even at zero quarters ahead. This period coincided with sporadic decline in the Nation's economic fortune and consequently declined construction demand which, may not have been anticipated by the BCIS experts. The frequency distribution of the MPE shown in Figure 9.3 shows that the accuracy of TPI forecast depreciates with the increase in forecast horizon.

9.3.3.2 Non-parametric analysis of forecast accuracy

Table 9.1 presents the non-parametric analysis of the TPI forecast produced by BCIS from 1980:2 through 1990:4 over eight quarters forecast horizon starting with zero-quarter ahead. Non-parametric measures of forecasting accuracy employed are ME, MAE, and MPE with their respective standard deviations; RMSE, RMSE(per cent) and Theil U^2. The Standard deviations denote the spreads of the accuracy measures. All the measures of forecasting accuracy point to increase in the accuracy of the forecasts as the horizon of the forecasts decreases. The increase in the spread of the ME, MEA and MPE as the horizon increase points to an increase in uncertainty

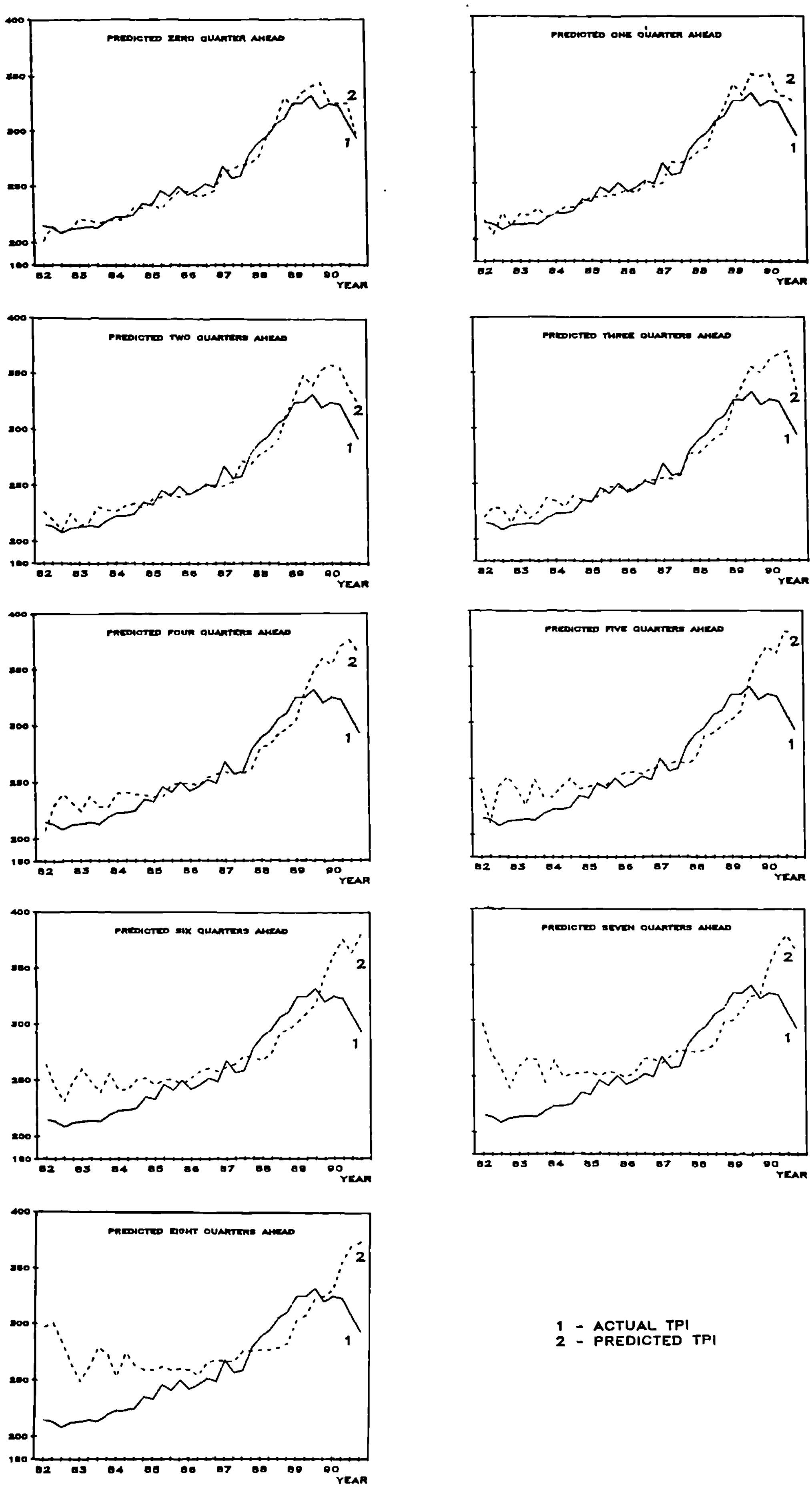


Figure 9.2 Actual and Predicted Tender Price Index

Building Cost Information Service 24-month index forecast

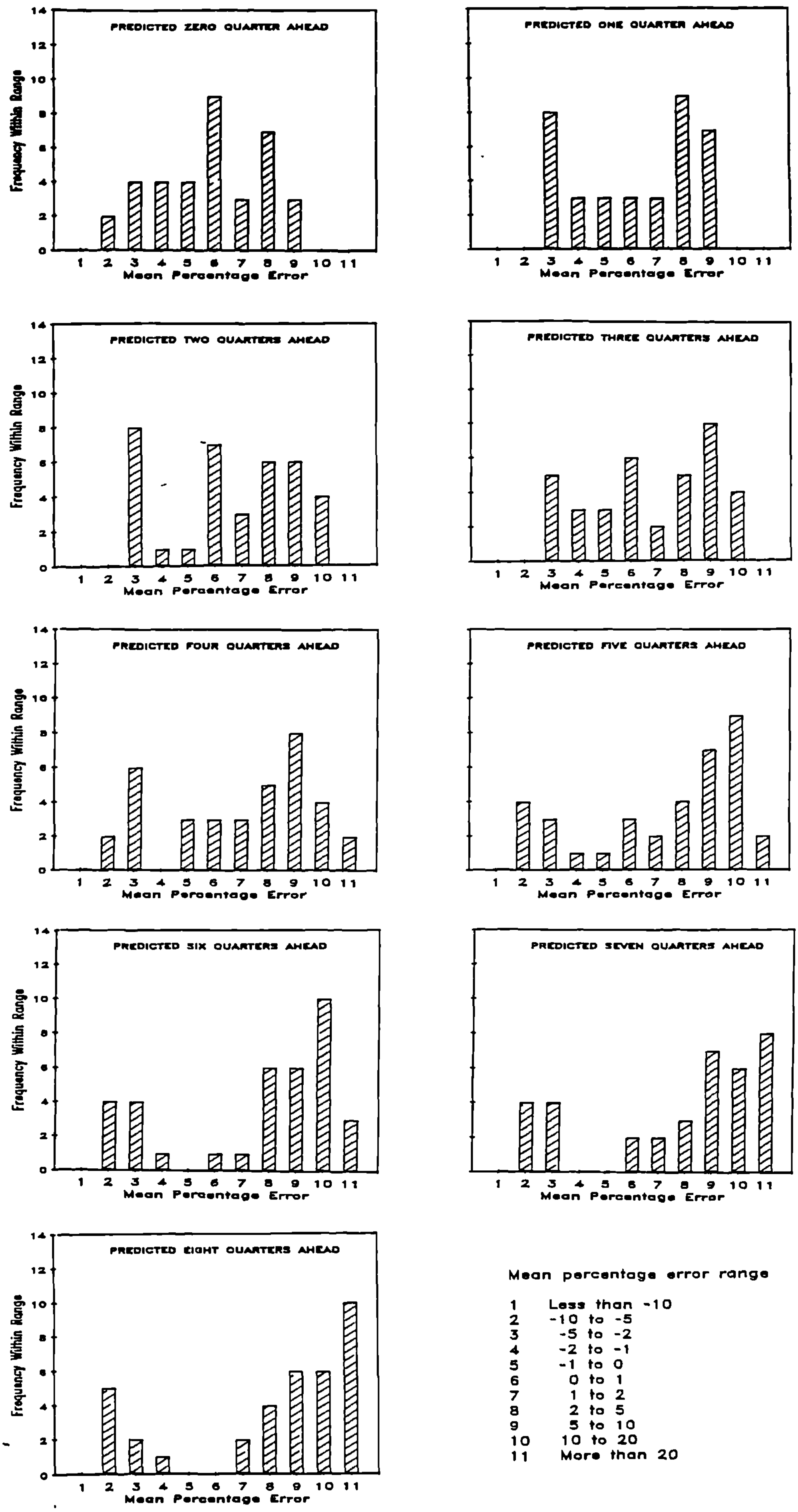


Figure 9.3 Frequency distribution of forecast Mean Percentage Error

concerning future economic events. The forecast of TPI is positively biased which, confirms a general over-estimation of TPI. The forecasts of TPI made from 1980:2 through 1981:1 were specifically high. This period could be considered a learning time as it coincided with the time that TPI forecasts were formally published for the first time. Apart from zero-quarter ahead (3.27%) and one-quarter ahead (4.66%), percentage error of other time horizon (2 to 8 quarters ahead) are more than 5 percentage error that one would expect by chance.

9.3.3.3 Error Decomposition

Decomposition of mean square error of TPI (after Theil, 1966) is shown in Table 9.2. These statistics are useful in identifying sources of TPI forecast error and offer possibility for correction.

Using Theil's first method of error decomposition, the values of the component show that covariance proportion U^C accounts for a greater proportion of the MSE of the level of forecasts. As the forecast horizon increases, the covariance proportion decreases while the bias proportion U^M increase which, confirms direct relationships between forecast horizon and over-estimation.

The second error decomposition method indicates that nearly all the MSE of the TPI forecasts is attributable to regression proportion U^R. The F-statistics are significant at 5 per cent confidence level (P=0.000 in all cases). This produces an evidence that the forecasters made errors of a systematic nature and produced statistical grounds to support the hypothesis that a = 0 and b = 1. This being the case the MSE of the forecast could be reduced using optimal linear correction technique. The resultant estimated coefficients for each of the forecast horizon could be used as correction factors thus:

$$A_t = a + bP$$

Table 9.1 The historical variability of TPI forecast errors (BCIS forecasts)

		FORECAST HORIZON								
		0	1	2	3	4	5	6	7	8
1980	1									
	2	1.0								
	3	2.0	16.0							
	4	8.0	15.0	31.0						
1981	1	-18.0	14.0	21.0	47.0					
	2	-4.0	-17.0	17.0	25.0	53.0				
	3	7.0	3.0	-7.0	28.0	42.0	69.0			
	4	8.0	18.0	12.0	0.0	33.0	51.0	79.0		
1982	1	-13.0	1.0	11.0	5.0	-8.0	25.0	49.0	82.0	
	2	1.0	-9.0	6.0	16.0	16.0	-3.0	31.0	57.0	89.0
	3	1.0	15.0	2.0	19.0	32.0	35.0	22.0	50.0	75.0
	4	-1.0	-1.0	13.0	2.0	20.0	40.0	37.0	27.0	52.0
1983	1	8.0	9.0	1.0	17.0	11.0	28.0	47.0	45.0	35.0
	2	6.0	7.0	3.0	4.0	23.0	12.0	34.0	52.0	48.0
	3	4.0	14.0	18.0	11.0	15.0	36.0	26.0	52.0	66.0
	4	0.0	1.0	9.0	18.0	9.0	15.0	37.0	25.0	53.0
1984	1	-2.0	10.0	4.0	11.0	17.0	11.0	18.0	41.0	30.0
	2	-2.0	5.0	9.0	6.0	18.0	20.0	18.0	26.0	51.0
	3	6.0	3.0	9.0	14.0	14.0	25.0	25.0	27.0	38.0
	4	-4.0	-3.0	-6.0	0.0	4.0	6.0	17.0	17.0	24.0
1985	1	2.0	4.0	5.0	1.0	4.0	10.0	13.0	21.0	26.0
	2	-16.0	-9.0	-6.0	-6.0	-9.0	-2.0	4.0	3.0	16.0
	3	-3.0	-3.0	2.0	6.0	7.0	3.0	10.0	13.0	18.0
	4	-5.0	-10.0	-10.0	-3.0	-1.0	0.0	-4.0	2.0	10.0
1986	1	3.0	1.0	1.0	2.0	7.0	13.0	10.0	6.0	17.0
	2	-5.0	-5.0	1.0	1.0	1.0	10.0	12.0	8.0	8.0
	3	-10.0	-2.0	-1.0	1.0	2.0	2.0	9.0	14.0	14.0
	4	-3.0	-3.0	2.0	4.0	8.0	10.0	9.0	16.0	19.0
1987	1	3.0	-10.0	-10.0	-5.0	-1.0	0.0	2.0	2.0	7.0
	2	8.0	12.0	-3.0	-3.0	0.0	6.0	8.0	11.0	10.0
	3	10.0	9.0	14.0	-1.0	-1.0	7.0	13.0	15.0	17.0
	4	-9.0	-8.0	-9.0	-2.0	-17.0	-16.0	-9.0	-7.0	-3.0
1988	1	-13.0	-11.0	-11.0	-12.0	-8.0	-21.0	-21.0	-17.0	-12.0
	2	0.0	-13.0	-12.0	-11.0	-12.0	-8.0	-21.0	-21.0	-18.0
	3	2.0	-2.0	-16.0	-14.0	-14.0	-16.0	-14.0	-27.0	-27.0
	4	19.0	8.0	2.0	-15.0	-14.0	-14.0	-16.0	-13.0	-28.0
1989	1	-2.0	15.0	5.0	-3.0	-21.0	-23.0	-23.0	-25.0	-22.0
	2	10.0	5.0	24.0	14.0	5.0	-15.0	-15.0	-15.0	-17.0
	3	8.0	17.0	8.0	23.0	16.0	5.0	-14.0	-10.0	-10.0
	4	24.0	27.0	34.0	29.0	40.0	36.0	24.0	4.0	5.0
1990	1	2.0	24.0	34.0	36.0	29.0	43.0	37.0	25.0	6.0
	2	2.0	7.0	33.0	43.0	48.0	38.0	53.0	44.0	33.0
	3	17.0	20.0	30.0	61.0	68.0	73.0	56.0	69.0	62.0
	4	2.0	29.0	31.0	41.0	72.0	87.0	87.0	70.0	81.0
Mean Error		1.26	4.83	7.34	10.25	13.03	15.74	17.57	19.14	22.03
Std. dev.		8.45	11.15	13.65	17.40	22.07	25.70	26.40	27.81	30.36
Mean Absolute Error		6.37	9.88	11.78	14.00	18.46	21.95	24.97	26.64	29.86
Std. dev.		5.69	7.08	10.08	14.56	17.78	20.65	19.54	20.74	22.70
RMSE		8.55	12.15	15.50	20.20	25.63	30.13	31.71	33.76	37.51
Theil U^2		0.0011	0.0022	0.0036	0.0061	0.0097	0.0133	0.0146	0.0163	0.0200
Mean Percent Error		0.37	1.83	2.85	4.07	5.34	6.61	7.56	8.37	9.74
Std. dev.		3.25	4.28	4.99	6.43	8.31	9.94	10.46	11.34	12.70
RMSE (percent)		3.27	4.66	5.74	7.60	9.87	11.94	12.91	14.10	16.01

Where

A_t = Corrected forecast value

P = Predicted value

The regression proportion decreases with the forecast horizon which shows that the degree at which MSE of forecast of TPI could be reduced decreases with increasing forecast horizon.

Table 9.2 Decomposition of Mean Squared Error (MSE) of TPI forecast (BCIS forecast)

Forecast Horizon	U^M	U^S	U^C	U^D	U^R	a	b	R	R^2 Adj.	RMSE	DW
0	0.009	0.114	0.874	0.178	0.809	19.57	0.919	0.983	0.965	7.68	1.92
1	0.116	0.063	0.815	0.132	0.752	19.93	0.908	0.972	0.944	9.85	1.27
2	0.182	0.050	0.775	0.120	0.701	22.23	0.890	0.957	0.914	12.27	0.80
3	0.228	0.011	0.763	0.065	0.709	17.81	0.901	0.939	0.879	14.64	0.40
4	0.234	0.002	0.766	0.024	0.743	10.81	0.921	0.903	0.810	18.34	0.48
5	0.244	0.027	0.728	0.006	0.749	1.34	0.949	0.860	0.731	21.79	0.47
6	0.278	0.067	0.657	0.000	0.723	-12.77	0.994	0.824	0.669	24.09	0.30
7	0.284	0.131	0.585	0.040	0.713	-34.39	1.066	0.778	0.593	26.42	0.29
8	0.307	0.212	0.408	0.017	0.675	-69.21	1.180	0.722	0.505	29.08	0.25

Where U^M Bias proportion

U^S Variance proportion

U^C Covariance proportion

U^D Regression proportion

U^R Disturbance proportion

9.4 Accuracy of Davis Langdon & Everest (DL&E) Tender Price Index Forecasts

9.4.1 Preamble

DL&E is a private firm of chartered quantity surveyors and a profit making organisation. This was formerly known as Davis Belfield and Everest (DB&E) until the end of 1987.

DB&E has been involved in monitoring building price since early 1970s though its first historical index and predictive index (forecast) of tender price was not published until 12 November 1975. This was published in *Architects' Journal* under the caption "technical study". In the 7th forecast feature (*Architects' Journal*, 26 October, 1977) of DB&E the caption was changed to "Building Costs". In November 1982, the caption was change to "COST FORECAST". The *Architects' Journal* continued to publish the quarterly edition of the cost information from DL&E until 5 July 1989. DL&E resumed publication of tender price level information in *Building* with the caption "COST FORECAST" in October, 1989.

The DL&E tender price index reflects changes in the level of pricing in bills of quantities for accepted tenders in the outer London area. The forecast of TPI produced and published by DL&E is an example of prediction interval forecast.

9.4.2 DL&E TPI forecast and activities

The organisation does not have a formal model of tender price movement. The forecast of TPI is based on "subjective assessment of In-house Experts". The forecasting method being adopted by this organisation could best be described as qualitative. Experts within the organisation seat at a conference to analyze the current economic climate and how this will affect the future prices of construction.

An important leading factor considered by the experts in forecasting tender price movements is the level of architects' appointments. The architect appointment advertisements are measured by determining the total area covered by advertisement for architects in *Architects' Journal.* The organisation has derived a lagged relationship between the architect appointment advertisement and market factor over time. Figures 9.4 and 9.5 show the annual and quarterly graphical illustrations, respectively, of correlation established by DL&E between the two. Normally, 'Market Factor Index' provides a measure of how tender prices relate to building costs thus:

$$\text{Market factor index (MFI)} = \frac{\text{Tender price index (TPI)}}{\text{Building cost index (BCI)}}$$

However, 'Market Factor Index' is pre-determined using the architects' appointment advertisement. Also DL&E is capable of forecasting Building cost index with high degree of accuracy. Having established these two indexes, tentative tender price index forecast is calculated thus:

$$\text{TPI} = \text{MFI X BCI}$$

Considering the tentative TPI prediction and other factors (financial, non-financial and prices) the experts are able to arrive at the minimum and maximum tender price index forecast over eight quarter forecast horizon starting with zero-quarter ahead.

However, this organisation considers the building cost trends to have low significance in tender price index forecast judgemental adjustment. The most important factor considered to have major impact on DL&E forecast of TPI relates to market condition and this predominantly includes interest rates, business confidence, general retail inflation and construction neworder.

The organisation claims to monitor the accuracy of its published forecasts sometimes and it is believed by the firm's experts that judgemental forecasting of TPI has helpful impact on the accuracy of its published forecast. Some factors have been identified as responsible for difficulties in forecasting TPI by this organisation: identification of timing of turning point in TPI and difficulty in forecasting general retail inflation beyond two years.

