# Models of UK private sector quarterly construction demand

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# MODELS OF UK PRIVATE SECTOR QUARTERLY CONSTRUCTION DEMAND

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**ABSTRACT**

*An analysis is made of private sector construction demand (quarterly new orders) grouped into housing, commercial and industrial construction respectively, and their relationship with a priori selected leading indicators of GNP, price level, real interest rate, unemployment and manufacturing profitability over the period 1974 to 1988. The results indicate that different variables explain the trends in these private sector construction demand sub-sectors. While construction price appeared to be an important elastic influence in housing investment, it was not found to be an important factor in respect to commercial and industrial construction. Trends in commercial and industrial constructions are explained by manufacturing profitability and economic conditions. The level of unemployment influences commercial construction only and with a negative inelastic relationship. Lead indicator forecasts of the groupings of private sector investment are above 10 percent of accuracy due to the unusual deep cut in private construction as a result of the recession although the models except increasing trends in these series. The implication of this level of accuracy is the need to investigate further variables for inclusion in the models to track the cut in private sectorial construction demand. This work is currently being*

*undertaken at the University of Salford through the financial support of the Science and Engineering Research Council.*

**Keywords:** Construction demand, private sector, price, unemployment, GNP, interest rate, forecasting.

**INTRODUCTION**

Knowledge of future demand for products and services is vital to all industries. It is prerequisite for any viable corporate strategy. Construction contractors need some knowledge of likely changes in demand for their services and the extent to which this will affect their workload in order to formulate appropriate pricing strategies (Carr and Sandahl, 1978). Indeed, as Lansley *et al* (1980) have shown, lack of strategic action can be fatal in times of falling workloads. Clearly, the earlier a contractor knows of likely changes in demand, the better he is placed to take strategic action.

Fortunately, changes in construction industry activity often follow similar earlier changes in the activities of other industries, especially those of the manufacturing industry, which are more immediately responsive to changes in the general economy of the country. Also, it is well known that construction demand is still very much influenced by the actions of the government. This has caused construction firms to examine government annual budgets and possible ramifications on private sector construction investment.

There are many possible causes of changes in construction demand, such as Gross National Product (GNP), real interest rate and unemployment. What is needed is a model or formula that will somehow combine these leading indicators for the purposes of explaining trends in construction demand. To identify potential indictors however, it is important to examine the nature of the investment that leads to the demand for construction.

The demand for construction work is broadly divided into two sectors: public and private (HMSO, 1989). The relative demand for these two sectors has varied considerably in recent years. Figure 1 shows the ratio of UK private and public sector construction demand (in terms of new orders) over the period 1974 to 1988 which clearly indicates an increasing level of private to public investment over the period, particularly when new housing is considered. Substantial increases have occurred in private sector investment generally in recent years, and public expenditure on construction work has declined, as the economy has moved into a freer market. In view of this trend, a trend that seems likely to continue at least during the term of the present government, it is appropriate to consider the nature of private sector demand.

In this paper, the literature is reviewed concerning construction investment, its trends in the UK, the likely factors affecting private sector investment, economic conditions, construction prices, real interest rates, unemployment levels and profitability. From this a causal model is proposed for each of the three major sectors of the construction industry - housing, commercial and industrial. The models are fitted by a standard ordinary least squares (OLS) step-wise multiple regression with different leads on each independent variable. The resulting parameter estimates are examined and found to be generally in accord with the literature. The forecasting accuracy of these models is examined within sample (1974 first quarter to 1988 fourth quarter) and *ex post* (1989 first quarter and 1991 fourth quarter).

The results provide a structural indication of important variables associated with the different private sector construction demand levels and their lead relationships.

## LITERATURE REVIEW

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. GNP 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). Investment undertaken primarily because of a 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 can bring about growth due to its multiplier effect on the economy. In developed countries, however, most investments in construction are regarded as growth-dependent, which makes construction investment a derived demand.