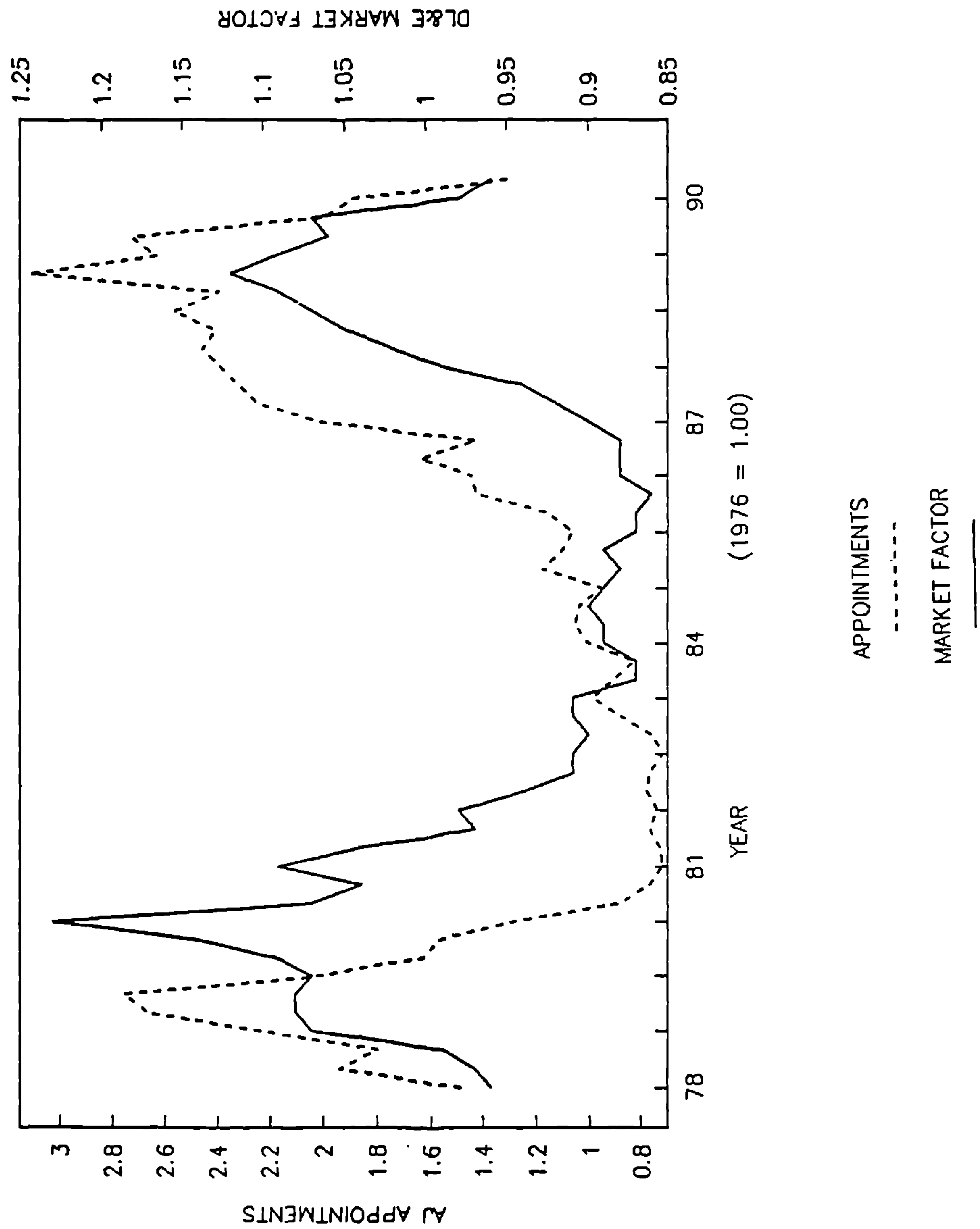


Figure 9.4 Relationship between Architects' appointments advertised in *Architects Journal* and DL&E Market Factor (based on first quarter each year)

Source: Davis, Langdon and Everest Office, London

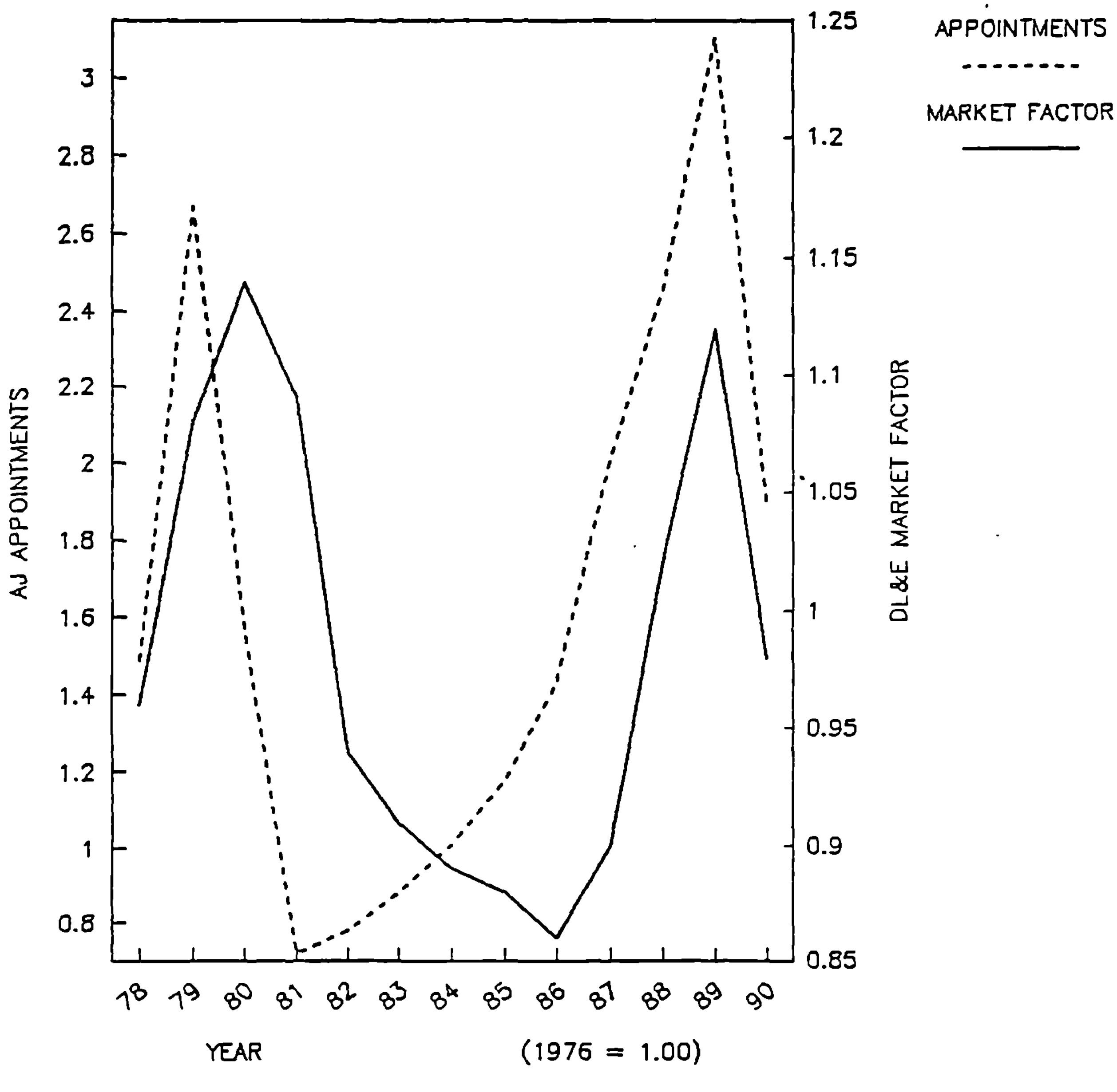


Figure 9.5 Relationship between Architects' appointments advertised in *Architects Journal* and DL&E Market Factor (on quarterly basis)

Source: Davis, Langdon and Everest Office, London

9.4.3 TPI forecast accuracy

The forecast accuracy of TPI has been investigated using both graphical presentation and non-parametric test of accuracy. The forecast period covers the fifteen years from 1975:4 through 1990:4. The forecast horizon (quarters ahead) covers eight quarters (0, 1, 3, ..., 8 quarters ahead). Thus there are 61 zero-quarters-ahead forecasts, 60 one-quarter-ahead forecast, 59 two-quarter-ahead forecast, and 53 eight-quarter-ahead forecast. The 54 eight-quarter-ahead forecast is long enough for one to be able to draw a generalised long-term performance of TPI forecast produced by DL&E

9.4.3.1 Graphical presentation of forecast accuracy

Figure 9.6 presents the plots of actual and predicted values of tender price index. The predictions show the minimum and maximum values. The plots presented in the figure relate to values (actual, minimum prediction and maximum prediction) from 1978:1 through 1990:4 to allow for standardized comparison of performances across forecast horizon. The plots on the predicted values cover the eight quarter forecast horizon. The plots present a clear picture of the performance of DL&E forecast of TPI.

Visual observations of these plots show that the forecasts of TPI generally track the actual levels somehow closely up to two quarters ahead. Because DL&E's forecast of TPI is prediction interval forecast one will expect the actual values of TPI to fall within the minimum and maximum predicted values in most cases. This was not so. For all forecast horizon from 2-quarter-ahead, the actual values of TPI were either below the minimum predicted values or above the maximum predicted values. The degree to which disparity between actual and predicted values is noticeable increased with increasing forecast horizon. The turning points in the predicted values follow the turning points in the actual value about 2 to 4 quarters thereafter which shows a postmortem judgemental adjustment strategy in DL&E forecast.

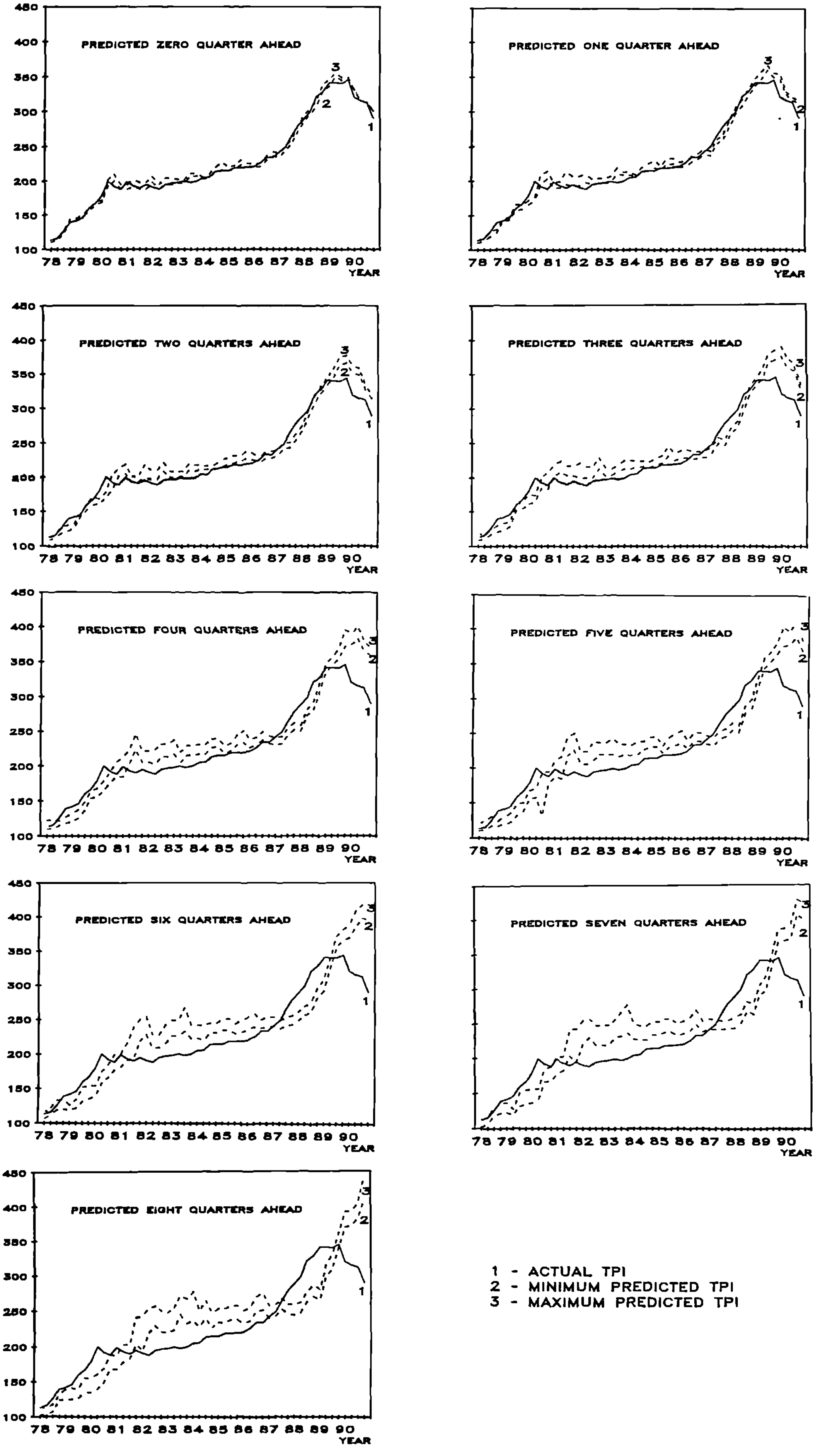


Figure 9.6 Actual and Predicted Tender Price Index
Davis, Langdon and Everest Cost Forecast

9.4.3.2 Non-parametric analysis of forecast accuracy

The predicted values of TPI comprise the minimum and the maximum values. To carry out non-parametric analysis of the forecast accuracy, the arithmetical averages of the minimum and maximum values were determined to represent DL&E forecast of TPI. This becomes necessary to make comparative analysis with other point forecast types of TPI.

Table 9.3 presents the non-parametric analysis of the TPI forecast produced by DL&E from 1976:4 through 1990:4 over eight quarters forecast horizon starting with zero-quarter ahead. Non-parametric measures of forecasting accuracy employed are ME, MAE, and MPE with their respective standard deviations; RMSE, RMSE(per cent) and Theil U^2. All the measures of forecasting accuracy point to an increase in the accuracy of the forecasts as the horizon of the forecasts decreases. The forecasts are generally positively biased, which confirms a general over-estimation of TPI. Apart from zero-quarter ahead (2.93%) and one-quarter ahead (4.86%), percentage error - RMSE(%) - of other time horizons (2 to 8 quarters ahead) are more than 5 percentage error than one would expect by chance.

9.5 Comparative performance in forecasting: BCIS Vs DL&E

BCIS and DL&E are both involved in monitoring and forecasting of TPI. The tenders included in the indexes from these two organisations come from both the public and the private sectors. However, there are some differences associated with the monitoring and forecasting of TPI by these two organisations, thus:

1. BCIS index series measures the trend of tender prices for new building work in the UK. DL&E index series measures the level of pricing contained in the lowest tenders for new work in the outer London area.

2. The BCIS base year is 1974 while DL&E base year is 1976.

Table 9.3 The historical variability of TPI forecast error (DL&E forecasts)

		FORECAST HORIZON								
		0	1	2	3	4	5	6	7	8
	4	-1.0								
1976	1	0.0	9.0							
	2	-1.0	0.0	10.0						
	3	1.0	-4.0	0.0	7.0					
	4	1.0	1.0	-1.0	-1.0	7.0				
1977	1	-1.0	0.0	-1.0	-3.0	-2.0	12.0			
	2	1.0	2.0	3.0	1.0	-2.0	4.0	13.0		
	3	-1.0	1.0	2.0	2.0	0.0	-5.0	-2.0	11.0	
	4	1.0	0.0	2.0	-2.0	3.0	-3.0	-3.0	-3.0	11.0
1978	1	-1.0	-1.0	-1.0	1.0	3.0	2.0	-2.0	-6.0	-6.0
	2	-1.0	-1.0	-1.0	-3.0	0.0	3.0	1.0	-2.0	-9.0
	3	-2.0	-3.0	-3.0	-5.0	-8.0	-1.0	0.0	-2.0	-14.0
	4	2.0	-12.0	-13.0	-14.0	-16.0	-18.0	-12.0	-10.0	-11.0
1979	1	1.0	1.0	-13.0	-14.0	-15.0	-17.0	-20.0	-12.0	-10.0
	2	2.0	-1.0	-1.0	-14.0	-15.0	-16.0	-18.0	-23.0	-13.0
	3	-2.0	1.0	-3.0	-3.0	-18.0	-19.0	-18.0	-18.0	-27.0
	4	-1.0	-5.0	-2.0	-8.0	-8.0	-22.0	-22.0	-22.0	-22.0
1980	1	-8.0	-10.0	-14.0	-11.0	-17.0	-17.0	-32.0	-32.0	-34.0
	2	-2.0	-25.0	-27.0	-31.0	-29.0	-35.0	-35.0	-50.0	-50.0
	3	13.0	12.0	1.0	0.0	-8.0	-29.0	-17.0	-17.0	-33.0
	4	5.0	17.0	22.0	12.0	15.0	26.0	25.0	18.0	17.0
1981	1	-7.0	-4.0	14.0	7.0	-1.0	1.0	-8.0	-8.0	-21.0
	2	4.0	2.0	4.0	24.0	21.0	8.0	11.0	0.0	-2.0
	3	3.0	15.0	7.0	20.0	45.0	42.0	26.0	33.0	3.0
	4	-2.0	5.0	13.0	15.0	18.0	43.0	40.0	24.0	28.0
1982	1	11.0	9.0	13.0	20.0	22.0	24.0	50.0	46.0	28.0
	2	4.0	16.0	12.0	20.0	25.0	27.0	31.0	56.0	49.0
	3	5.0	4.0	21.0	13.0	27.0	30.0	24.0	39.0	47.0
	4	3.0	4.0	8.0	24.0	25.0	32.0	32.0	37.0	39.0
1983	1	2.0	3.0	7.0	11.0	29.0	31.0	40.0	36.0	36.0
	2	0.0	3.0	5.0	9.0	13.0	32.0	38.0	44.0	40.0
	3	11.0	17.0	17.0	17.0	24.0	28.0	52.0	52.0	61.0
	4	9.0	11.0	15.0	19.0	22.0	27.0	32.0	57.0	50.0
1984	1	-1.0	6.0	11.0	14.0	19.0	22.0	28.0	34.0	52.0
	2	2.0	2.0	10.0	14.0	18.0	23.0	25.0	28.0	33.0
	3	3.0	3.0	2.0	6.0	19.0	19.0	24.0	33.0	38.0
	4	6.0	5.0	5.0	4.0	18.0	23.0	23.0	29.0	22.0
1985	1	3.0	10.0	8.0	8.0	8.0	23.0	28.0	29.0	29.0
	2	1.0	0.0	8.0	8.0	8.0	8.0	24.0	29.0	25.0
	3	8.0	10.0	9.0	19.0	18.0	18.0	18.0	29.0	29.0
	4	3.0	8.0	12.0	10.0	23.0	22.0	22.0	22.0	28.0
1986	1	1.0	3.0	11.0	13.0	11.0	24.0	24.0	24.0	21.0
	2	-2.0	-2.0	0.0	9.0	10.0	9.0	24.0	24.0	19.0
	3	-1.0	-3.0	-2.0	-2.0	9.0	12.0	10.0	26.0	26.0
	4	5.0	1.0	0.0	0.0	4.0	11.0	13.0	13.0	29.0
1987	1	-5.0	0.0	-6.0	-7.0	-7.0	-1.0	6.0	8.0	7.0
	2	-2.0	-10.0	-3.0	-8.0	-12.0	-11.0	-6.0	0.0	2.0
	3	-8.0	-9.0	-17.0	-10.0	-15.0	-18.0	-18.0	-17.0	-5.0
	4	-4.0	-15.0	-20.0	-28.0	-22.0	-27.0	-29.0	-30.0	-26.0
1988	1	1.0	-5.0	-18.0	-21.0	-35.0	-28.0	-24.0	-38.0	-37.0
	2	0.0	2.0	-6.0	-21.0	-22.0	-42.0	-36.0	-41.0	-44.0
	3	-10.0	-9.0	-8.0	-18.0	-34.0	-35.0	-53.0	-45.0	-51.0
	4	5.0	-21.0	-1.0	0.0	-15.0	-35.0	-40.0	-57.0	-50.0
1989	1	3.0	1.0	-1.0	-1.0	0.0	-17.0	-40.0	-43.0	-68.0
	2	12.0	11.0	11.0	9.0	9.0	11.0	-8.0	-33.0	-33.0
	3	6.0	23.0	30.0	33.0	21.0	21.0	23.0	2.0	-19.0
	4	1.0	7.0	28.0	28.0	38.0	28.0	28.0	30.0	6.0
1990	1	25.0	29.0	38.0	62.0	62.0	70.0	58.0	58.0	61.0
	2	15.0	22.0	39.0	50.0	76.0	73.0	81.0	68.0	68.0
	3	0.0	5.0	18.0	47.0	79.0	88.0	95.0	105.0	82.0
	4	10.0	22.0	28.0	40.0	81.0	88.0	119.0	121.0	136.0

Table 9.3 The historical variability of TPI forecast error (Contd)

Mean error	2.07	2.72	4.78	6.40	9.28	10.16	11.73	12.15	10.13
Std. dev.	5.76	9.93	13.11	18.03	25.17	29.07	33.43	36.77	38.58
Mean Absolute error	4.13	7.38	10.27	14.16	19.84	24.30	27.84	31.00	32.21
Std. dev.	4.51	7.18	9.45	12.87	18.06	18.91	21.91	23.20	23.52
RMSE	6.12	10.30	13.96	19.13	26.83	30.80	35.43	38.72	39.88
RMSE (percent)	2.93	4.86	6.47	8.72	11.97	13.57	15.36	16.61	17.10
Theil U^2	0.0008	0.0022	0.0039	0.0073	0.0142	0.0184	0.0240	0.0283	0.0296
Mean Percent error	0.84	1.16	1.98	2.44	3.67	4.24	5.02	5.39	4.50
Std. dev.	2.37	4.38	5.60	7.31	10.05	11.91	13.55	15.08	15.88
Mean Absolute Percent error	1.86	3.37	4.66	6.27	8.69	10.76	12.18	13.56	14.16
Std. dev.	1.68	3.02	3.68	4.49	6.23	6.64	7.78	8.52	8.48

3. BCIS forecast of TPI is point forecast while DL&E's is a prediction interval forecast.

4. BCIS commenced publication of TPI forecast in 1980 while DL&E commenced earlier (1976).

Despite these differences, there are no problems in comparing the accuracy of TPI forecasts published by these organisations. These comparative performance analyses cover the entire period over which these two organisations have published TPI forecast (BCIS, 1980-1990; DL&E, 1976-1990) so that the period of learning could be equally included in the analysis.

Tables 9.1 and 9.3 present the non-parametric summary analysis of the forecasting accuracy. Two measures of forecasting accuracy enables us to make a direct comparison between these two forecasts apart from graphical representation: RMSE(%) and Theil U^2. Though DL&E forecast at zero-quarter ahead performed better than BCIS's, RMSE(%) and Theil U^2 show that BCIS forecast of TPI is more accurate than DL&E forecast at any other forecast horizon.