## Trends in UK Construction Investment

Figures 2, 3 and 4 clearly show the fluctuation in the construction investment between 1974 and 1988 (HMSO, 1989). Figures 2 and 3 show the investment by construction type at current and real prices (1974 rebased) respectively. Figure 4 shows the shares of the construction type in the total quarterly construction investment within this period.

Except private sector industrial work, none of these investment types have been stable over the years. There have been large fluctuations in the share of individual construction types, notably the rising share of private sector commercial work and housing, and a 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 relatively stable.

Changes in the pattern of investment in various construction types over the period is likely to be associated with changes in government policies. There has been a move towards a freer market economy and greater emphasis on private investment. The increase in the private sector new housing in the 1980s compared with the 1970s was most probably a result of 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. That there is currently a slump in private sector construction investment is probably due to the current domestic and international recessions.

**Factors influencing private sector construction demand**

Economic theory regarding free market enterprise 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. General factors are political, economical, social, technological, and legal/legislative based. Local factors include a combination of building types, procurement types and geographical location (Skitmore, 1987). The consensus in the construction industry is that the interest rates and general business confidence have the greatest bearing on private sector workloads (Beard Dove, 1991). Hillebrandt (1985), however, has extended this to the following list of general leading indicators of construction demand:

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) to be the most significant leading indicators of construction demand.

For the UK, the general factors of construction demand are grouped into the following: economic conditions, construction price, real interest rate, unemployment level, and profitability.

**Economic conditions**

A trend measurement of economic condition is a trade cycle. The construction cycle is closely linked with the general business cycle (Tan, 1989). A single indicator of economic conditions is national income. 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 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 work 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 real GNP growth with growth in expected sales and consequently growth in investment spending.

**Construction price**

The relationship between the demand and price is a recurring theme in the economic literature. 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 the demand for construction may depend on the relative price level of construction. A common measure of trends in price in the construction industry is the tender price index, which measures the trends in the cost of construction to construction clients and reflects the trend in the accepted tender prices.

**Real interest rate**

Real interest 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.

Investment in construction is 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 rate 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.

The real interest rate also reflects an unobserved variable - the real cost of funds. In this sense a rise in the real cost of funds may be implied as a result of the rise in nominal interest rate and fall in inflation. This rise in the cost of funds is likely to cause a declining capital investment unless offset by other economic variables such as a fall in real investment prices and cuts in taxes.

**Unemployment level**

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 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, 1991). In the USA for example, there is a negative relationship between unemployment and construction investment which, outweighs the beneficial effects of investment tax cuts (Anonymous, 1982).

**Profitability**

The manufacturing price/cost ratio could be used as a proxy for the profitability in view of the general importance of the manufacturing industry in the private sector general consumption pattern. The importance of the manufacturing sector is recognised by Hillebrandt (1985) regarding surplus manufacturing capacity and expectation of continued increased demand for manufacturing goods as they affect construction investment. Therefore, 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 as increased pay to personnel and increased returns to shareholders, encouraging increased spending on housing or other forms of construction works associated with private sector.

**MODEL STRUCTURE**

Causal relationships in econometric models have to be derived from some relevant theory, while the strengths of such relationships are often estimated empirically by various econometric techniques. Five variables are posited in this study as potential leading indicators of construction demand - GNP, price level, real interest rate, unemployment and manufacturing profitability. The strengths of relationships were estimated by a multiple regression technique.

For each sectorial demand *J*, the following economic specification was estimated:

$$Q_j^d = f(P_t, Y_t^d, r_t, U_t^e, M_t^p) \quad \textbf{(1)}$$

where

$Q^d$ = Construction demand

$P$ = Construction price

$Y^d$ = GNP

$r$ = Real interest rate

$U^e$ = Unemployment level

$M^p$ = Manufacturing profitability

$t$ = Time lead (quarterly)

$j$ = Private sector construction demand (Commercial, Industrial and Housing)

Elasticities of response of the dependent variable to independent variables are a point of interest in this study. The elasticity of the dependent variable with respect to (in response to a change in) an independent variable is defined as the proportionate change in dependent variable in response to a tiny proportionate change in independent variable (Hebden, 1981).