Two practical lessons become obvious from these forecasts of TPI thus:

a. The forecast accuracy of these organisations has varied greatly over time. For example, while BCIS has found it easy to forecast TPI from 1985:1 through 1987:4, some periods have been very difficult to predict. 1985:1 through 1987:4 coincided with steady growth in UK economic condition (a conducive condition for economic forecast). An unexpected decline in economic fortune leads to large error in forecast accuracy.

b. Fluctuating forecast accuracy over this period could be attributable to the forecasters. Over this period different people have been involved in the forecast of TPI within these organisations that are no longer there (This situation was specifically confirmed by BCIS and DL&E during the course of oral interview). This fluctuation in accuracy could therefore be attributable to lack of continuity and/or systematic differences in forecasting skills of participants in TPI forecast over time. Obviously, new entrants need time to get used to the specific skills required by a different organisation irrespective of whether the new entrant has done the same thing elsewhere.

9.6 Accuracy of Reduced Form Model forecast

This section is designed to study the forecasting accuracy of the reduced form model over different horizon lengths. There is interest in determining if the model will display a tendency to accumulate errors as the forecasting horizon increases.

The reduced-form model (Eqn 8.20) will readily produce the forecast of TPI at zero-quarter ahead. However, the model is such that it can be manipulated to produce the forecast of TPI up to three quarters ahead.

C^p, Y^d and R^r in reduced form model (Eqn 8.20) have the starting lagged distribution of 0, 0, and 1 respectively which, tend to suggest that these concurrent relationships have little forecasting value. The starting point of distributed lags in respect of remaining variables is three or more quarters lead which, do not post forecasting problems. There are three options for taking care of the concurrent relationship variables in the model:

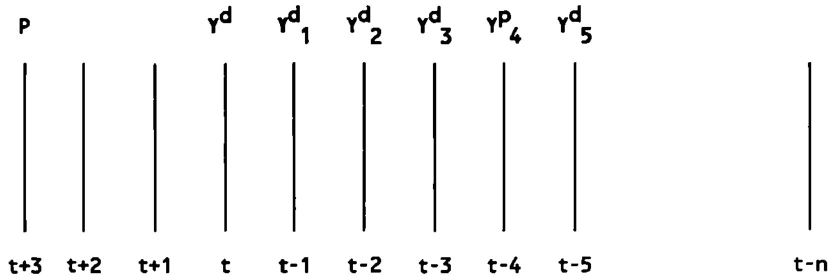
1. The forecast of these concurrent independent variables for the relevant period could be used where available, provided these forecasts are very accurately predicted in the past. Example in this respect is C^p (Building Cost Index). BCIS is known to forecast this variable with a high degree of accuracy (Fellows, 1988).

2. These variables could be simulated provided they have a fairly steady growth trend.

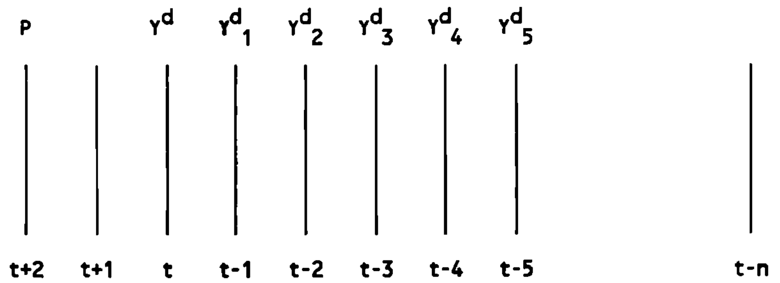
3. The current values of these variables could be lagged 3, 2, or 1 quarter ahead of TPI depending on the forecast span (horizon) intended. Figure 9.7 shows the illustration of how current value of Y^d for example, could be used in predicting TPI up to three quarters ahead. As the latest values of variable become available, the forecast is revised to fit these new information (after McNees, 1986).

Figure 9.7 Lag relationship between P and Y^d

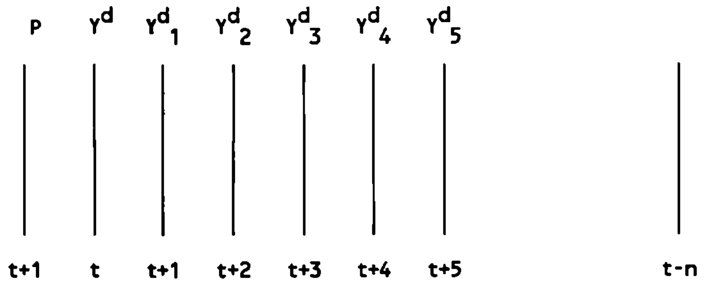
In three-quarter forecast horizon



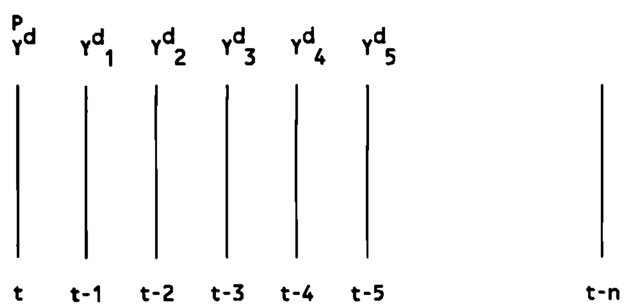
In two-quarter forecast horizon



In one-quarter forecast horizon



In zero-quarter forecast horizon



Options 1 and 3 are adopted in determining the accuracy of the reduced-form model of TPI. It is worth mentioning that the in-sample and post-sample forecasts analyzed are pure mechanically-generated reduced-form model based forecasts.

9.6.1 Non-parametric analysis of forecast accuracy

Ex post simulation or "historical" simulation forecast accuracy

The simultaneous equations estimation were based on quarterly data 1974:1 to 1987:4. This period is regarded, therefore, as in-sample period. The in-sample non-parametric forecast accuracy of the reduced-form model of construction price is shown in Table 9.4. The RMSE is less than 10 in all cases. The percentage error of less than 5 per cent across the forecast horizon indicates that the model as a whole does not display any substantial tendency to accumulate errors as the forecasting horizon lengthens. Though MPE and ME statistics show negative signs, their standard deviations (spread) indicate almost equal tendency of the model towards under-prediction and over-prediction.

Table 9.4 In-sample analysis of forecasting accuracy of the Reduced Form Model (1976:1 - 1987:4)

Forecast Span	MPE	MAPE	ME	MAE	RMSE	RMSE(%)	U^2
0	-0.321	3.024	-0.370	5.841	7.132	3.475	0.0012
	(3.787)	(2.302)	(7.122)	(4.092)			
1	-0.558	3.995	-0.433	7.403	9.017	4.393	0.0018
	(3.363)	(5.192)	(9.007)	(5.149)			
2	-0.479	4.318	-0.649	8.137	9.617	4.690	0.0021
	(5.353)	(3.200)	(9.595)	(5.127)			
3	-0.281	4.301	-0.970	8.393	9.841	4.794	0.0022
	(5.301)	(3.001)	(9.793)	(5.138)			

Ex post forecast accuracy

1988:1 to 1990:4 is considered as the ex-post or out-sample period. The choice of this period is of interest because it has witnessed a significant downturn in the tender price level and coupled with severe economic recession. The non-parametric forecast accuracy of the reduced-form model of construction price was compared with the forecast accuracy of BCIS and DL&E over this period. Table 9.5 contains error statistics for the forecasts. The table indicates that the post-sample error statistics are not significantly larger than the in-sample error statistics.

The table also shows that the reduced-form model has a better predictive behaviour than the BCIS and DL&E forecasts. RMSE(per cent) of the reduced-form model forecasts is less than 6 per cent in all cases over the three quarter forecast horizon. The reduced-form model, however, generally underestimated the TPI values compared to a general overestimation in respect of BCIS and DL&E forecasts.

9.6.2 Graphical presentation of forecast accuracy

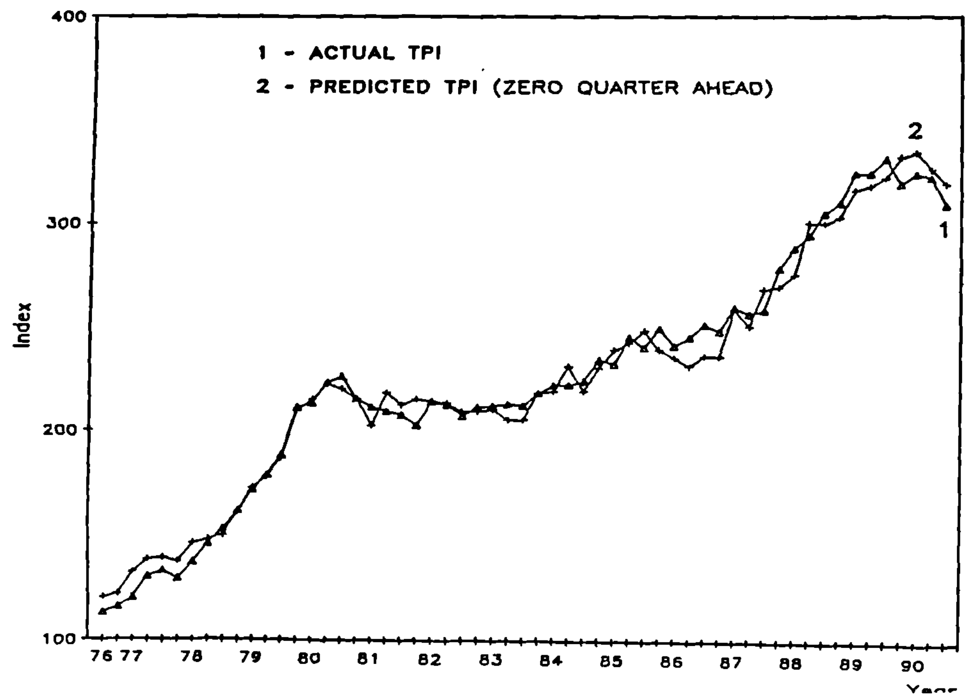
Figure 9.8 which, shows the graphical plots of actual values of TPI and the predicted values from 1976 through 1990 presents a clear picture of the performance of the reduced-form model in tracking the historical record.

Ex post simulation - within sample

The period 1976:2 to 1987:4 represents the in-sample period. The model simulates the historical record quite well particularly over the zero-quarter-ahead and one-quarter-ahead forecast horizon. The figure (which covers three quarter ahead forecasts, that is, zero-quarter-ahead, one-quarter-ahead, two-quarter-ahead, and three-quarter-ahead) shows that the reduced-form model can pick the turning point in the TPI movements not later than a quarter thereafter. This is considered an advantage over BCIS and DL&E published forecasts.

Table 9.5 Comparative analysis of forecasting accuracy of the Reduced-form Model forecast, BCIS forecast and DL&E forecast (1988:1 - 1990:4)

	Forecast Span	MPE	MAPE	ME	MAE	RMSE	RMSE(%)	U^2
Reduced form model	0	-0.184	2.650	-0.536	8.301	8.740	2.781	0.0008
		(2.796)	(0.910)	(8.723)	(2.734)			
	1	-0.693	3.330	-2.055	10.439	11.264	3.580	0.0013
		(3.555)	(1.426)	(0.425)	(9.648)			
	2	-1.273	4.038	-3.828	12.628	13.457	4.277	0.0018
		(4.150)	(1.593)	(2.106)	(11.786)			
	3	-2.128	5.092	-6.480	15.893	17.597	5.593	0.0031
		(5.277)	(2.539)	(4.205)	(14.560)			
BCIS Forecast	0	2.27	2.38	7.18	5.55	10.43	3.32	0.0011
		(2.40)	(2.29)	(7.57)	(7.20)			
	1	3.75	4.67	12.00	14.73	16.61	5.29	0.0028
		(3.74)	(2.50)	(11.49)	(7.69)			
	2	4.77	6.46	15.27	20.36	23.76	7.57	0.0066
		(5.83)	(3.88)	(18.21)	(12.25)			
	3	5.68	8.24	18.09	25.91	31.25	9.96	0.0099
		(8.22)	(5.65)	(25.48)	(17.47)			
	4	6.13	9.70	19.27	30.36	38.00	12.11	0.0146
		(10.62)	(7.50)	(32.75)	(22.84)			
	5	5.88	10.26	18.27	32.09	41.38	13.18	0.0173
		(12.04)	(8.61)	(37.13)	(26.13)			
	6	4.39	10.50	13.55	32.82	40.17	12.80	0.0016
		(12.24)	(7.67)	(37.81)	(23.16)			
	7	2.87	9.63	8.73	30.00	37.22	11.86	0.0140
		(11.72)	(7.26)	(36.18)	(22.03)			
	8	1.86	9.21	5.45	28.55	36.80	11.72	0.0137
		(11.86)	(7.70)	(36.40)	(25.23)			
DL&E Forecast	0	1.77	2.29	5.57	7.33	10.27	3.21	0.0010
		(2.69)	(2.26)	(8.57)	(7.19)			
	1	2.27	4.10	7.25	13.08	16.03	5.01	0.0025
		(4.49)	(2.92)	(14.30)	(9.27)			
	2	4.04	5.93	13.17	18.83	22.92	7.16	0.0051
		(5.97)	(4.10)	(18.76)	(13.06)			
	3	5.36	8.73	17.33	27.50	33.31	10.41	0.0108
		(9.13)	(5.99)	(28.44)	(18.79)			
	4	6.83	12.60	21.67	39.33	47.85	14.95	0.0223
		(13.90)	(9.01)	(42.67)	(27.25)			
	5	5.90	14.28	18.50	44.67	51.92	16.23	0.0262
		(15.75)	(8.88)	(48.51)	(26.47)			
	6	5.59	16.11	16.92	50.42	59.42	18.57	0.0343
		(18.52)	(10.71)	(56.96)	(31.45)			
	7	3.65	17.08	10.58	53.42	61.84	19.33	0.0372
		(19.78)	(10.63)	(60.93)	(31.16)			
	8	1.81	17.45	4.25	54.58	63.30	19.78	0.0390
		(20.56)	(11.01)	(63.16)	(32.05)			



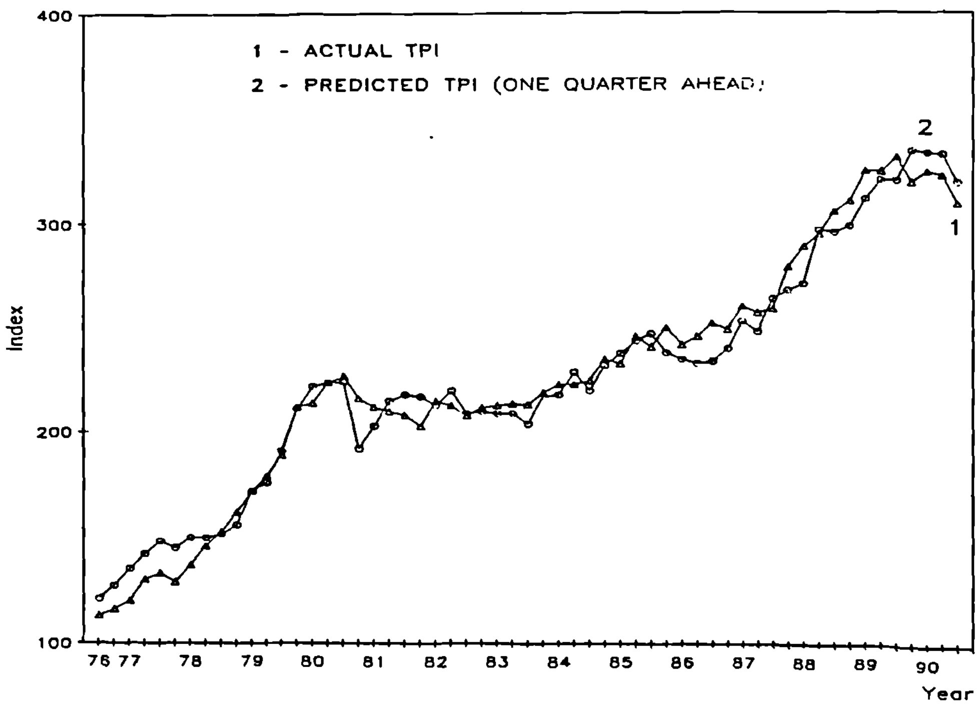
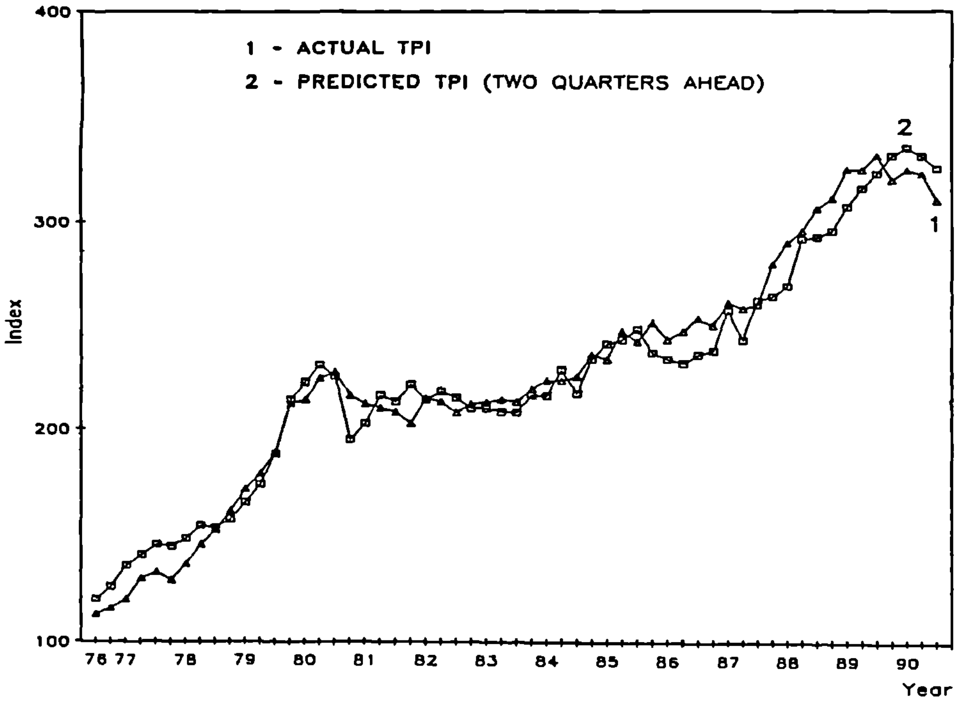
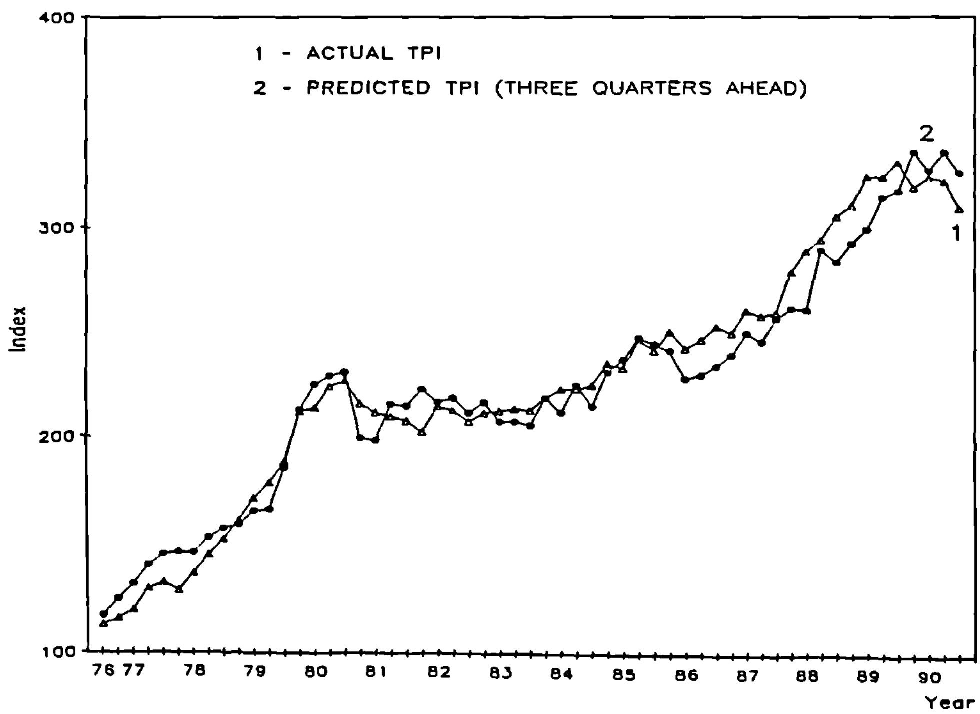


Figure 9.8 Actual and Predicted Tender Price Index
Reduced-Form Model of Construction Price

Figure 9.8 Contd





Ex post forecast - post sample

1988:1 to 1990:4 is the out-sample or *ex post* forecast period. The magnitude and direction of the forecasting errors are illustrated by the plot over the three quarters forecast horizon. The disparity between actual values and predicted values during the *ex post* forecast period is not as pronounced as in BCIS and DL&E published forecasts.

The over-prediction of the model from 1989:4 is probably due to the continuous severity of the recession. In principle the model does understand the recession through its impact on GNP, the unemployment level, and interest rate, however, there are other factors associated with the recession that the model could not understand. This current recession is unique in the sense that it is too sudden.

9.7 Conclusion

Analysis of the accuracy of TPI forecasts produced and published by Building Cost Information Service from 1980 through 1990 and Davis Langdon and Everest from 1976 through 1990 was undertaken. The disparities between the actual values of TPI and the predicted values published by these organisations increased with increasing forecast horizon.

The evaluation of forecasting accuracy of the reduced-form model shows that this model has a good in-sample forecasting behaviour. Table 9.5 shows that the out-sample forecasting behaviour of the model is better than published forecasts of TPI by BCIS and DL&E.

The forecasts from the reduced-form model forecast are "pure" mechanically-generated forecast. It is possible that the accuracy of forecasts based on the reduced-form model could be improved further if used as a forecasting tool by experts. In this respect, experts would be expected to be capable of making "objective" judgemental adjustments of the mechanically-generated model based forecasts.

CHAPTER 10

Summary and Conclusions

SUMMARY AND CONCLUSIONS

10.1 Summary

The construction industry is one the largest industries in most of the countries throughout the world. It is also one of the most volatile in economic terms - with extreme behaviour in both good and bad times. Understanding the nature of such behaviour is crucial at both macro and micro levels in the management of the industry and its constituent organisations. As yet, surprisingly little substantive work has been carried out aimed at deriving suitable predictive or even explanatory models, all economic reports being essentially intuition based. This research work therefore examined the construction tender price index to identify suitable models that are capable of explaining, monitoring and forecasting the trends in this index.

The research work was carried out in three phases. The first phase produced a preliminary work on the subject. This phase started with a literature review; examined the movements in construction price and cost in relation to construction profitability (*cf.* Akintoye and Skitmore, 1991a); developed a data collection strategy and developed an initial version of the construction price model (*cf.* Akintoye and Skitmore, 1990); At this stage it was found that the disparity between the trends in construction price and cost could not be explained by the trends in construction profitability. Also the likelihood of other factors having important influence on the trends in construction price became obvious. This phase concluded by examining pricing polices in the construction industry. A tentative conclusion at this stage was that the industry has tendencies to oscillate between one pricing strategy to the other depending on circumstances. For example pricing strategies could be fine tuned to prevailing economic condition in which case a firm can change from cost-based pricing to market-based pricing in time of economic uncertainty, and when there is a need to break-even or penetrate into a new construction market. Since bids are submitted for construction contracts based on pricing strategy adopted the link between contractors' tender prices, accepted tender price and tender price indices suggested.

In the second phase final research strategy and models were developed. This phase formed the bulk of the research work. This stage comprised the identification and examination of the various types of construction price indices based on questionnaire and oral interview of eight organisations; analyzing the movements in construction price; identification of indicators of construction price; development of construction demand and supply equations, and development of construction price equations.

It was found based on the questionnaire and oral interviews that the construction price trend monitoring is based on analysis of accepted tender prices while the mode of forecasting tender price index was predominantly based on the subjective judgements of in-house experts.

Factors considered by experts in judging the movements in tender price index were building cost trends, general retail inflation, construction new-order and output, general public expenditure, architect commission, unemployment level, sterling exchange rate and lagged tender price index. Contrary to expectations, experts opinion of the influence of building cost trends on tender price movements was low. Two main factors responsible for difficulties in monitoring and forecasting the tender price index were identified as lack of appropriate database and sporadic fluctuation in the construction market conditions.

The trends in tender price index was found to increase with a quarterly growth rate of 3.21 percent between 1974 and 1990, which was above construction new-order and below building cost index, gross national product, unemployment and retail price index. The tender price index was less volatile than construction new-order and output, unemployment level, retail price index, but more volatile than building cost index and gross national product.

The cyclical and annualized growth rate of tender price index followed the general cyclical movements of UK economy. From the analysis recessions slowed down tender price level and economic recovery geared this up.

Two experiments on identification of construction price trends' indicators produced some useful results. The first experiment which employed a diagrammatic method by plotting the annualized growth rate in these potential variables with annualized growth rate in tender price index (Figures 5.3 to 5.22) showed by visual observations that some of the time series were inconsistent indicators of tender price index. Most exhibited combinations of leading, lagging and coincident indicators of TPI over time. However some leading indicators of TPI identified from this experiment were unemployment level, ratio of price to cost indices in manufacturing sector, industrial production, construction demand, construction output, productivity, sterling exchange rate, producers price index.

The second experiment, which adopted a univariate analysis using OLS regression analysis, showed that there were inconsistencies in the predictive power of the time series, which corroborated the first experiment. The disaggregated analysis of the data showed that the predictive power of some of these variables changed with time. For example sterling exchange rate had the highest predictive power in 1970s which was not so in 1980s. From the two experiments it became clear that it was difficult to identify clear cut leading indicators of tender price index. Due to this reason, the need to examine tender price trend from another perspective became obvious. Literature from economics seemed to produce the answer using classical economic theory of demand and supply.

A model was specified and estimated for construction demand. The explanatory variables for trends in construction demand in real terms were tender price index, gross national product, real interest rate, unemployment level and manufacturing sector profitability. The explanatory variables fitted the trends in construction demand with an r^2 adjusted of 0.81 and these variables had the theoretically expected signs. A summary of the model successfully fitted to the data was provided in Table 6.2. Analysis of the residuals of this model was carried out. The Durbin-Watson statistics was 1.92 implying non-rejection of null hypothesis of zero autocorrelation. This analysis showed that the model is statistically stable with approximately normal distribution shape and lack of pattern in the plots of residual values against the predicted values and the predictor variables.

A model was also specified and estimated for construction supply. Explanatory variables identified were tender price index, input costs and production capacity. The production capacity comprised of productivity, number of construction firms and construction work stoppage. The variables fitted the trends in construction supply with r^2 adjusted of 0.84 and these variables had the theoretically expected signs. A summary of the model successfully fitted to the data was provided in Table 7.2. Analysis of residuals of this model was carried out. The Durbin-Watson statistics was 1.71 implying non-rejection of null hypothesis of zero autocorrelation. This analysis showed that the model is statistically stable with approximately normal distribution shape and lack of pattern in the plots of residual values against the predicted values and the predictor variables.

This phase concluded by developing two different models of construction price: single structural model and reduced-form model. A Single structural equations of construction price was estimated using the combination of construction demand and supply determinants. The variables fitted the trends in construction price with r^2 adjusted of 0.97 and all these variables had the theoretically expected signs with Durbin-Watson statistics of 2.17. The variables comprised of building cost index, construction work stoppage, number of construction companies, productivity, real interest rate, unemployment, gross national product, dummy variable for oil crisis shock and manufacturing profitability. The analysis of the residuals showed that the model is statistically stable with normal distribution shape and lack of pattern in the plots of residual values against the predicted values and the predictor variables.

The reduced-form of construction price utilised simultaneous equation models comprising of construction demand, supply and equilibrium models. The reduced-form is generally regarded as having better predictive power than structural equations.

In the third phase, the predictive performance of the reduced-form model was validated. In doing this, analyses were undertaken of the forecast accuracy of tender price index by the two leading organisations (Tables 9.1 and 9.3). The model was validated by comparing its accuracy with those of these two organisations. The out-of-sample forecast errors of the reduced-form model were 2.78, 3.58, 4.28 and 5.59 RMSE percent over 0, 1, 2 and 3 quarter forecast horizons respectively, which were better than the Building Cost Information Service (3.32, 5.29, 7.57 and 9.96 RMSE percent) and Davis, Langdon and Everest (3.21, 5.01, 7.16 and 10.41 RMSE percent) forecast errors.

10.2 Scope and Limitations

In this section, the scope of the research is outlined and the limitations of the model of construction price trend are pointed out.

The questionnaire survey was conducted among eight organisations that were identified as responsible for producing, monitoring and forecasting tender price index. This list is compiled based on published indices by these organisations. It is not unlikely that there are other organisations producing 'in-house' indices of construction price.
All-in Tender price index produced by Building Cost Information Service (BCIS) is used as synonymous with trends in construction price in this research and this relates to building works. The analysis is based on quarterly data from 1974 to 1990. Earlier data would have been preferred, but 1974 was specifically chosen as this period correspond to 'base year' for BCIS indices.

The models produced are expected to be used as decision support tools in relation to construction investments and pricing policies. For the models to continue to be useful for this purpose, they will need to be re-estimated periodically so as to fine-tune them to current and updated data.

10.3 Conclusions

The following concluding remarks can be made on the basis of the findings of this study.

The indicator is expected to bear a consistent relationship over time with movements and turns in the economic variable of interest. Contrary to this, indicators of construction price are inconsistent, exhibiting combinations of leading, lagging and co-incidence depending on time period. All these types of indicators have usefulness in economic analysis but the most useful for economic predictions are the leading indicators. For time series to continue to be useful predictive series for TPI, a period analysis will need to be undertaken to identify when they are leading indicators.

The research hypothesis:

> "The tender price trend is more influenced by the market condition than the level of construction input cost."

is supported. Five organisations out of eight interviewed claimed 'low importance' of building cost trends in construction price level forecasts (Table 3.4). Also contributions of variables to structural equation of construction price (section 8.5.4) supports this hypothesis. The market oriented factors contributed 76 per cent to variability in construction price equation against 17 per cent contributed by cost factors.

The current mode of forecasting construction price trends is judgemental based. Most often judgement reflects the particular interests, knowledge and experience of forecasters. This being the case, it may not be too pessimistic to say that forecasting accuracy of construction price will continue to be highly fluctuating, attributable to lack of continuity, systematic differences in forecasting skills of forecaster and inability to transfer knowledge, as long as this continue to be the case. This does not bode well for the industry that contributes substantially to national economy. The construction clients need fair dealing in terms of construction information produced by construction experts. This may become difficult where the requisite tools are not available. The work described in this thesis may provide an initial tool. This is hopefully, the first of many approaches to modelling the construction industry's economic forces. The development of single structural form models with R^2 adjusted values of 0.97 for deflated data of these kind is most encouraging and bodes well for future work in this field. The reduced form model is likely to be better than all other current methods, including the single structural form equation, at construction price forecasting.

10.4 Suggestions for further research

While the models, developed in this research explain and predict construction price better than the two leading TPI forecasts, additional research would seem to be necessary if the models are to be used as tools for *ex-ante* forecasting and policy analysis. Further research on the model should focus on the following issues.

1. Chapter 5 examined the indicators of tender price, which failed to come up with consistent leading indication of construction price. This inconsistency demands that further research is done into the dynamic relationships of some of these potential variables with construction price. There is a need to investigate the possibility of developing composite leading indicator of tender price index as a way of reducing this inconsistency.

2. The model as presented relates to aggregate tender price. It might be useful to develop construction price models that incorporate changes in the composition of construction market aggregate tender price. Also there is a need to develop tender price movement on construction market basis. It would be interesting to see if the methodology used to model general construction tender price in this thesis holds for disaggregated construction market.

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APPENDIX A

Data, Sources and Transformation

DATA, SOURCES AND TRANSFORMATION

This appendix contains a list of data sources, transformations and raw data for all variables used in this thesis

	Variables	Abreviations		Sources
1.	Sterling Exchange Rate	SER		Economic Trends (CSO)
2.	Industrial Production	IOP		Economic Trend (CSO))
3.	Level of Unemployment	EMP	U^E	Economic Trends and Employment Gazette (CSO)
4.	Construction Output	PUT	Q^s	Housing and Construction Statistics (CSO)
5.	Ratio of Price to Cost Indices in Manufacturing	MAN	M^p	Economic Trends (CSO)
6.	Building Cost Index	BCI	C^p	Building Cost Information Service Quarterly Bullettin
7.	Implicit GDP Deflator - market prices	GDF		Economic Trends (CSO)
8.	Construction Neworder	ORD	Q^d	Housing and Construction Statistics (CSO)
9.	Gross National Product	GNP	Y^d	Economic Trends (CSO)
10.	Capacity Utilisation	UTC		onfederation of British Industry (CBI) Quarterly Surveys
11.	Bank Base Rate	BBR		Economic Trends, Financial Statistics, Datastream Internationsl Ltd On-Line (A company of Dun and Bradstreet corporation)
12.	Retail Price Index	RPI		
13.	Real Interest Rate (Bank Base Rate - Inflation)	RIR	R^r	
14.	Work Stoppage in the construction industry	STR	S^T	Economic Trends (CSO)
15.	All Share Index	ASI		Datastream International Ltd On-LIne
16.	Income per Capital - Whole Economy (GNP/Head)	GPH		Economic Trends (CSO)
17.	Corporation Tax	CTX		Economic Trends (Bank of England)
18.	Money supply (M3)	MSS		Datastream International Ltd On-Line
19.	Output per Person Employed - construction industry (Productivity)	PRO	P^r	Employment Gazette (CSO)
20.	Industrial and Commercial Companies - Gross profits	ICP		Datastream International Ltd On-Line
21.	Wages/Salaries/Unit of Output - Whole Economy	AEA		Economic Trends
22.	Number of Registered Private Contractors	FRM	F^r	Housing and Construction Statistics (CSO)
23.	Producers Price Index - Output Prices	PPI		Economic Trends (CSO)
24.	Tender Price Index	TPI	P	Building Cost Information Service Quarterly Bullettin

Data Transformations

1. The number of registered private contractors (FRM) are published on annual basis. A quarterly series for FRM was derived by first assuming each annual value to occur in the repective fourth quarter. Linear interpolation was then used to estimate the quarterly values between successive fourth quarters.

2. To reduce the dominating effects of general inflationary trends, the values of all affected variables (PUT, BCI, ORD, GNP, GPH, MSS, ICP, AEA, PPI, and TPI) were rebased to 1974 by dividing by the retail price index for non-food items or by multiply by debase factor (the debase factor is reciprocal of retail price index multiplied by 100). The retail price index was choosen in preference to some other deflator such as building cost index or GDP deflator as one of purest measures of inflation available in order to avoid any possible confounding effects caused by any inadvertent contamination with the variables.

Data used for the research

		TPI	BCI	RPI	DEBASE	PUT	ORD	GNP	FLA	BBR	STR	EMP	PRO	FRM	MAN
		Index			Factor	Million			%	%		Million	Index	Thous.	Index
1974	1	100	100	100.0	0.9999	2258	1471	19334	12.87	13.00	31	.7115	100.0	99.691	98.9
	2	100	107	107.0	0.9346	2462	1502	20847	15.88	12.00	76	.6880	109.0	99.806	101.2
	3	99	113	111.1	0.9001	2558	1536	21937	17.02	12.00	41	.6821	127.7	99.921	100.9
	4	100	118	114.2	0.8757	2455	1502	23004	18.18	12.00	53	.7154	119.3	98.035	99.0
1975	1	105	124	102.4	0.9766	2532	1479	24613	20.30	10.50	63	.8501	109.7	97.781	98.2
	2	103	132	128.7	0.7770	2775	1654	26054	24.27	9.50	60	.9133	107.1	97.527	98.8
	3	105	139	139.2	0.7184	2910	1732	27176	26.57	10.00	17	.9467	99.0	89.273	97.7
	4	105	143	143.8	0.6954	2864	1512	28540	25.31	11.00	55	1.1009	101.0	88.017	97.8
1976	1	111	147	147.9	0.6761	2883	1809	30021	22.47	9.50	107	1.2649	102.2	86.947	97.8
	2	109	152	152.7	0.6549	3004	1947	30745	16.03	10.50	146	1.2347	104.4	85.877	96.8
	3	113	163	157.2	0.6361	3112	1628	31814	13.65	12.00	151	1.3848	104.3	84.807	97.0
	4	116	169	161.8	0.6180	3182	1490	33642	14.93	14.00	167	1.3112	107.2	83.737	97.8
1977	1	120	175	169.3	0.5907	3045	1640	34587	16.51	9.50	105	1.3858	108.1	82.214	101.0
	2	130	180	179.3	0.5577	3281	1893	35796	17.41	8.50	83	1.3253	107.4	80.670	101.2
	3	133	186	181.5	0.5510	3484	1857	36910	16.58	7.00	62	1.5172	108.4	79.166	102.5
	4	129	189	184.9	0.5408	3504	1791	38358	13.08	7.13	46	1.4261	108.7	77.642	103.7
1978	1	137	193	187.6	0.5330	3490	2100	39888	9.50	6.50	87	1.4655	106.0	81.111	104.3
	2	146	197	192.0	0.5208	3969	2301	41766	7.68	10.00	158	1.3698	110.3	84.581	104.1
	3	153	205	195.9	0.5105	4144	2385	42872	7.85	10.00	103	1.4708	109.0	88.050	103.8
	4	162	211	199.8	0.5005	4100	2144	44094	8.09	12.50	68	1.3358	106.9	91.520	101.0
1979	1	172	216	204.3	0.4895	3949	2173	45462	9.58	13.00	69	1.3728	99.8	93.910	98.8
	2	179	222	212.1	0.4715	4618	2764	48582	10.58	14.00	58	1.2609	104.7	96.300	100.6
	3	199	241	228.6	0.4374	5094	2578	51335	15.98	14.00	142	1.3473	102.9	98.690	99.3
	4	212	250	235.9	0.4239	5209	2509	53241	17.26	17.00	106	1.2675	102.8	101.080	97.9
1980	1	214	260	245.5	0.4073	5122	2518	55178	19.08	17.00	33	1.3737	102.2	104.218	97.6
	2	224	270	262.7	0.3807	5490	2772	56618	21.55	17.00	80	1.4181	99.1	107.356	96.9
	3	227	290	270.1	0.3702	5919	2511	58642	16.36	16.00	79	1.7365	97.0	110.494	95.2
	4	216	294	275.4	0.3631	5520	2314	60037	15.28	14.00	32	1.9164	94.0	113.632	95.0
1981	1	212	298	280.3	0.3568	5278	2591	61382	12.71	12.00	57	2.2710	93.5	114.020	94.6
	2	210	304	297.2	0.3365	5400	2910	62824	11.70	12.00	17	2.3727	91.6	114.109	95.0
	3	208	311	302.0	0.3311	5652	2800	64622	11.26	14.00	7	2.5118	96.9	114.797	93.8
	4	203	318	309.5	0.3231	5217	2420	66277	11.91	14.50	7	2.7718	94.9	115.186	93.4
1982	1	215	325	314.6	0.3179	5215	2749	67258	11.13	13.00	10	2.8963	98.1	122.488	94.4
	2	213	332	324.5	0.3082	5583	2890	69258	9.35	12.50	22	2.8185	102.1	129.791	95.1
	3	208	340	329.4	0.3036	5912	2948	70566	7.98	10.50	11	2.8525	100.1	137.093	97.1
	4	212	343	332.2	0.3010	5830	2857	72328	6.17	10.13	1	3.0790	102.1	144.395	95.1
1983	1	213	344	332.6	0.3007	5649	3311	74585	4.97	10.00	18	3.2252	101.8	148.445	96.5
	2	214	353	340.3	0.2939	5852	3384	74883	3.78	9.50	12	3.1699	100.2	152.495	98.0
	3	213	363	344.3	0.2904	6506	3541	77422	4.64	9.50	33	3.0200	105.5	156.545	98.6
	4	219	367	347.9	0.2874	6336	3281	78905	5.05	9.00	8	3.0944	104.4	160.596	98.9
1984	1	223	370	348.9	0.2866	6128	3527	80348	5.16	8.50	45	3.1997	103.7	162.946	98.7
	2	223	376	355.9	0.2810	6500	3896	80924	5.14	9.25	97	3.1077	103.9	165.297	99.1
	3	225	385	358.0	0.2793	6949	3686	82052	4.71	10.50	74	3.1005	104.4	167.648	98.5
	4	235	387	366.4	0.2729	6626	3522	85209	4.84	9.50	118	3.2251	102.8	169.999	97.3
1985	1	233	392	367.8	0.2719	6558	3673	86761	5.52	13.50	27	3.3410	105.4	169.456	97.8
	2	246	398	383.5	0.2608	6851	4099	88493	6.96	12.50	16	3.2725	105.1	168.912	100.0
	3	241	407	386.7	0.2586	7248	3769	90323	6.32	11.50	3	3.2350	104.8	168.369	101.1
	4	250	408	388.4	0.2575	7194	3803	91480	5.52	11.50	4	3.2769	107.4	167.825	101.0
1986	1	242	409	390.2	0.2563	6814	3996	93715	4.94	11.50	8	3.4077	105.5	168.783	102.3
	2	246	413	395.6	0.2528	7435	4472	94881	2.77	10.00	15	3.3250	108.5	169.742	105.2
	3	252	421	394.9	0.2532	7952	4567	96227	2.61	10.00	1	3.2795	109.9	170.701	106.8
	4	249	424	399.6	0.2503	7922	4074	99071	3.41	11.00	9	3.2372	111.8	171.660	105.6
1987	1	260	428	405.6	0.2465	7965	4796	101157	3.94	10.00	5	3.2092	114.0	172.518	105.4
	2	257	433	412.9	0.2422	8264	5232	103068	4.19	9.00	4	3.1071	109.5	173.377	107.7
	3	259	443	414.1	0.2415	9086	7120	107055	4.31	10.00	9	2.9065	112.9	174.236	107.3
	4	279	446	419.8	0.2382	9265	4971	108698	4.12	8.50	4	2.7514	116.8	195.095	106.7
1988	1	289	450	419.4	0.2384	9507	6542	112703	3.36	8.50	4	2.7222	118.1	209.076	107.7
	2	295	456	429.9	0.2326	9879	6442	115121	4.25	9.50	7	2.5350	115.2	210.125	107.6
	3	306	468	434.8	0.2300	10439	6479	119205	5.45	12.00	3	2.3267	114.3	217.076	108.6
	4	311	474	447.8	0.2233	10921	6836	122523	6.52	13.00	1	2.1189	111.5	219.076	107.5
1989	1	325	482	450.6	0.2219	11971	6994	124932	7.71	13.00	13	2.0773	114.4	186.782	107.5
	2	325	490	464.8	0.2151	11437	7588	126221	8.19	14.00	57	1.8836	118.9	191.547	107.2
	3	335	506	469.2	0.2131	11886	6430	127582	7.71	14.00	43	1.7714	115.3	196.311	107.8
	4	327	510	478.0	0.2092	11880	6194	131075	7.58	15.00	14	1.6358	125.3	201.076	106.1
1990	1	327	514	485.4	0.2060			134161	7.70	15.00	1	1.6870			106.7
	2	318	526	510.1	0.1960			136489	9.63	15.00	1	1.6363			108.6
	3	308	542	520.0	0.1923			137363	10.43	15.00		1.6236			107.5
	4	294	546	528.3	0.1893				9.43	14.00					105.6