In this case, equation (1) was expressed as log-linear or double-log as shown in equation (2). Double-log in the sense that both the dependent and independent variables have been expressed in natural logarithm.

**(2)**

Apart from the need to determine elasticities, the raw independent variables were transformed as they exhibited non-linear scatter when plotted against the dependent variable.

**Analysis**

The method of analysis was based on the OLS multiple regression and anticipates lead relationships between the dependent and independent variables. From *a priori* considerations, there was no reason to believe that one time period alone, would exert the influence of all the past changes in an independent variable. Therefore, distributed lag relationships between the independent variables and private sector construction demand were envisaged. However, *a priori* restriction of finite lag distribution was adopted for two reasons: (1) it was expected that the influence of a change in a factor on the private sector construction demand would be completed after a finite period, that is, there is a finite maximum lag; (2) the total maximum lag length (that is, the number of parameter to be estimated) may be so large relative to the sample size, that too many degrees of freedom may be lost.

Initially, Almon lag transformations were considered but rejected due to the five possible leading indicators of construction demand being considered. The equations were eventually estimated based on OLS lag distribution using Stepwise Selection Method analysis. A maximum lag of 8 quarters was used as this was considered a long enough period for the influence of a change in a factor on the private sector construction demand to be completed. To this effect, nine in-sample data (zero to eight quarters lead) data were created for each of the variables - a total of 45 variables - producing a revised model in the form:

**(3)**

Equation (3) was estimated on quarterly, unadjusted data over the period 1974 to 1988. The variables that enter and remain in the regression equation are determined by stepwise regression analysis criteria (probability of F-to-enter = 0.05, probability of F-to-remove = 0.10). Using this method, few variables were selected that meet the stepwise regression analysis criteria. The equations were then re-estimated using only the selected variables.

This method of analysis is not unusual in economic analysis. Burridge *et al* (1991) for instance, state that it is commonplace for economic theory to specify the economic relationships with the precise quantification of the lag distribution being best left to the data. On the other hand, this method of analysis is expected to show us which of the *a priori* variable relationships may be found unsupported by the data.

**Results**

As a result of the model fitting process, using quarterly data (see quarterly data and sources appendix) from the first quarter of 1974 to the fourth quarter of 1988, equation (3) was completely specified for each of the demand sectors as follows:

*(1) Private Sector Housing Construction Model* (PRHG)

$$PRHG = \underset{(0.892)}{-13.400} + \underset{(0.704)}{2.287}\, r_{t-6} + \underset{(0.198)}{2.442}\, Y^{d}_{t-1} - \underset{(0.281)}{2.207}\, P_{t-3}$$

$R^2 = 0.970$ $\quad$ $R^2$ Adjusted = 0.937

SEE = 0.151 $\quad$ F = 264.1

d.f = 3, 50 $\quad$ DW = 1.647

*(2) Private Sector Commercial Construction Model* (PRCM)

$$PRCM = \underset{(1.928)}{-31.908} - \underset{(0.460)}{1.381}\, r_{t-1} + \underset{(1.048)}{2.683}\, M^{p}_{t-4} + \underset{(1.062)}{1.795}\, M^{p}_{t-5}$$

$$+ \underset{(0.096)}{1.802}\, Y^{d}_{t-8} - \underset{(0.008)}{0.454}\, U^{e}_{t-7}$$

$R^2 = 0.991$ $\quad$ $R^2$ Adjusted = 0.980

SEE = 0.090 $\quad$ F = 492.7

d.f = 5, 46 $\quad$ DW = 1.762

*(3) Private Sector Industrial Construction Model* (PRID)

$$PRID = \underset{(1.892)}{-7.125} + \underset{(0.074)}{0.856}\, Y^{d} + \underset{(0.339)}{0.801}\, M^{p}_{t-4}$$

$R^2 = 0.845$ $\quad$ $R^2$ Adjusted = 0.703

SEE = 0.246 $\quad$ F = 66.2

d.f = 2, 53 $\quad$ DW = 1.372

(The figures in parentheses denote the standard error, SEE is the equation standard error, d.f. is the degree of freedom, Estimated period: 1974-1988).