Data used for the research Contd

		ASI	IOP	AEA	PPI	SER	CTX	GPH	MSS	ICP	UTC	GDF
				Index					Million		%	Index
1974	1	118.3	85.6	29.2	28.4		140	310	35226	3134	29	25.9
	2	105.3	93.0	29.8	30.1		194	332	35812	3163	49	27.5
	3	76.9	92.9	32.3	31.4		387	355	36424	2907	47	28.8
	4	66.9	89.4	35.1	33.1		266	373	38663	3450	45	30.6
1975	1	118.3	88.2	39.3	35.2	131.2	282	400	38228	3376	40	32.9
	2	128.2	84.7	40.5	37.4	127.0	176	419	38192	2948	30	35.4
	3	144.7	83.4	43.3	38.7	122.3	243	435	39505	2809	25	37.0
	4	158.1	85.0	43.8	40.1	119.1	198	458	40100	3857	27	38.4
1976	1	164.6	86.1	44.6	41.4	117.7	260	480	39769	3668	23	39.6
	2	155.4	87.7	45.4	43.0	108.0	195	495	41083	3646	24	40.7
	3	135.0	87.6	46.6	44.7	105.4	269	511	42986	3781	28	41.8
	4	152.0	91.1	46.8	46.8	97.1	242	539	43973	5288	32	43.3
1977	1	176.5	93.3	47.8	49.3	100.7	308	554	42757	5380	35	44.9
	2	190.7	92.7	48.8	51.4	100.5	239	565	44392	5138	34	46.7
	3	224.4	92.2	49.5	53.1	100.7	330	582	45716	5176	34	47.8
	4	214.5	92.5	50.9	54.0	102.9	288	604	48105	5834	31	48.9
1978	1	205.3	92.8	52.6	55.4	105.0	349	637	49359	5804	34	50.5
	2	210.7	95.6	53.9	56.6	99.2	247	659	51141	5969	34	52.0
	3	228.3	96.4	54.7	57.8	100.1	410	679	52800	6053	35	52.9
	4	220.2	96.2	56.3	58.7	99.6	317	694	55454	6690	40	54.2
1979	1	266.3	96.6	58.9	60.2	101.6	406	718	55176	6668	39	56.0
	2	247.9	101.2	59.2	62.3	106.9	331	759	57942	7846	45	57.6
	3	254.7	99.1	63.2	64.5	111.9	364	794	59877	7775	49	62.0
	4	229.8	99.1	66.2	66.2	107.7	343	823	62746	8980	40	64.3
1980	1	240.4	97.5	69.9	69.2	113.1	793	853	62345	8874	37	67.3
	2	269.5	93.8	74.5	71.9	115.5	292	873	66897	8003	30	70.4
	3	290.3	90.4	78.3	73.3	118.3	525	904	69646	6798	25	73.2
	4	292.0	88.3	81.0	74.3	123.6	421	927	74346	7617	45	75.8
1981	*1*	*309.7*	*88.3*	*81.4*	*76.3*	*127.1*	*585*	*949*	*73646*	*7179*	*16*	*77.6*
	2	320.6	88.8	82.6	78.8	122.7	290	956	78226	7786	17	79.0
	3	278.5	90.1	83.7	79.8	114.1	470	980	71456	8224	21	80.3
	4	313.1	91.1	85.3	81.4	112.2	527	1009	84592	9550	23	82.4
1982	1	326.6	90.3	86.2	83.5	114.3	706	1021	84305	7864	23	84.0
	2	322.8	91.9	87.0	84.9	113.4	442	1055	87349	9213	23	85.0
	3	361.8	91.9	87.4	85.7	115.0	572	1071	88873	9134	25	86.5
	4	382.2	91.1	88.3	86.7	112.2	394	1101	92113	10859	24	88.1
1983	1	411.9	93.0	89.3	87.9	101.3	814	1140	94677	10401	24	89.2
	2	458.3	94.0	90.1	89.6	106.3	309	1140	98025	9933	27	89.3
	3	445.5	94.9	90.9	90.3	107.6	451	1186	99124	11034	33	90.8
	4	470.5	96.7	91.5	91.5	105.8	275	1207	101658	12325	35	92.3
1984	1	524.2	97.2	91.1	93.0	104.1	1083	1231	101958	12230	35	92.6
	2	487.7	94.3	94.1	94.9	101.7	400	1234	105535	12236	40	94.2
	3	535.9	93.2	96.0	95.5	99.9	755	1256	107767	11730	46	95.0
	4	592.9	94.9	98.1	96.5	96.6	624	1306	111956	14538	45	96.4
1985	1	616.2	97.7	97.9	98.2	92.9	1370	1335	114079	15236	46	97.8
	2	595.5	101.8	98.5	99.9	101.0	496	1360	118018	13717	46	99.4
	3	626.2	100.6	101.3	100.5	104.6	1021	1372	122956	12847	54	100.7
	4	682.9	99.6	102.3	101.4	101.4	978	1384	126976	15302	51	102.1
1986	1	810.5	101.1	103.9	102.8	95.0	1313	1420	133378	11837	46	120.2
	2	815.7	101.8	105.3	104.2	96.1	720	1434	140326	11807	43	103.2
	3	768.8	102.6	106.0	104.6	90.2	1143	1459	146486	13059	51	103.7
	4	835.5	103.0	106.9	105.5	85.1	1041	1490	151030	15310	50	105.0
1987	1	1000.0	103.6	107.7	106.9	86.7	1551	1521	159483	14693	49	106.3
	2	1153.1	105.3	109.0	108.0	90.4	868	1554	167901	14674	50	108.1
	3	1208.8	106.7	110.2	108.6	90.5	1323	1605	175885	15279	55	109.4
	4	870.2	107.7	112.4	109.8	92.7	1119	1653	185435	16813	58	111.1
1988	1	896.8	107.9	114.3	111.0	93.5	1629	1690	192838	15764	63	112.4
	2	963.0	109.7	116.1	112.6	96.6	1064	1715	201829	16125	67	115.1
	3	946.3	110.8	117.8	113.9	95.2	1615	1779	215597	17015	69	117.0
	4	926.6	109.9	121.1	115.2	95.7	1385	1833	223418	20166	69	119.5
1989	1	1076.1	109.7	123.5	116.8	97.1	2139	1880	233333	18158	69	121.6
	2	1101.7	109.5	128.1	118.2	93.6	1321	1909	270790	17504	65	123.7
	3	1169.5	110.5	130.7	119.7	91.7	1747	1910		16816	62	124.0
	4	1204.7	110.6	133.8	121.2	88.1	1653	1973		18864	56	126.5
1990	1		110.3	137.1	123.1	88.1	2624	2009		17324	57	128.8
	2		113.0	141.2	125.7	88.6	1463	2048		16748	52	129.7
	3		108.3	145.2		94.2		2079		16459		
	4		106.6	148.1		94.2		2086				

APPENDIX B

Choice of Software for Regression Analysis

CHOICE OF SOFTWARE FOR REGRESSION ANALYSIS

Two software have been used for the analyses reported in this thesis: NAG FORTRAN and Statistical Package for the Social Sciences (SPSS-X). These two software are available on the University of Salford Prime Computer Network.

1. NAG FORTRAN Program

Fortran program as shown below was written that utilised NAG FORTRAN Library. The NAG FORTRAN library is a comprehensive collection of algorithms for the solution of numerical problems on computers. There are various subject areas (NAG chapters) covered by the NAG FORTRAN Library.

Specific Nag program used for analysis in this thesis is G02CJF under "Correlation and Regression Analysis" NAG chapter. G02CJF performs one or more multiple regressions, regressing each of a set of dependent variables separately on the same set of independent variables. Input to the routine is in the form of raw data. Output includes, for each dependent variable, estimates of the regression coefficients, and an estimate of the variance of residuals.

NAG FORTRAN Library Manual Volume 10 provides descriptions of issues involved in regression analysis, choice of parameters and a prototype programm capable of performing one regression.

G02CJF is a general routine, enabling several regressions to be performed using the same independent variables data matrix x. This attribute was used in the development of the program used in this thesis. The essence of the multiple regression program, shown below, was to combine possible leads of independent variables and produce the combination in order of minimum mean squared error. Therefore, the program was written such that each independent variable had an integer range of 0 to 8 lead periods. A total of 9^v regression models is produced during a complete run of the program (v = number of independent variables that take on integer range 0 to 8 lead periods). The program shown below has 6 independent variables (BCI, PRO, FRM, RIR, EMP and GNP) with TPI as the dependent variable. With these 6 independent variables, 531441 separate regression models would be examined in a complete run of the program.

The essence of the model is to produce the model that suit our theoretical expectation in terms of lead period. The program was written such that only the consecutive model whose mean squared error is lower the previously printed mean squared error is printed. Our considerations for the choice of the best model is the one that meets all the following conditions thus:

1. minimum mean squared error
2. maximum number of cases or set of observations on which the regression is based
3. consistently produces a lead period for each variable in relation to the other models.
4. the lead relationships being theoretically reasonable.

NAG FORTRAN Program

```
      Program Akin1
*
*     Time series regression on indexes
*
      Implicit double precision (A-H,O-Z)
*
      PARAMETER (IX=60,M=7,IY=60,IR=1,IT=7,IC=60,N=60,LIMIT=8)
      DIMENSION X(IX,M),Y(IY,IR),THETA(IT,IR),SIGSQ(IR),C(IC,M),
     *WK1(M,4),WK2(N),IPIV(M),Z(IX,M),Y1(IY,IR)
*
      OPEN ( 60,FILE='DATM',STATUS='OLD')
*
      XOUT=500
      DO 200 I =1,N
      READ(60,151)TPI,BCI,RPI,DEF,PUT,WKL,
     *GNP,FLA,BBR,STR,EMP,PRO,FRM,PANUPC,DBETP,DBEBC,OIL
151   FORMAT (2F3.0,F5.1,F5.4,F6.0,F5.0,F7.0,2F5.2,
     *F4.0,F6.4,F5.1,F7.0,F5.1,F4.0,F3.0,F1.0)
      X(I,1)=1.
      X(I,2)=LOG(BCI*DEF)
      Y(I,1)=LOG(TPI*DEF)
      X(I,3)=LOG(STR)
      X(I,4)=LOG(PRO)
      X(I,5)=LOG(FRM)
      X(I,6)=LOG(PANU)
      X(I,7)=(BBR-FLA)
      X(I,8)=LOG(UNEMP)
      X(I,9)=LOG(GNP*DEF)
      X(I,10)=OIL
200   CONTINUE
      CLOSE(60)
```

```
      PRINT *,'DATA IN'
      PRINT *,'BC  ST  PR  FM  MA  BB  EM  GP   OL   SEE'
*
      DO 241 LIM1=0,0
      DO 242 LIM2=0,LIMIT
      DO 243 LIM3=2,2
      DO 244 LIM4=0,LIMIT
      DO 245 LIM5=0,LIMIT
      DO 246 LIM6=0,LIMIT
      DO 247 LIM7=0,LIMIT
      DO 248 LIM8=0,0
      DO 249 LIM9=1,1
      ISMALL=LIM1
      IBIG=LIM1
      IF(LIM2.LT.ISMALL)ISMALL=LIM2
      IF(LIM2.GT.IBIG)IBIG=LIM2
      IF(LIM3.LT.ISMALL)ISMALL=LIM3
      IF(LIM3.GT.IBIG)IBIG=LIM3
      IF(LIM4.LT.ISMALL)ISMALL=LIM4
      IF(LIM4.GT.IBIG)IBIG=LIM4
      IF(LIM5.LT.ISMALL)ISMALL=LIM5
      IF(LIM5.GT.IBIG)IBIG=LIM5
      IF(LIM6.LT.ISMALL)ISMALL=LIM6
      IF(LIM6.GT.IBIG)IBIG=LIM6
      IF(LIM7.LT.ISMALL)ISMALL=LIM7
      IF(LIM7.GT.IBIG)IBIG=LIM7
      IF(LIM8.LT.ISMALL)ISMALL=LIM8
      IF(LIM8.GT.IBIG)IBIG=LIM8
      IF(LIM9.LT.ISMALL)ISMALL=LIM9
      IF(LIM9.GT.IBIG)IBIG=LIM9
      NROWS=N
      IF(IBIG.GT.0)NROWS=NROWS-IBIG
      IF(ISMALL.LT.0)NROWS=NROWS+ISMALL
      ISTART=IBIG+1
```

```
*
      IPT=ISTART
      IPT1=ISTART-LIM1
      IPT2=ISTART-LIM2
      IPT3=ISTART-LIM3
      IPT4=ISTART-LIM4
      IPT5=ISTART-LIM5
      IPT6=ISTART-LIM6
      IPT7=ISTART-LIM7
      IPT8=ISTART-LIM8
      IPT9=ISTART-LIM9
*
      DO 500 I=1,NROWS
      Y1(I,1)=Y(IPT,1)
      Z(I,1)=X(IPT,1)
      Z(I,2)=X(IPT1,2)
      Z(I,3)=X(IPT2,3)
      Z(I,4)=X(IPT3,4)
      Z(I,5)=X(IPT4,5)
      Z(I,6)=X(IPT5,6)
      Z(I,7)=X(IPT6,7)
      Z(I,8)=X(IPT7,8)
      Z(I,9)=X(IPT8,9)
      Z(I,10)=X(IPT9,10)
*
      IPT=IPT+1
      IPT1=IPT1+1
      IPT2=IPT2+1
      IPT3=IPT3+1
      IPT4=IPT4+1
      IPT5=IPT5+1
      IPT6=IPT6+1
      IPT7=IPT7+1
      IPT8=IPT8+1
```

```
      IPT9=IPT9+1
  500 CONTINUE
*
*
      IFAIL=0
      CALL G02CJF(Z,IX,Y1,IY,NROWS,M,IR,THETA,IT,SIGSQ,C,IC,
     *IPIV,WK1,WK2,IFAIL)
      IF(SIGSQ(1).GE.XOUT)GOTO 249
      XOUT=SIGSQ(1)
      WRITE(1,102)LIM1,LIM2,LIM3,LIM4,LIM5,LIM6,LIM7,LIM8,
     *LIM9,SIGSQ(1),THETA(1,1),THETA(2,1),THETA(3,1),
     *THETA(4,1),THETA(5,1),THETA(6,1),THETA(7,1),THETA(8,1),
     *THETA(9,1),THETA(10,1),NROWS
  102 FORMAT(I3,8I4,F9.5,F7.3,9F7.3,I4)
  249 CONTINUE
  248 CONTINUE
  247 CONTINUE
  246 CONTINUE
  245 CONTINUE
  244 CONTINUE
  243 CONTINUE
  242 CONTINUE
  241 CONTINUE
      END
```

2. Statistical Package for the Social Sciences (SPSS-X)

SPSS-X is a comprehensive package for managing, analyzing and displaying data. SPSS-X can take data from a file and turn it into meaningful information, for example, results from a variety of statistical procedures, plots of distribution, and tabulated reports. A new version of this software is SPSS-X Trends™ which is a comprehensive set of procedures for analyzing and forecasting time series.

These two software (SPSS-X and SPSS-X Trends™) were used in the univariate and multivariate statistical analysis of data. The models identified using the NAG FORTRAN Library were crosschecked using the SPSS-X statistical packages. This latter analysis sorted out statistical information on coefficients and significance levels of the explanatory variables, beta coefficients and analysis of residuals.

APPENDIX C

Ordinary Least Square (OLS) Regression Analysis

ORDINARY LEASE SQUARE (OLS) REGRESSION ANALYSIS

Regression analysis generally

Regression analysis provides two useful tools: summarizes or explains the actual (historical) economic phenomenon and\or predicts future economic phenomenon. This could be classified into two basic groups: univariate and multivariate analyses. Univariate analysis comprises of two variables and is usually regarded as two-variable function. In this case one variable depends on the other. A model based on this is two-variable linear model. An example of such model is as follows:

$$Y = a + bX + U$$

Where a and b are unknown parameters: a indicates the intercept, b is the slope of the function. Y depends on X and hence, regarded as the dependent variable while X is independent variable. U is the random disturbance or error term and this represents error that cannot be explained by the equation. Such random error could be due to sampling error, the model specification error, data measurement error. However, the smaller and random this error term, the better the dependent variable is explained by the independent variable.

Where the dependent variable is explained by more than one variable we have multiple regression analysis. An example is shown as follows:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + U$$

In this case Y depends on three independent variables: X_1, X_2, and X_3. B_1, B_2, and B_3 are regarded as regression coefficient of X_1, X_2, and X_3 in relation to Y and B_0

is the intercept for a population. The regression fitted to a sample of n observations from the population could be represented as shown below:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + u$$

b_0, b_1, b_2, and b_3 are regarded as the OLS estimates of B_0, B_1, B_2, and B_3 in the population model.

Statistical assumptions of OLS regression analysis

Six statistical assumptions are made in linear regression models and they are desirable properties of the OLS estimates of B_0, B_1, B_2, and B_3 thus:

1. $E(U_i) = 0$ for all $i = 1, 2, \ldots . n$

The population residuals are random variable with a zero expected value (mean) and the *ith* sample observation of size n drawn from the population must have the property.

2. $Var(U_i) = \delta^2$ for all $i = 1, 2, \ldots . n$

The variance of the error term for each observation is expected to be constant.

3. $Covar(U_iU_j) = 0$ for all $i, j = 1, 2, \ldots . n$

This assumes that various values of error term are uncorrelated to each other, that is, there is no connection between any pair of residuals U_i, U_j.

4. $E(X_iU_i) = 0$ for all $i = 1, 2, \ldots n$

This assumes that there is no connection between any of the regressors and the residual.

5. $k + 1 < n$

This means that the number of parameter to be estimated must be less than numbers of observations, *n*. Opinion varies as to the number of observations required per independent variable: Ashworth (1981) suggested that 2.5 times the number of variables should equal the number of sets of data required. Bowen (1982) proposed a rule of thumb of 30 observations per independent variable in the equation especially where "normality" is being approximated. It is necessary to say that there is no consensus among econometricians on this although the number of parameter must be less than number of observations.

6. No exact linear relationship exists between two or more of the independent variables.

Properties of Estimators

Three properties of estimators are desirable: Unbiased, efficient and consistent estimators.

1. An estimator is unbiased if the mean of the sampling distribution coincides with the true parameter.

2. Also an estimator is best unbiased estimator or an efficient estimator when the spread of distribution (variance) about the mean is small. Hence, the smaller the variance the greater the accuracy of the estimator. This is associated confidence interval of the estimator.

3. An estimator b is consistent if it approaches the true B as the sample size increases.

However, it is generally regarded that OLS method generates efficient estimators among all available methods of estimation (Gujarati, 1979).

Determining 'goodness-of-fit' by the OLS method

Once a regression line has been fitted by the OLS method, it is therefore necessary to determine how 'good' is the fit of the line to the sample data. Some measures of the goodness of the fit are usually available: mean squared error, coefficient of determination, regression coefficients being statistically significant at the 1% or 5% level and having the expected sign or magnitudes.

Where more than one lines are used to fit the sample data, the line with the minimum mean squared error is desirable. Though this may incorporate element of bias in the estimator, it is desirable for forecasting purpose.

Coefficient of determination R^2 is another measure of the goodness of fit, based on the dispersion of observations around the regression line. This shows the percentage of the total variations of the dependent variable, which are explained by the variations in the explanatory variables over the sample period. This is expressed as follows:

$$R^2 = \frac{\Sigma (Y_i - Y)^2}{\Sigma (Y_i - Y)^2} = 1 - \frac{\Sigma U_i^2}{\Sigma (Y_i - Y)^2}$$

Where

$$Y = \frac{1}{n} \Sigma Y_i = \text{the sample mean of observations}$$

$\Sigma (Y_i - Y)^2$ = total variations around the sample mean

$\Sigma (Y_i - Y)^2$ = explained variation,

ΣU_i^2 = unexplained variation (residuals).

The close R^2 is to unity (1) the better, is the fit of the regression line to the scatter of observations. R^2 Adjusted is sometimes used. This is a transformation of R^2 that takes into account the degree of freedom for residual in the equation based on the number of regressors. The residual degree of freedom fall with the use of more regressors as the regression degree of freedom rise. This is accounted for by a fall of R^2 Adjusted. R^2 Adjusted is expressed as shown below:

$$R^2 \text{ Adjusted} = R^2 - (1 - R^2) \frac{k}{(n - k - 1)} \quad \text{where k regressors are used}$$

k = number of regressor (regression degree of freedom)
n = number of observations
n - k - 1 = residual degree of freedom

Key econometric problems

The estimation of OLS multiple linear regression models, generally involves a number of key econometric problems, which emerge as a result of the break-down of the assumptions concerning the regression model and the error term. These econometric problems are: serial correlation, multicollinearity and heteroscedasticity.

Multicollinearity

Multicollinearity occurs in a regression model when two or more independent variables tend to move together in the same pattern, in which case, they are highly correlated. This is more noticeable in time-series data. In a multiple regression models it leads to a situation where the regression coefficients are indeterminants due to larger standard error of the coefficients than the case of no collinearity.

Rule of thumb to judging the degree of multicollinearity was suggested by Klein (1962). This indicates that if the R^2 between two independent variables is higher than the coefficients of determination of the entire regression equation, then the collinearity between these two variables may be a problem. Pindyck and Rubinfeld (1981) suggested an evidence of multicollinearity when several regression coefficients have high standard error, and the removal of one or more independent variables reduces the standard error of the remaining variables.

Hu (1982) has suggested some ways of solving problem multicollinearity including:

1. Collection of more data - it is assumed with more time-series data the phenomenon of close association between independent variables may be reduced.

2. Change the function form. This may be achieved in time-series data by taking a first difference of the variables, provided that the first difference of the variables are not themself highly correlated.

3. To either leave the variables in the function or to drop one of them from the model, which depends on the objection of the study. If the purpose of the model is for forecast the problem of multicollinearity may not warrant much attention.

Serial correlation

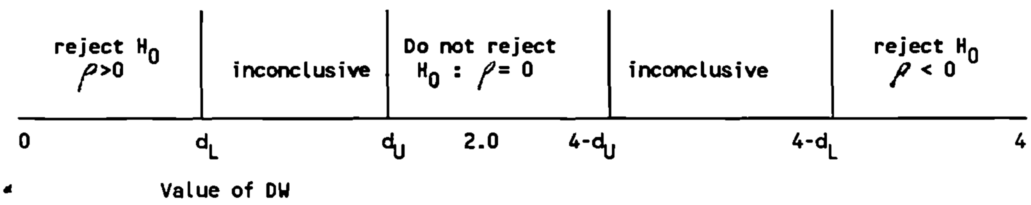
Serial correlation occurs when the error term in one period is related to error term in the next time period. This could be due to the influence of variable(s) omitted from a model or mis-specification of the functional form of the regression model. When this is present, the least squares estimators are no longer efficient.

Presence of serial correlation is detected, commonly, by Durbin-Watson test. Durbin-Watson test statistics is presented below:

$$DW = \frac{\sum_{t=2}^{n} (u_t - u_{t-1})^2}{\sum_{t=1}^{n} u_t^2}$$

Where u is the estimated residual based on OLS analysis

The technique is discussed by Durbin and Watson (1951). Hu (1982) produces a diagram to summarise the critical values of this test statistics. This is shown below.



Source: HU, *Econometrics: An Introductory Analysis*, 2nd Edt. 1982, pp. 94

The null hypothesis of the DW test is lack of serial correlation among error terms, that is $\rho = 0$. The statistics is often biased towards the value of 2. When DW is close to 0, it is an evidence of positive serial correlation; when close to 2 no significant serial correlation, positive or negative is concluded; and when close to 4, it is an evidence of negative serial correlation.

Heteroscedasticity

Heteroscedasticity occurs where the residuals do not have constant variance and this affects the efficiency of estimated regression coefficients, that is, the variance of the estimated coefficient.

This is mostly detected by plotting the residuals (U) against the dependent variable and examine the pattern form by this scatter plot. Other methods of testing for heteroscedasticity are produced by Goldfeld and Quandt (1965) and Glejser (1969).

Method of correcting or reducing the problem of heteroscedasticity is the use of generalised least-squares method (known as weighted regression). Another method is to change the functional form of the regression.

Analysis of Residuals

The residuals are the differences between the actual or observed dependent variables and their corresponding estimated dependent variables. These constitute the observed dependent variables that are not explained by OLS regression model. The residuals are not expected to have pattern (randomly scattered) if the OLS regression model is fitted correct ($E(U_i) = 0$, $Var(U_i) = \delta^2$). Also, it is expected that the residuals are normally distributed.

For a model to be accepted it is essential that the residuals meet all the assumptions of OLS regression analysis and absorbed of the key econometric problems. Investigation of these assumptions calls for analysis of residuals. Methods of analysis of residuals include the following:

Statistics

This includes Durbin-Watson Test and determining the minimum, maximum, mean and standard deviation of twelve variables as follows:

PRED	Unstandardized predicted values
RESID	Unstandardized residuals
DRESID	Deleted residuals
ADJPRED	Adjusted predicted values
ZPRED	Standardized predicted values
ZRESID	Standardized residuals
SRESID	Studentized residuals
SDRESID	Studentized deleted residuals
SEPRED	Standard errors of the predicted values
MAHAL	Mahalanobis' distance
COOK	Cook's distances
LEVER	Leverage values

From the information on the mean and standard deviation of these twelve temporary variables it may be possible to determine if the residuals meet some of the assumptions of the OLS regression analysis. For example, leverage values reveal multivariate outliers, which can not be revealed like in univariate outliers using scatter plot of residuals. Leverage values provide the extent of leverage influence of the observed dependent variable on estimated dependent variable. Diagonal element of the hat matrix (Hoaglin and Welsch, 1978) sums up all the leverage points of residuals produced by a model. In multivariate analysis a residual is considered to have high-leverage points if its leverage point is greater than the mean of leverage values multiplied by two.

Residuals plotting

Residuals plotting includes the scatterplot of residuals against dependent, independent and estimated dependent variables; and a normal probability plot. Anscombe (1973) has discussed and illustrated some of these. However, it is expected that the scatterplot of the residuals against dependent, independent or estimated dependent variable should be randomly scattered without any specific pattern. This is the most common way of examining the residuals pattern.

APPENDIX 3.1

Questionnaires completed by the eight organisations

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?

   1961

3. How many quarters ahead do you forecast tender price level?

   8

4. Do you have specific model(s) which ~~form the basis for~~ provide guidance your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [✓] NO [ ]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
       Linear [✓]
       Exponential [ ]
   (b) Moving averages [ ]
   (c) Auto Regression (time series analysis)
       Univariate (Box-Jenkins analysis) [ ]
       Multivariate [ ]
   (d) Others ________

5. If **NO**, what form the basis for your tender price forecast?

   ____

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [✓] NO [ ]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   In the MG - Contr Orders and Output.
   In the Judg Adj - factors listed in 10)

8. Do you monitor the accuracy of your published forecast?

   Always [ ] Sometimes [✓] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [ ] Harmful [ ] Not sure [✓]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[✓]
Corporation tax	[ ]	[ ]
Others: Inflation		✓
Non financial variables		
Construction new-order	[✓]	[ ]
Construction output	[✓]	[ ]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[✓]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[ ]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[✓]
Industrial Production	[ ]	[ ]
Others: Contractors State of Trade Enq		✓
Merchants Sales		✓
Housing Starts		✓
Prices		
Lagged TPI	[ ]	[ ]
All share index	[ ]	[ ]
Building cost trend	[✓]	[ ]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[ ]
Others		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

The reaction to changes in demand
The speed of changes in demand

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ] High [ ] Fairly high [ ] Low [✓] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends? Demand

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?
   Informally for many years, formally for 14 months

3. How many quarters ahead do you forecast tender price level?
   14 – 16 quarters

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [ ] NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
      Linear [ ]
      Exponential [ ]
   (b) Moving averages [ ]
   (c) Auto Regression (time series analysis)
      Univariate (Box-Jenkins analysis) [ ]
      Multivariate [ ]
   (d) Others ______

5. If **NO**, what form the basis for your tender price forecast?
   A review of trends in cost inflation tempered by a judgement of future market conditions based upon consideration of wider economic factors.

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [ ] N/A.

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?
   N/A

8. Do you monitor the accuracy of your published forecast?

   Always [✓] Sometimes [ ] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [✓] Harmful [ ] Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL N/A	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[✓]
Corporation tax	[ ]	[ ]
Others ______		
Non financial variables		
Construction new-order	[ ]	[✓]
Construction output	[ ]	[✓]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[✓]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[ ]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[✓]
Industrial Production	[ ]	[ ]
Others Discussions with contractors.		
Prices		
Lagged TPI	[ ]	[✓]
All share index	[ ]	[ ]
Building cost trend	[ ]	[✓]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[ ]
Others ______		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

Delays in availability of up to date indices
Speed in which changes in market conditions can change tender levels

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [✓] High [ ] Fairly high [ ] Low [ ] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends?

Mainly the items listed in 10 together with personal experience of market conditions.

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

YES [✓]   NO [ ]

2. Since when has your organisation involved in this monitoring?

PRE 1975

3. How many quarters ahead do you forecast tender price level?

3 for publication 20 internally

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

YES [ ]   NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

(a) Regression model (causal analysis)
  Linear [ ]
  Exponential [ ]
(b) Moving averages [ ]
(c) Auto Regression (time series analysis)
  Univariate (Box-Jenkins analysis) [ ]
  Multivariate [ ]
(d) Others ______

5. If **NO**, what form the basis for your tender price forecast?

Subjective assessment of market trends

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

YES [ ]   NO [ ]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

______

8. Do you monitor the accuracy of your published forecast?

Always [ ]   Sometimes [✓]   Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

Helpful [✓]   Harmful [ ]   Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	**TPIJUD -ADJU**
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[✓]
Corporation tax	[ ]	[ ]
Others ______		
Non financial variables		
Construction new-order	[ ]	[✓]
Construction output	[ ]	[✓]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[✓]
Unemployment level (or rate)	[ ]	[✓]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[✓]
Gross National Product	[ ]	[✓]
General public expenditure	[ ]	[✓]
Industrial Production	[ ]	[✓]
Others [illegible]		
Prices		
Lagged TPI	[ ]	[✓]
All share index	[ ]	[ ]
Building cost trend	[ ]	[✓]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[✓]
Others ______		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

[illegible]

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ] High [ ] Fairly high [ ] Low [✓] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends?

[illegible]

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring? 1988

   ____

3. How many quarters ahead do you forecast tender price level? 4 Qtrs + 2 Years

   ____

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [✓] NO [ ]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
       Linear [ ]
       Exponential [ ]
   (b) Moving averages [ ]
   (c) Auto Regression (time series analysis)
       Univariate (Box-Jenkins analysis) [ ]
       Multivariate [ ]
   (d) Others Cost Models

5. If **NO**, what form the basis for your tender price forecast?

   ____
   ____
   ____

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [✓]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   ____
   ____

8. Do you monitor the accuracy of your published forecast?

   Always [✓] Sometimes [ ] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [ ] Harmful [ ] Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	**TPIJUD -ADJU**
Financial variables		
Interest rate	[ ]	[ ]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[ ]
Corporation tax	[ ]	[ ]
Others The views of 300 or so contractors + specialists which we obtain confidentially.		
Non financial variables		
Construction new-order	[ ]	[ ]
Construction output	[ ]	[ ]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[ ]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[ ]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[ ]
Industrial Production	[ ]	[ ]
Others ______		
Prices		
Lagged TPI	[ ]	[ ]
All share index	[ ]	[ ]
Building cost trend	[ ]	[ ]
Retail price index	[ ]	[ ]
Producer price index	[ ]	[ ]
Others ______		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?
Tendency of contractors to bid at prices below the level of profitability

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ]   High [ ]   Fairly high [ ]   Low [ ]   V.Low [✓]

13. What major factors do you consider as determining your construction market condition trends?
Market competitiveness
Contractors tendency to press claims where bids to low.

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?

   1987

3. How many quarters ahead do you forecast tender price level?

   8

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [ ] NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
   - Linear [ ]
   - Exponential [ ]

   (b) Moving averages [ ]

   (c) Auto Regression (time series analysis)
   - Univariate (Box-Jenkins analysis) [ ]
   - Multivariate [ ]

   (d) Others ________________

5. If **NO**, what form the basis for your tender price forecast?

   Major Contractors' predictions based on a telephone survey and BCIS predictions.

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [✓]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   ____

8. Do you monitor the accuracy of your published forecast?

   Always [✓] Sometimes [ ] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [✓] Harmful [ ] Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[ ]
Corporation tax	[ ]	[ ]
Others ____________		
Non financial variables		
Construction new-order	[ ]	[✓]
Construction output	[ ]	[ ]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[ ]
Unemployment level (or rate)	[ ]	[✓]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[ ]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[ ]
Industrial Production	[ ]	[ ]
Others ____________		
Prices		
Lagged TPI	[ ]	[ ]
All share index	[ ]	[ ]
Building cost trend	[ ]	[✓]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[ ]
Others ____________		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?
Lack of accurate historic data & forecast data

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ]   High [ ]   Fairly high [ ]   Low [✓]   V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends? Mainly the amount of demand in the industry and the industry's capability of responding.

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?

   UNKNOWN (I HAVE ONLY BEEN HERE 4 MONTHS)

3. How many quarters ahead do you forecast tender price level?

   8

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [ ] NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
   - Linear [ ]
   - Exponential [ ]

   (b) Moving averages [ ]

   (c) Auto Regression (time series analysis)
   - Univariate (Box-Jenkins analysis) [ ]
   - Multivariate [ ]

   (d) Others ______

5. If **NO**, what form the basis for your tender price forecast?

   BASED [illegible] RETURNS OF [illegible] MACRO ECONOMIC FACTORS

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [✓]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   [illegible]

8. Do you monitor the accuracy of your published forecast?

   Always [ ] Sometimes [✓] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [ ] Harmful [ ] Not sure [✓]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model (TPIMG-MODL) and factors which are considered in your judgemental adjustment (TPIJUD-ADJ). They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[✓]
Corporation tax	[ ]	[ ]
Others: INFLATION RATES		✓
Non financial variables		
Construction new-order	[ ]	[✓]
Construction output	[ ]	[✓]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[✓]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[ ]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[ ]
Industrial Production	[ ]	[ ]
Others: [illegible]		✓
Prices		
Lagged TPI	[ ]	[✓]
All share index	[ ]	[ ]
Building cost trend	[ ]	[✓]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[✓]
Others		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

QUANTIFYING CONFIDENCE - IN THE ECONOMY IN THE INDUSTRY IN THE [illegible] OF THE GOVERNMENT [illegible]

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ] High [ ] Fairly high [✓] Low [ ] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends? WORKLOAD IN THE INDUSTRY (OR THE PERCEPTION THEREOF)

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL

Please tick/fill as appropriate to the practice of your organisation.

MONK DUNSTONE ASSOCIATES

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?

   Early '80s

3. How many quarters ahead do you forecast tender price level?

   18 Qtrs

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [ ] NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
       Linear [ ]
       Exponential [ ]
   (b) Moving averages [ ]
   (c) Auto Regression (time series analysis)
       Univariate (Box-Jenkins analysis) [ ]
       Multivariate [ ]
   (d) Others ______

5. If **NO**, what form the basis for your tender price forecast?

   [illegible]

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [ ]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   [illegible]

8. Do you monitor the accuracy of your published forecast?

   Always [ ] Sometimes [ ] Never [✓]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast?

   Helpful [ ] Harmful [ ] Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[✓]
Money supply	[ ]	[✓]
Sterling exchange rate	[ ]	[ ]
Corporation tax	[ ]	[ ]
Others ______________		
______________		
______________		
Non financial variables		
Construction new-order	[ ]	[✓]
Construction output	[ ]	[✓]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[ ]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[ ]
Construction productivity	[ ]	[redacted]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[ ]
Industrial Production	[ ]	[ ]
Others ______________		
______________		
______________		
Prices		
Lagged TPI	[ ]	[ ]
All share index	[ ]	[ ]
Building cost trend	[ ]	[ ]
Retail price index	[ ]	[ ]
Producer price index	[ ]	[ ]
Others ______________		
______________		
______________		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

[illegible]

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ] High [ ] Fairly high [ ] Low [ ] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends?

[illegible]

A SURVEY ON TRENDS AND ANALYSIS OF UK BUILDING PRICES

RESPONSE WILL REMAIN STRICTLY CONFIDENTIAL
Please tick/fill as appropriate to the practice of your organisation.

1. Do you monitor the quarterly trends in the tender price movement?

   YES [✓] NO [ ]

2. Since when has your organisation involved in this monitoring?

   CIRCA 1950

3. How many quarters ahead do you forecast tender price level?

   12

4. Do you have specific model(s) which form the basis for your tender price forecast (here-in called mechanically generated model-based forecast)?

   YES [ ] NO [✓]

5. If **YES**, which of the following system of mechanical generated model is your forecast based?

   (a) Regression model (causal analysis)
   Linear [ ]
   Exponential [ ]
   (b) Moving averages [ ]
   (c) Auto Regression (time series analysis)
   Univariate (Box-Jenkins analysis) [ ]
   Multivariate [ ]
   (d) Others ______

5. If **NO**, what form the basis for your tender price forecast?

   PROFESSIONAL JUDGEMENT

   WE HAVE TRIED MECHANICAL/STATISTICAL METHODS. WE FOUND THAT THEY TOOK MUCH LONGER TO COMPILE & WERE LESS ACCURATE

6. Is your published forecast a judgemental adjustment of the mechanically generated model-based forecast?

   YES [ ] NO [✓]

7. What do you consider in your mechanically generated model-based forecast before such judgemental adjustment is carried out?

   N/A

8. Do you monitor the accuracy of your published forecast?

   Always [✓] Sometimes [ ] Never [ ]

9. What has been the impact of the judgemental adjustment on the accuracy and usefulness of your published forecast? N/A

   Helpful [ ] Harmful [ ] Not sure [ ]

10. Please tick and add other factors which are built into your TPI forecast mechanically generated model **(TPIMG-MODL)** and factors which are considered in your judgemental adjustment **(TPIJUD-ADJ)**. They have been classified into three groups of variables (Financial, Non-financial and Prices).

	TPIMG -MODL	TPIJUD -ADJU
Financial variables		
Interest rate	[ ]	[ ]
Money supply	[ ]	[ ]
Sterling exchange rate	[ ]	[ ]
Corporation tax	[ ]	[ ]
Others INFLATION RATE		✓
Non financial variables		
Construction new-order	[ ]	[ ]
Construction output	[ ]	[ ]
Construction work stoppage (strike)	[ ]	[ ]
Architect commission	[ ]	[ ]
Unemployment level (or rate)	[ ]	[ ]
Number of registered construction firms	[ ]	[✓]
Construction productivity	[ ]	[✓]
Gross National Product	[ ]	[ ]
General public expenditure	[ ]	[✓]
Industrial Production	[ ]	[ ]
Others POLITICAL CLIMATE, STATE OF ECONOMY i.e EXPANDING/CONTRACTING (BOOM/RECESSION)		
Prices		
Lagged TPI	[ ]	[ ]
All share index	[ ]	[✓]
Building cost trend	[ ]	[✓]
Retail price index	[ ]	[✓]
Producer price index	[ ]	[ ]
Others		

11. What factors have you noticed as been responsible for difficulties in forecasting TPI?

THE SPEED WITH WHICH THE MARKET CAN TURN AROUND (IT CAN CHANGE WITHIN ONE QUARTER)

12. If your published tender price index (TPI) forecast is mainly determined by trends in input costs (i.e. building costs) and the trends in construction market condition, of what significance is building costs trends in the forecast

V. High [ ] High [ ] Fairly high [✓] Low [ ] V.Low [ ]

13. What major factors do you consider as determining your construction market condition trends?

INFLATION RATE
POLITICAL CLIMATE STATE OF ECONOMY

APPENDIX 4.1

Glossary on Economic Cycle

Glossary on Economic Cycle

Below figure is an illustration of the stages involved in the trade cycle. The glossary of the terms associated with cycle are presented and described as follows (Lipsey, 1989)

Trough: This is the time (or period) when the economy is at the lowest ebb or bottom characterised by high unemployment, low consumer demand in relation to the industrial capability, least confidence in the economy, low investment incentive and low profitability.

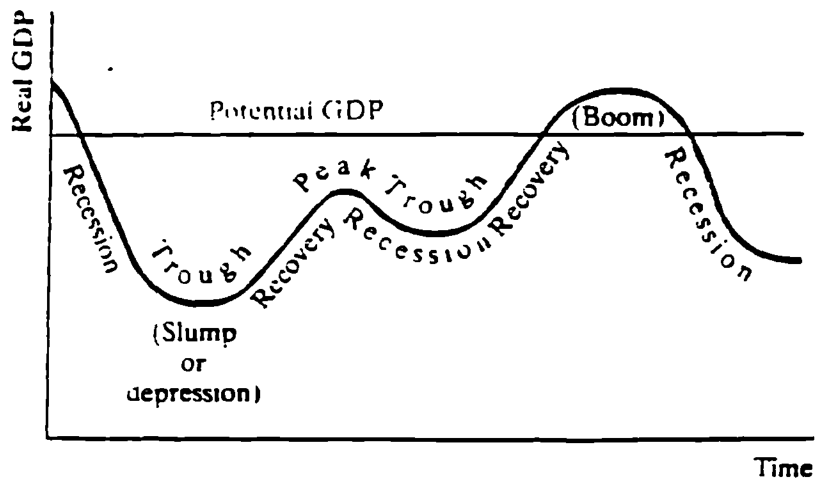
Recovery: This is a period following the trough. It is characterised by a rising confidence in the economy and a rise in the economic activities. The rise in the economic activities gear up the demands generally and a need for investment to replace the worn out machinery.