The independent variables tested for possible inclusion in these models were the price level, GNP, real interest rate, unemployment and manufacturing profitability. PRHG indicates that demand is negatively correlated with price level and positively correlated with GNP and real interest rate. The relationships with unemployment and manufacturing profitability are unsupported by the data. The total variation in private sector housing construction demand is highly explained by the variations in these three variables ($R^2 = 0.968$). PRCM indicates that the private sector commercial construction trends can be explained by the trends in real interest rate, manufacturing profitability, gross national product and unemployment level. This model of private sector commercial construction demand has some intuitive appeal from a theoretical viewpoint (*in terms of signs*) and statistical viewpoint (adjusted $R^2 = 0.98$). The Durbin-Watson (*DW*) statistic of 1.76 indicates, by Stewart's (1984) criteria, a lack of autocorrelation.

For private sector industrial construction demand PRID, the positive relation with GNP and manufacturing profitability does seem to have theoretical basis. Contrary to our expectation, relationships with unemployment, real interest rate and construction price are not supported by the data. The stepwise method regression analysis indicates that the t-values of these variables are not statistically significant at the five percent level. The adjusted $R^2$ value of this model is also relatively low (0.703).

In general, the models, except commercial construction demand, fail to support a distributed lag structure, which is contrary to our expectation.

**Discussion**

The models produced for the three groupings of private sector construction demand seem satisfactory as they have some intuitive appeal besides being statistically significant.

From this analysis it is clear that housing construction demand is responsive to changes in price level unlike the commercial and industrial construction demand. This suggests that private sector housing demand may increase with elastic response (all else being equal) to a given fall in the price level. The instantaneous response of housing demand to changes in GNP at lead period *t=1* tends to support the importance of national income or economic conditions on private sector investment in housing. A period of declining economic conditions provides little or no incentive to private sector speculative housing construction.

Private sector industrial construction investment has a positive inelastic relationship with GNP. Again, the instantaneous response tends to support the importance of national income or economic conditions in private sector industrial investment. This coincidence between the industrial construction demand and GNP is not surprising. Private industrial construction is a derived demand resulting from consumers' and firms' demand for final and intermediate products and technological requirements for capital as input to the production process. This means that industrialists will depend on the expected sales signals. If sales are expected to rise relative to current capital stock, firms may have to invest in new capital to meet the increased output demanded. This result is consistent with near coincidence of peak and slump investment years; and the peaks and troughs of real GNP between 1950 and 1976 in USA studies (Gordon, 1984).

Unemployment is negatively and inelastically related to private sector commercial construction investment with lead period $t=7$. This has two implications: (1) increasing unemployment has a declining effect on commercial construction investment generally and (2) changes in unemployment in an economy is good indicator of the trend in commercial construction investment.

Manufacturing profitability is only relevant to private sector commercial and industrial construction investment. In the two cases (commercial and industrial construction) the lead period is $t = 4$ or $5$ indicating that manufacturing industry activity leads the private sector investment in commercial and industrial construction by around one year. High profitability in manufacturing sector is eventually filters into construction as further investment in capital projects.

Real interest rate has a negative relationship with commercial construction with lead period ($t=1$) and an unexpected positive relationship with housing construction (lead period $t=6$). The positive relationship with housing construction is unexpected as this determines the cost. This may imply one of three things:

1. The effect of interest rates is outweighed by economic conditions and construction prices at a later date. This is indicated by Model PRHG having significant relationships with GNP at lead period t=1 and construction price at lead period t=3.