Peak: This is the time when the economic activity is at the top characterised by high degree of resources utilization and shortage of resources due to rising demand for goods and services. This period is also characterised by high cost of resources due to many industries completing for the same resources and inability of the output to meet the excessive demand in the short-run; and these engender a rising prices of goods and services. Nonetheless business is generally profitable during this period.

Recession: This often follows a peak and is characterised by falling demand, profit, investment, employment, household incomes and economic activity generally. It is a period of downward movement in the economic activity.

Boom and slumps: These are two terms generally used to represent the 'super' peak and depression in economy respectively.

A Stylized Trade Cycle



Adapted from Lipsey, R.G., 1989, *An Introduction to Positive Economics*, 7th Edition, London: Weidenfeld and Nicolson, pp. 635.

APPENDIX 6.1

Construction Demand: Actual, Predicted, Residuals
and Residuals Statistics

*: Selected M: Missing

Cases	NEWORDER	*PRED	*RESID	*SRESID	*SDRESID	*LEVER	*MAHAL	*COOK D
1	7.29	.	.	.	.	.	.	.
2	7.25	.	.	.	.	.	.	.
3	7.23	.	.	.	.	.	.	.
4	7.18	.	.	.	.	.	.	.
5	7.28	7.2290	.0465	1.1209	1.1239	.6452	35.4861	.4121
6	7.16	7.0741	.0846	1.2603	1.2679	.0993	5.4601	.0351
7	7.13	7.0784	.0479	.7287	.7253	.1353	7.4394	.0160
8	6.96	6.9561	1.8025E-03	.0302	.0299	.2861	15.7366	.0001
9	7.11	7.0950	.0141	.2159	.2138	.1449	7.9670	.0015
10	7.15	7.1036	.0472	.7218	.7183	.1453	7.9933	.0169
11	6.94	7.0001	-.0574	-.8689	-.8667	.1270	6.9865	.0213
12	6.83	6.9462	-.1209	-1.7929	-1.8348	.0908	4.9960	.0653
13	6.88	6.9138	-.0378	-.5616	-.5577	.0947	5.2066	.0067
14	6.96	6.9233	.0387	.5660	.5621	.0678	3.7277	.0050
15	6.93	6.9510	-.0203	-.3031	-.3003	.1028	5.6531	.0021
16	6.88	7.0271	-.1513	-2.2688	-2.3713	.1103	6.0666	.1261
17	7.02	7.0544	-.0340	-.4955	-.4917	.0619	3.4032	.0035
18	7.09	7.0667	.0220	.3153	.3125	.0256	1.4102	.0008
19	7.10	7.0467	.0579	.8645	.8623	.1042	5.7324	.0173
20	6.98	7.0631	-.0848	-1.2688	-1.2767	.1063	5.8439	.0380
21	6.97	7.0251	-.0556	-.8558	-.8535	.1561	8.5836	.0257
22	7.17	7.0756	.0970	1.4487	1.4652	.1034	5.6884	.0483
23	7.03	6.9916	.0362	.5486	.5447	.1277	7.0259	.0085
24	6.97	7.0043	-.0349	-.5056	-.5018	.0495	2.7226	.0031
25	6.93	6.9316	1.4440E-03	.0211	.0209	.0608	3.3464	.0000
26	6.96	6.9121	.0494	.7338	.7304	.0923	5.0787	.0111
27	6.83	6.8862	-.0515	-.7985	-.7955	.1669	9.1817	.0241
28	6.73	6.8619	-.1283	-1.8922	-1.9441	.0816	4.4855	.0659
29	6.83	6.8706	-.0414	-.6058	-.6020	.0663	3.6461	.0056
30	6.89	6.7975	.0893	1.3069	1.3165	.0679	3.7350	.0267
31	6.83	6.7777	.0544	.7893	.7863	.0527	2.9009	.0079
32	6.66	6.7526	-.0909	-1.3227	-1.3329	.0574	3.1583	.0237
33	6.77	6.7542	.0188	.2722	.2696	.0451	2.4823	.0008
34	6.79	6.7753	.0167	.2404	.2381	.0404	2.2242	.0006
35	6.80	6.7685	.0284	.4136	.4102	.0613	3.3694	.0024
36	6.76	6.7378	.0191	.2806	.2780	.0773	4.2540	.0014
37	6.90	6.8098	.0936	1.3632	1.3753	.0583	3.2073	.0255
38	6.90	6.8171	.0852	1.2390	1.2458	.0550	3.0223	.0201
39	6.94	6.8703	.0653	.9383	.9371	.0321	1.7669	.0077
40	6.85	6.8350	.0141	.2040	.2021	.0503	2.7665	.0005
41	6.92	6.8979	.0207	.2984	.2957	.0406	2.2343	.0009
42	7.00	6.9281	.0702	1.0127	1.0130	.0396	2.1761	.0104
43	6.94	6.9421	-5.2319E-03	-.0748	-.0741	.0239	1.3144	.0000
44	6.87	6.9355	-.0674	-.9616	-.9609	.0189	1.0384	.0059
45	6.91	6.9743	-.0678	-.9699	-.9693	.0240	1.3180	.0068
46	6.97	6.9154	.0591	.8543	.8520	.0432	2.3770	.0079
47	6.88	6.9352	-.0531	-.7575	-.7542	.0179	.9828	.0035
48	6.89	6.9308	-.0440	-.6323	-.6285	.0335	1.8424	.0036
49	6.93	6.9447	-.0130	-.1875	-.1857	.0370	2.0338	.0003
50	7.03	7.0028	.0276	.3941	.3907	.0216	1.1904	.0011
51	7.05	7.0186	.0344	.4915	.4878	.0225	1.2373	.0017
52	6.93	7.0692	-.1419	-2.0415	-2.1109	.0349	1.9181	.0387
53	7.08	7.0869	-.0118	-.1694	-.1678	.0326	1.7937	.0003
54	7.14	7.1408	3.7492E-03	.0553	.0547	.0802	4.4092	.0001
55	7.45	7.2594	.1904	2.8450	3.0764	.1042	5.7332	.1876
56	7.08	7.2143	-.1376	-2.0189	-2.0854	.0719	3.9571	.0670
57	7.35	7.3098	.0424	.6397	.6359	.1230	6.7638	.0112
58	7.31	7.3386	-.0265	-.3984	-.3950	.1180	6.4898	.0042
59	7.31	7.3396	-.0329	-.5006	-.4968	.1340	7.3694	.0075
60	7.33	7.2984	.0323	.4893	.4856	.1285	7.0664	.0068

APPENDIX 7.1

Construction Supply: Actual, Predicted, Residuals
and Residuals Statistics

*: Selected   M: Missing

Cases	CONSTRPUT	*PRED	*RESID	*SRESID	*SDRESID	*LEVER	*MAHAL	*COOK D
1	7.72	.	.	.	.	.	.	.
2	7.74	.	.	.	.	.	.	.
3	7.74	.	.	.	.	.	.	.
4	7.67	.	.	.	.	.	.	.
5	7.81	.	.	.	.	.	.	.
6	7.68	.	.	.	.	.	.	.
7	7.65	.	.	.	.	.	.	
8	7.60	.	.	.	.	.		.
9	7.58	7.5805	-5.2983E-03	-.1485	-.1469	.1540	7.8556	.0008
10	7.58	7.5613	.0231	.6391	.6349	.1325	6.7598	.0122
11	7.59	7.5386	.0520	1.4398	1.4573	.1348	6.8762	.0629
12	7.58	7.5343	.0497	1.3770	1.3910	.1336	6.8132	.0570
13	7.49	7.5004	-5.6352E-03	-.1490	-.1474	.0525	2.6795	.0003
14	7.51	7.5285	-.0165	-.4396	-.4357	.0642	3.2750	.0029
15	7.56	7.5381	.0218	.5773	.5730	.0543	2.7674	.0044
16	7.55	7.5428	4.1797E-03	.1198	.1185	.1903	9.7038	.0006
17	7.53	7.5788	-.0504	-1.3752	-1.3891	.1104	5.6305	.0469
18	7.63	7.6139	.0200	.5325	.5283	.0686	3.4988	.0046
19	7.66	7.6445	.0126	.3355	.3322	.0714	3.6425	.0019
20	7.63	7.6632	-.0366	-.9782	-.9777	.0708	3.6087	.0158
21	7.57	7.6473	-.0804	-2.1404	-2.2310	.0639	3.2593	.0692
22	7.69	7.6809	4.9312E-03	.1341	.1327	.1028	5.2418	.0004
23	7.71	7.7031	5.7712E-03	.1576	.1559	.1099	5.6041	.0006
24	7.70	7.7172	-.0173	-.4765	-.4724	.1206	6.1515	.0062
25	7.64	7.6459	-2.7574E-03	-.0787	-.0779	.1846	9.4138	.0003
26	7.64	7.6487	-3.7355E-03	-.1011	-.1000	.0948	4.8334	.0002
27	7.69	7.6371	.0551	1.4978	1.5189	.1013	5.1683	.0513
28	7.60	7.6286	-.0256	-.6735	-.6694	.0460	2.3449	.0053
29	7.54	7.5526	-.0119	-.3214	-.3183	.0953	4.8600	.0022
30	7.50	7.4793	.0257	.6983	.6944	.1025	5.2274	.0113
31	7.53	7.4680	.0664	1.8096	1.8572	.1067	5.4399	.0786
32	7.43	7.4165	.0134	.3601	.3567	.0848	4.3271	.0025
33	7.41	7.4761	-.0628	-1.7152	-1.7534	.1102	5.6207	.0729
34	7.45	7.4526	-2.1695E-03	-.0614	-.0607	.1693	8.6345	.0001
35	7.49	7.4652	.0275	.7389	.7352	.0824	4.2021	.0103
36	7.47	7.4606	9.4857E-03	.2548	.2522	.0810	4.1333	.0012
37	7.44	7.4671	-.0296	-.7734	-.7700	.0328	1.6705	.0055
38	7.45	7.4983	-.0482	-1.2871	-1.2966	.0689	3.5154	.0267
39	7.54	7.5227	.0213	.6353	.6312	.2531	12.9070	.0252
40	7.51	7.4866	.0205	.5434	.5392	.0575	2.9348	.0041
41	7.47	7.5081	-.0371	-.9790	-.9786	.0462	2.3574	.0112
42	7.51	7.4665	.0437	1.1532	1.1574	.0498	2.5387	.0164
43	7.57	7.5473	.0236	.6271	.6230	.0628	3.2006	.0059
44	7.50	7.5290	-.0289	-.7641	-.7606	.0499	2.5446	.0072
45	7.49	7.4909	-4.7402E-03	-.1318	-.1304	.1411	7.1966	.0006
46	7.49	7.5245	-.0364	-.9886	-.9883	.1010	5.1485	.0222
47	7.54	7.4925	.0435	1.2227	1.2295	.1599	8.1556	.0544
48	7.52	7.5613	-.0371	-1.0120	-1.0123	.1091	5.5639	.0251
49	7.47	7.5554	-.0900	-2.3672	-2.4985	.0413	2.1054	.0602
50	7.54	7.5967	-.0579	-1.5309	-1.5543	.0527	2.6853	.0303
51	7.61	7.6136	-5.9839E-03	-.1589	-.1573	.0606	3.0885	.0004
52	7.59	7.6019	-9.6268E-03	-.2546	-.2520	.0524	2.6716	.0008
53	7.58	7.5849	-2.4331E-03	-.0645	-.0638	.0576	2.9395	.0001
54	7.60	7.6447	-.0430	-1.1917	-1.1973	.1343	6.8474	.0429
55	7.69	7.6122	.0814	2.1557	2.2488	.0557	2.8391	.0627
56	7.70	7.6929	6.4064E-03	.1720	.1701	.0797	4.0638	.0005
57	7.73	7.7328	-6.8620E-03	-.1867	-.1847	.1035	5.2760	.0008
58	7.74	7.6852	.0546	1.4664	1.4855	.0818	4.1727	.0403
59	7.78	7.7438	.0399	1.0924	1.0948	.1166	5.9459	.0313
60	7.80	7.7664	.0328	.9100	.9082	.1384	7.0579	.0258

APPENDIX 8.1

Construction Price Model: Equation, Statistics
and Residuals Plotting

8.1.1 Analysis of Construction Price Equation 8.1: Statistics

```
**** MULTIPLE REGRESSION ****

Listwise Deletion of Missing Data

Equation Number 1    Dependent Variable..   TPI    CONSTRUCTION PRICE LEVEL

Beginning Block Number  1.  Method:  Enter

                                                  Lags
Variable(s) Entered on Step Number  1..   OIL   [1]  Oil Crisis Shock
                                    2..   RIR   [3]  Real Interest Rate
                                    3..   PRO   [2]  Productivity
                                    4..   STR   [4]  Construction Strike
                                    5..   MAN   [7]  Manufacturing Profitability
                                    6..   BCI   [0]  Building Cost Index
                                    7..   FRM   [5]  Number of Construction Companies
                                    8..   EMP   [2]  Unemployment Level
                                    9..   GNP   [0]  Gross National Product

Multiple R           .98577      Analysis of Variance
R Square             .97175                        DF      Sum of Squares      Mean Square
Adjusted R Square    .96583      Regression         9              .59539           .06615
Standard Error       .02006      Residual          43              .01731           .00040

                                 F =     164.32829      Signif F =  .0000

------------------ Variables in the Equation -----------------

Variable              B          SE B        Beta         T     Sig T

OIL             .061173      .013824     .150287     4.425   .0001
RIR             .002979  9.8909E-04      .172863     3.012   .0043
PRO           -.295796      .084654    -.149890    -3.494   .0011
STR             .008770      .003253     .108179     2.696   .0100
MAN             .541741      .232164     .163171     2.333   .0244
BCI             .807283      .238030     .147611     3.392   .0015
FRM           -.258239      .028617    -.688389    -9.024   .0000
EMP           -.135807      .029416    -.536081    -4.617   .0000
GNP             .605803      .164199     .462317     3.689   .0006
(Constant)    -3.613731      .941059                -3.840   .0004

End Block Number   1   All requested variables entered.
```

8.1.2 Construction Price: Actual, Predicted, Residuals and Statistics

Casewise Plot of Standardized Residual

Case #	ATPI	*PRED	*RESID	*SRESID	*SDRESID	*LEVER	*MAHAL	*COOK D
1	4.61	.	.	.	.	.	.	.
2	4.54	.	.	.	.	.	.	.
3	4.49	.	.	.	.	.	.	.
4	4.47	.	.	.	.	.	.	.
5	4.63	.	.	.	.	.	.	.
6	4.38	.	.	.	.	.	.	.
7	4.32	.	.	.	.	.	.	.
8	4.29	4.3032	-.0125	-.9448	-.9436	.5430	28.2357	.1145
9	4.32	4.2973	.0208	1.2106	1.2174	.2453	12.7559	.0526
10	4.27	4.2635	4.5742E-03	.2670	.2641	.2519	13.0998	.0026
11	4.27	4.2635	.0115	.6994	.6952	.3114	16.1951	.0241
12	4.27	4.2962	-.0239	-1.3222	-1.3342	.1700	8.8380	.0407
13	4.26	4.2970	-.0359	-1.9149	-1.9788	.1063	5.5272	.0525
14	4.28	4.2700	.0136	.8081	.8048	.2762	14.3614	.0273
15	4.29	4.2941	1.8094E-04	.0103	.0101	.2091	10.8712	.0000
16	4.25	4.2980	-.0529	-2.7969	-3.0561	.0939	4.8849	.0995
17	4.29	4.2849	5.8356E-03	.3267	.3233	.1885	9.7996	.0028
18	4.33	4.3060	.0252	1.5134	1.5372	.2922	15.1959	.1034
19	4.36	4.3471	.0110	.5986	.5941	.1458	7.5829	.0071
20	4.40	4.3853	.0101	.5548	.5502	.1559	8.1085	.0065
21	4.43	4.4127	.0204	1.1498	1.1542	.1992	10.3607	.0369
22	4.44	4.4413	-5.7456E-03	-.3269	-.3235	.2137	11.1104	.0032
23	4.47	4.4500	.0164	.9879	.9876	.2955	15.3647	.0447
24	4.50	4.5021	-3.7358E-03	-.2177	-.2152	.2494	12.9707	.0017
25	4.47	4.4842	-.0164	-.9501	-.9490	.2418	12.5742	.0318
26	4.45	4.4175	.0284	1.7205	1.7621	.3064	15.9337	.1427
27	4.43	4.4395	-8.2295E-03	-.5043	-.4999	.3196	16.6184	.0130
28	4.36	4.3548	7.4263E-03	.4374	.4332	.2650	13.7809	.0076
29	4.33	4.3192	6.7963E-03	.3852	.3814	.2079	10.8122	.0044
30	4.26	4.2678	-9.8569E-03	-.5320	-.5275	.1283	6.6712	.0049
31	4.23	4.2407	-8.5332E-03	-.4653	-.4611	.1458	7.5829	.0043
32	4.18	4.2243	-.0408	-2.2638	-2.3839	.1726	8.9736	.1213
33	4.22	4.2004	.0242	1.2695	1.2789	.0751	3.9035	.0167
34	4.18	4.1705	.0138	.7408	.7369	.1237	6.4304	.0091
35	4.15	4.1545	-8.9885E-03	-.4872	-.4828	.1355	7.0451	.0043
36	4.16	4.1503	5.6866E-03	.3036	.3003	.1094	5.6876	.0014
37	4.16	4.1824	-.0227	-1.2269	-1.2344	.1280	6.6582	.0259
38	4.14	4.1394	2.0802E-03	.1099	.1086	.0906	4.7100	.0001
39	4.12	4.1407	-.0159	-.8441	-.8412	.0978	5.0853	.0094
40	4.14	4.1272	.0150	.8689	.8664	.2426	12.6156	.0267
41	4.16	4.1502	7.3453E-03	.3878	.3840	.0901	4.6845	.0018
42	4.14	4.1374	3.7431E-04	.0197	.0195	.0845	4.3939	.0000
43	4.14	4.1417	-1.0520E-03	-.0579	-.0572	.1601	8.3248	.0001
44	4.16	4.1263	.0347	1.7900	1.8389	.0499	2.5947	.0237
45	4.15	4.1605	-.0118	-.6228	-.6183	.0948	4.9289	.0050
46	4.16	4.1363	.0250	1.3587	1.3726	.1405	7.3037	.0350
47	4.13	4.1348	-2.5147E-03	-.1370	-.1355	.1446	7.5188	.0004
48	4.16	4.1514	.0133	.7332	.7292	.1609	8.3662	.0118
49	4.13	4.1422	-.0147	-.7606	-.7568	.0568	2.9513	.0047
50	4.13	4.1210	9.1752E-03	.4743	.4699	.0514	2.6744	.0017
51	4.16	4.1291	.0267	1.4070	1.4237	.0838	4.3595	.0227
52	4.13	4.1391	-6.7555E-03	-.3538	-.3502	.0756	3.9335	.0013
53	4.16	4.1567	3.5487E-03	.1825	.1804	.0415	2.1561	.0002
54	4.13	4.1597	-.0286	-1.5030	-1.5261	.0792	4.1177	.0246
55	4.14	4.1673	-.0314	-1.7376	-1.7809	.1710	8.8911	.0708
56	4.20	4.1990	-2.4768E-03	-.1290	-.1275	.0658	3.4222	.0002
57	4.23	4.2342	-1.5733E-03	-.0852	-.0842	.1339	6.9630	.0001
58	4.23	4.2279	6.4035E-04	.0363	.0358	.2066	10.7431	.0000
59	4.25	4.2481	5.8251E-03	.3214	.3180	.1649	8.5772	.0023
60	4.24	4.2431	-2.5497E-03	-.1444	-.1427	.2067	10.7501	.0006

8.1.3 Analysis of Residuals: Residuals Statistics

	Min	Max	Mean	Std Dev	N
*PRED	4.1210	4.5021	4.2459	.1070	53
*ZPRED	-1.1671	2.3942	.0000	1.0000	53
*SEPRED	.0049	.0150	.0085	.0020	53
*ADJPRED	4.1203	4.5034	4.2456	.1068	53
*RESID	-.0529	.0347	.0000	.0182	53
*ZRESID	-2.6344	1.7274	.0000	.9094	53
*SRESID	-2.7969	1.7900	.0065	1.0038	53
*DRESID	-.0596	.0420	.0003	.0224	53
*SDRESID	-3.0561	1.8389	-.0006	1.0324	53
*MAHAL	2.1561	28.2357	8.8302	4.8206	53
*COOK D	.0000	.1427	.0236	.0347	53
*LEVER	.0415	.5430	.1698	.0927	53

Total Cases = 60

Durbin-Watson Test = 2.17220

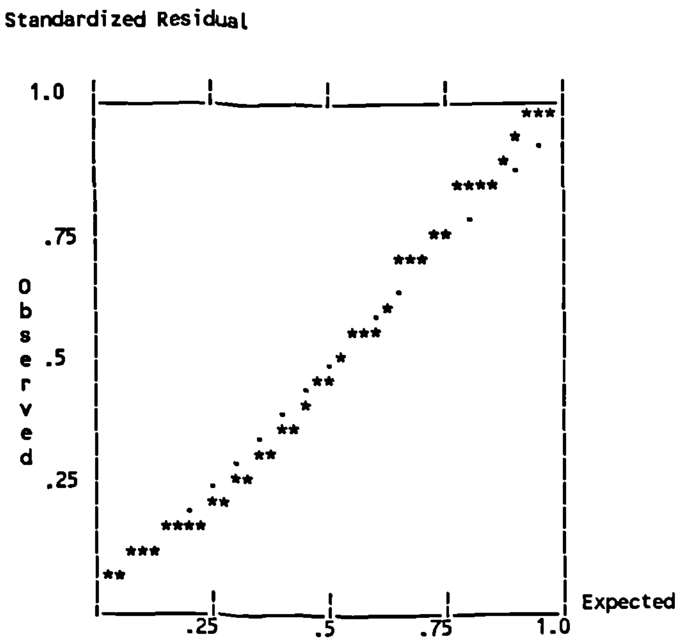
8.1.4 Analysis of Residuals: Outliers - Standardized Residuals

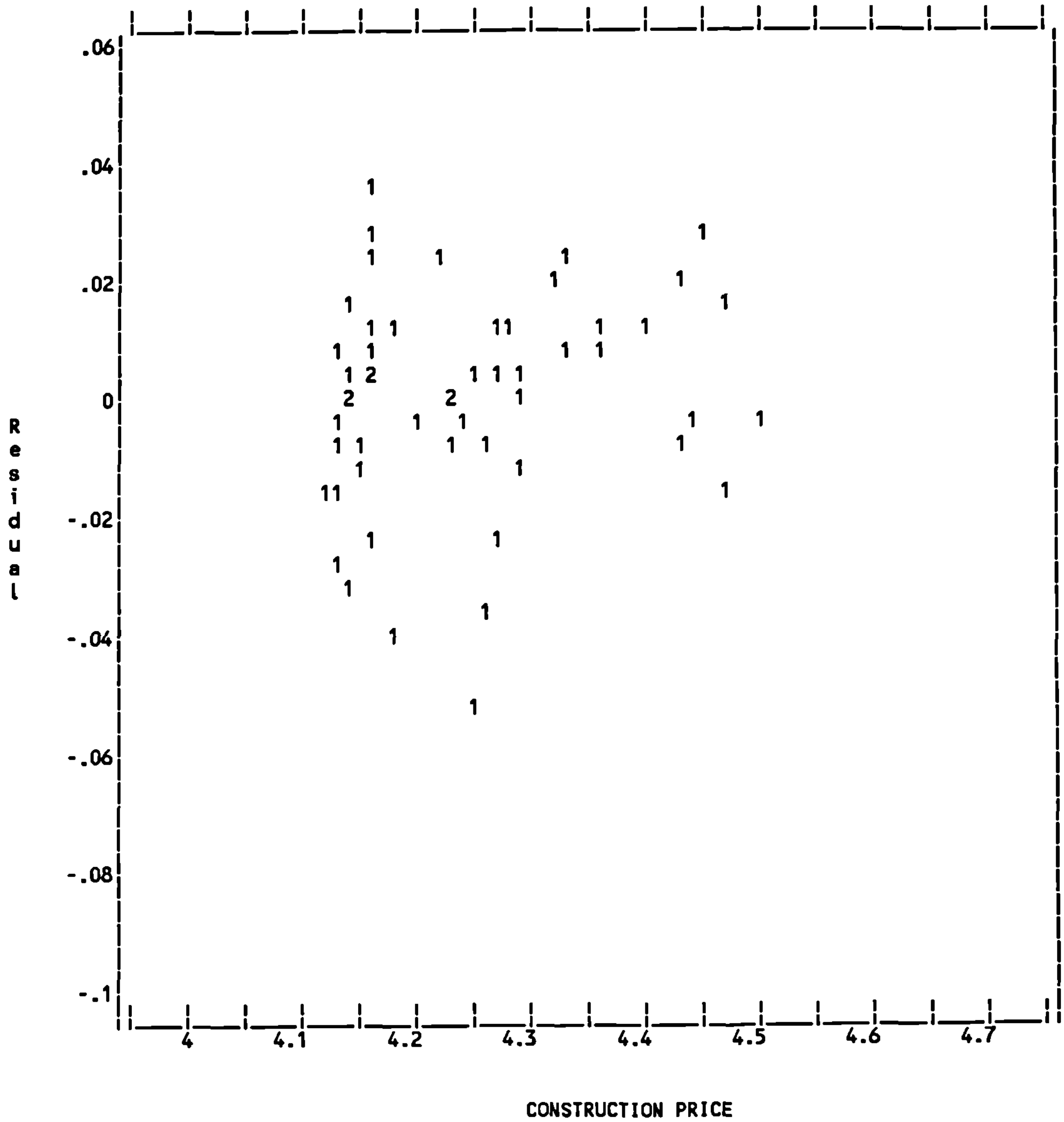
Case #	*ZRESID
16	-2.63442
32	-2.03563
13	-1.79110
44	1.72740
55	-1.56398
54	-1.42743
26	1.41324
51	1.33277
18	1.25609
46	1.24579

8.1.5 Analysis of Residuals: Histogram - Standardized Residual

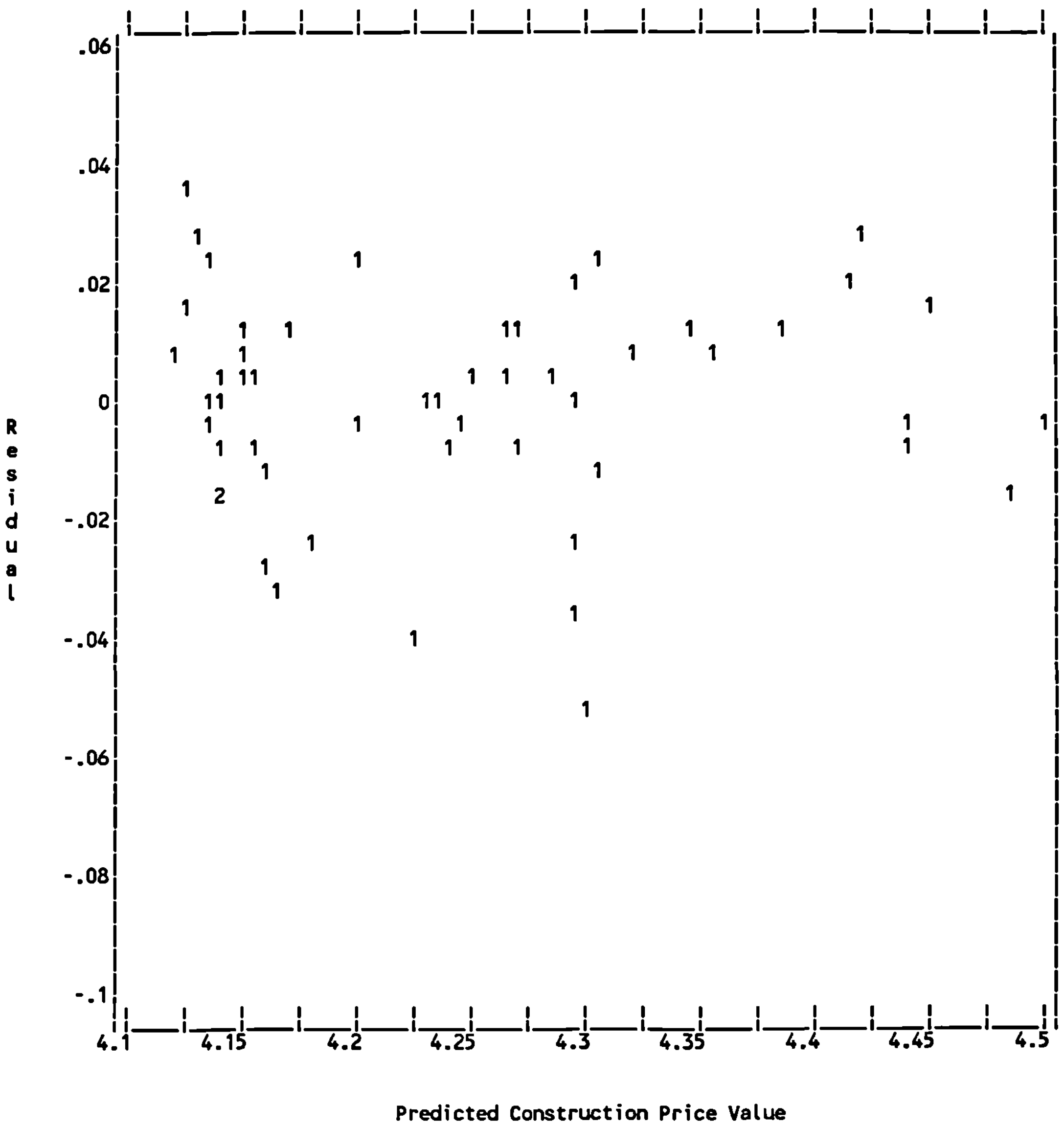
```
NExp N      (* = 1 Cases,     . : = Normal Curve)

0  .04   Out
0  .08  3.00
0  .21  2.67
0  .47  2.33
0  .97  2.00 .
1 1.77  1.67 *.
5 2.91  1.33 **:**
2 4.27  1.00 **  .
8 5.63   .67 *****:**
9 6.64   .33 ******:**
9 7.02   .00 ******:**
7 6.64  -.33 ******:
5 5.63  -.67 *****.
1 4.27 -1.00 *   .
2 2.91 -1.33 **.
2 1.77 -1.67 *:
1  .97 -2.00 :
0  .47 -2.33
1  .21 -2.67 *
0  .08 -3.00
0  .04   Out
```

8.1.6 Analysis of Residuals: Normal Probability Plot





8.1.7 Plot of Residuals against Construction Price (Tender Price Index)



8.1.8 Plot of Residuals against Predicted Construction Price

APPENDIX 8.2

Full Description of Polynomial relationships between
Construction Supply and Demand (Polys)

Poly31

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3})$$

Poly32

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3}) + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3})$$

Poly43

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3} + Q^d_{t-4}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3} + 4Q^d_{t-4}) + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3} + 16Q^d_{t-4}) + \phi_3(Q^d_{t-1} + 8Q^d_{t-2} + 27Q^d_{t-3} + 64Q^d_{t-4})$$

Poly53

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3} + Q^d_{t-4} + Q^d_{t-5}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3} + 4Q^d_{t-4} + 5Q^d_{t-5}) + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3} + 16Q^d_{t-4} + 25Q^d_{t-5}) + \phi_3(Q^d_{t-1} + 8Q^d_{t-2} + 27Q^d_{t-3} + 64Q^d_{t-4} + 125Q^d_{t-5})$$

Poly63

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3} + Q^d_{t-4} + Q^d_{t-5} + Q^d_{t-6}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3} + 4Q^d_{t-4} + 5Q^d_{t-5} + 6Q^d_{t-6}) + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3} + 16Q^d_{t-4} + 25Q^d_{t-5} + 36Q^d_{t-6}) + \phi_3(Q^d_{t-1} + 8Q^d_{t-2} + 27Q^d_{t-3} + 64Q^d_{t-4} + 125Q^d_{t-5} + 216Q^d_{t-6})$$

Poly73

$$Q^s_t = \alpha + \phi_0(Q^d_t + Q^d_{t-1} + Q^d_{t-2} + Q^d_{t-3} + Q^d_{t-4} + Q^d_{t-5} + Q^d_{t-6} + Q^d_{t-7}) + \phi_1(Q^d_{t-1} + 2Q^d_{t-2} + 3Q^d_{t-3} + 4Q^d_{t-4} + 5Q^d_{t-5} + 6Q^d_{t-6} + 7Q^d_{t-7}) + \phi_2(Q^d_{t-1} + 4Q^d_{t-2} + 9Q^d_{t-3} + 16Q^d_{t-4} + 25Q^d_{t-5} + 36Q^d_{t-6} + 47Q^d_{t-7}) + \phi_3(Q^d_{t-1} + 8Q^d_{t-2} + 27Q^d_{t-3} + 64Q^d_{t-4} + 125Q^d_{t-5} + 216Q^d_{t-6} + 343Q^d_{t-7})$$

APPENDIX 9.1

Forecasting - The State of Art

9.1.1 Measures of forecast accuracy

All measures of forecast accuracy compare the predicted values from either qualitative or quantitative forecasting models with those that were observed. The forecast error is represented by Eqn 9.1

$$e_t = y_t - \hat{y}_t \qquad \text{Eqn 9.1}$$

Where

e_t = forecast error
y_t = actual value
$\hat{y}_t$ = predicted value

To produce a reliable forecasting accuracy it is imperative that the forecast error does not exhibit a pattern over time. In other words, a condition of random distribution of errors is important in determining forecast accuracy.

Makridakis and Hibon (1984) have identified the most common measures of accuracy as comprising of mean square error (MSE), Theil's *U*-coefficient (Theil, 1966) and the mean absolute percentage error (MAPE). Other measures of accuracy (Holden and Peel, 1988; Treham, 1989) include root mean square error (RMSE), Mean Error (ME), mean absolute error (MAE) and graphical representation. All these, except graphical representation, are non-parametric measures of forecasting accuracy.

9.1.1.1 Mean Error (ME)

This tells more about the presence of bias - that is, differences in the average levels of actual and forecast values - than about the precision of estimates. It is arithmetic average that permits negative and positive error to offset one another and this is represented by Eqn 9.2 for all forecast.

$$ME = \frac{\sum_{t=1}^{n} (e_t)}{n} = \frac{\sum_{t=1}^{n} (y_t - y_t)}{n}$$

Eqn 9.2

9.1.1.2 Mean Absolute Error (MAE)

This is a better measure of the precision of forecasts by ignoring the signs of the forecast errors and considering only their absolute magnitudes. This is represented by Eqn 9.3.

$$MAE = \frac{\sum_{t=1}^{n} |e_t|}{n} = \frac{\sum_{t=1}^{n} |y_t - y_t|}{n}$$

Eqn 9.3

9.1.1.3 Mean Squared Error (MSE)

This is the most frequently employed measure of forecast accuracy. It is the average of the squared errors for all forecasts. This is represented by Eqn 9.4.

$$MSE = \frac{\sum_{t=1}^{n} (e_t)^2}{n} = \frac{\sum_{t=1}^{n} (y_t - y_t)^2}{n}$$

Eqn 9.4

9.1.1.4 Root Mean Squared Error (RMSE)

This has the same units as the ME and MAE, namely basis points. This is achieved by taking the root of Mean Squared Error (MSE) of forecast. The RMSE is, by mathematical necessity, always greater than the MAE when the forecast errors are not all of the same size. This can be expressed as a percentage of the mean of the variable and interpreted as the percentage error - RMSE(%).

9.1.1.5 Theil U^2 or Inequality Coefficient (U^2)

This statistic is the MSE divided by the mean of the squared actual levels. Like the RMSE or the MSE, U^2 attains its smallest possible value, zero, when forecasts are perfect, and it lacks theoretical upper value. The advantage of U^2 over the RMSE or MSE is that its denominator acts as a scaling factor to take account of the size of the variables to be predicted. This method which, weighs errors relative to the actual movements of the predicted variable, produces the most appropriate way to standardize for difference between different time intervals (McNees and Ries, 1983) or variables with different base years. Hence, U^2 is more useful in making comparisons of forecast accuracy across different forecast span.

9.1.1.6 Mean Absolute Percentage Error (MAPE)

The mean percentage error (MPE) is the mean of the difference between the actual values and the predicted values divided by actual values and expressed in percentage.

When the signs of the percentage forecast errors are ignored and absolute magnitudes are considered, the result got is the MAPE. This is represented by Eqn 9.5

$$\text{MAPE} = \frac{1}{n} \sum_{t=1}^{n} \frac{|e_t|}{y_t} (100) = \frac{1}{n} \sum_{t-1}^{n} \frac{|y_t - y_t|}{y_t} (100)$$

Eqn 9.5

9.1.1.7 Graphical Technique

This is the plot of actual values and predicted values based on models. This is the most straightforward method of evaluating the accuracy of forecasts. This shows the movements in actual values and predicted values and produces a convenient way of knowing if predicted values mimic the turning point in actual values.

9.1.2 Decomposition of Mean Squared Error (MSE)

The mean square error can be decomposed into several sets of statistics such that the sources of forecast errors can be identified. In this respect, Theil (1966) produces two ways of decomposing MSE.

The first is represented by Eqn 9.6.

$$\text{MSE} = (A - P)^2 + (S_A - S_P)^2 + 2(1 - r)S_A S_P \qquad \text{Eqn 9.6}$$

Where

A and P are means of actual values and predicted values respectively
S_A and S_P are their standard deviations
r is their correlation coefficient

The three components of MSE which, necessarily must sum to one can therefore be defined as:

$$\text{Bias proportion} = U^M = \frac{(A - P)^2}{MSE}$$

Eqn 9.7

$$\text{Variance proportion} = U^S = \frac{(S_A - S_P)^2}{MSE}$$

Eqn 9.8

$$\text{Covariance proportion} = U^C = \frac{2(1 - r)S_A S_P}{MSE}$$

Eqn 9.9

The second decomposition of MSE produces some insight into the possibility of linear correction of forecasts and is represented by Eqn 9.10.

$$MSE = (A - P)^2 + (S_A - rS_P)^2 + 2(1 - r^2)S_A^2$$ Eqn 9.10

The three components of MSE which, necessarily must sum to one can therefore be defined as:

$$\text{Bias proportion} = U^M = \frac{(A - P)^2}{MSE}$$

Eqn 9.11

$$\text{Regression proportion} = U^R = \frac{(S_A - S_P)^2}{MSE}$$

Eqn 9.12

$$\text{Disturbance proportion} = U^D = \frac{2(1 - r)S_A S_P}{MSE}$$

Eqn 9.13

This second decomposition is related to the regression of the actual values on the predicted values, using Eqn 9.13.

$$A = a + bP + E$$ Eqn 9.14

The coefficient a and b are estimated using OLS regression analysis or Eqn 9.15

$$b = \frac{rS_A}{S_P} \quad \text{and} \quad a = A - bP$$

Eqn 9.15

When predicted values fit actual values, $a = 0$ and $b = 1$.

Hence by regressing actual values on predicted values and using the resultant estimated coefficients as correction factors, the MSE of forecasts could be reduced to U^D times the MSE of the original forecast. This procedure is called optimal linear correction.

The possibility of significant improvement of forecast accuracy through this technique could be investigated based on F-test of the joint hypothesis that $a = 0$ and $b = 1$

9.1.3 Forecast accuracy and forecast horizon

It is a general consensus that the accuracy of a forecast of a given time span generally increases as the horizon of the forecast decreases (McNees and Ries, 1983). The reason being that the distance future is more uncertain. Most forecast based on cause-and-effect models assume that the future will, in some respects, be similar to the past. In the actual sense, in distance future, large changes are likely to occur in respect of most economic variables particularly in fast growing economy. Corroborative of this, Zarnowitz (1979) has inferred that the predictive value of forecasts more than a few quarters into the future diminish quite rapidly.

9.1.4 Mechanically generated model-based forecast

This is "pure model" forecast of economic variable of interest. This has been described by McNees (1985) as a tool for enhancing a forecaster's understanding of the economy and its history than as a substitute for careful analysis.

An important advantage of pure model results, based on specific sample period data, as processed through a model, is that these forecasts contain all information of systematic predictive value. That is, these results are systematic and are unadulterated.

However, mechanically generated model-based forecasts are based on two assumptions (McNees, 1985): that all information of predicted value is embodied in the specific data sample period on which the model is based and that the empirical regularities that the model identified in the sample period will continue to hold in the forecast period. As this is most unlikely to be the case, forecasters result to judgemental adjustment of model forecasts.

9.1.5 Adjustment of mechanically generated model-based forecast

Most published forecast of macroeconomic variables are judgemental adjusted forecast given the inherent limitations in constructing a system of equations that can reliably and completely represent a macroeconomic variable of interest. Forecasters are therefore, known to adjust their preliminary mechanically generated model-based predictions on the basis of information on a variety of factors (McNees and Ries, 1983). However, arguments for and against judgemental adjustment of model forecast varied. For example, Evans, Haitovsky and Treyz (1972), Haitovsky and Treyz (1972) have pointed to evidence that predictive accuracy of macroeconomics variable improves with such adjustment. On the other hand, Lucas (1976) and Sims (1980) have the opinion that such adjustments point to the fact that the mechanical models are incredible and provide no useful information. Evidence from McNees (1990) shows that the judgemental adjustment could have some impact on the forecast accuracy depending on macroeconomic variables under consideration. The conclusion from this work is that models and judgement are not mutually exclusive, and can be complementary. However, the circumstances where too much weight is placed on judgement and too little on the model has been described as "the major error of intuitive prediction" (Kahneman and Tversky, 1982)

This basis for most judgemental adjustments and factors considered include the followings:

1. availability of recent economics data and data revisions; for example the incoming new data may indicate that the forecast based on historical data is likely to be wrong.
2. past errors;
3. feedback from forecast users;
4. anticipated events outside the structure of the model;
5. predictions of other forecasters; and
6 purely subjective (based on forecaster's preconceptions) - in this case the forecaster may see the forecast from models as being unreasonable for no stated reason etc.

Anticipation of events outside the model deals with identification of ways in which the future is likely to differ from the past such that their probable future impact can be incorporated into forecasts.

The survey by McNees and Ries (1983) indicates that the mechanically generated model-based forecast framework and the forecasters' adjustment is a two-way interaction. The mechanically generated model-based forecast provides insight into necessary adjustment while also a forecaster may decide to override the model forecast results. In essence, final or published forecasts are combined results of model prediction and judgemental adjustment. McNees, 1989, however describes forecast as a complex interaction among the model, the input assumptions and forecaster's judgemental adjustments. The input assumption is the conditioning information used to generate a model forecast while the judgemental adjustment is incorporated through extra-model information. Most often the judgement reflects the particular interests, knowledge, and experience of the forecaster