2. The lead period for real interest rate (t=6) is more than what is observable. Interest rates may have a more immediate impact than is suggested by the analysis. Easton (1990) shows that real interest rates have an immediate negative effect on residential investment and over a long time period the impact tends to be zero.

3. The econometric specification of private construction housing demand differs from the specifications for other types of provate sector construction demand. A similar econometric specification by Buyst (1989) shows that the Belgian private housing investment is determined by national income, ratio of price of rent index and index of construction cost, real interest rates on morgtages and a dummy variable to incorporate the threat of war. this analysis is based on annual data. Although the analysis shows a negative relationship between real interest rates and housing investment, the impact of the real interest rate on housing investment is instantaneous (t=0). Like

our own model, demographic variables such as population, number of families, etc., that one would expact to feature in housing demand functions are not significant in the model.

The general impression is that these models could form a basis for forecasting sectorial construction demand provided reliable estimates of the parameters can obtained sufficiently in advance for useful forecasts to be made.

## DEMAND FORECASTING

The models may be used in two contexts, (1) to **explain** past movements and (2) to **forecast** future movements of an endogenous variable. Attention is focused here on the forecasting behaviour of the models. The motivation for investigating forecasting behaviour is that if a model could be developed to estimate the relationship between the sectorial demand and exogenous variables that is statistically and theoretically acceptable, the model could also be used to forecast sectorial construction demand.

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 estimate 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.

*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). The work described in this paper was focused at the *ex post* simulation period and the *ex post* forecast period.

All measures of forecast accuracy compare the values forecast by the models with those that were actually observed. Here the forecast error is used, ie., the difference between actual and forecast values, expressed as a percentage of the actual value.

A non-parametric approach to the evaluation of forecasting behaviour was adopted. Three typical non-parametric methods of assessing forecasting accuracy are:

a. Mean percentage error (MPE), which is the mean of the differences between the actual and the predicted values divided by the actual values and expressed as a percentage. This provides a measure of the bias in the forecast.

b. Mean absolute percentage error (MAPE), which is a measure of the precision of forecasts and considers only the absolute magnitudes of the errors.

c. Root mean squared error (RMSE) as a percentage of the mean of the variables. The mean of the variables is the mean of the values of the dependent variable over the forecasting period. The RMSE is interpreted as the percentage error.

**Results**

Tables 1 and 2 summarise the forecasting accuracy for the *ex post* simulation period, estimate period 1976:1 to 1988:4 (52 quarters) and *ex post* forecast period 1989:1 to 1990:4 (120 quarters). MPE describes both the magnitudes and sign patterns of the forecast error, while only the magnitudes are described by MPAE. The standard deviation provides a measure of the consistency of the forecasts.

The MPE shows that all the models are positively biased in the *ex post* simulation period, with the private sector commercial work model (PRCM) producing the best result in terms of MPE and standard deviation. PRCM also produced the best accuracy based on MPAE and RMSE% criteria.

The *ex post* forecasting accuracy results given in Table 2 show a positive bias in respect of private sector Housing (PRHG) and commercial work (PRCM) models. However, private sector industrial model (PRID) exhibit systematic negative bias, that is, it consistently underestimated private sector industrial demand.

The RMSE for the models is less than 15 percent within the sample period and generally poor for the *ex post* forecast period.

**Discussion**

The performance of the private sector construction demand models in the *ex post* forecast period is generally poor and unexpected. However, forecasting models are known to retain their accuracy beyond the estimate period only to the extent that the behaviour of the economic environment does not change significantly between the two periods (Bechter and Zell, 1979). Business confidence in the economy has been very low in recent years starting from the *ex post* forecast period, and organisations are failing to respond to historical economic signals. Many projects have been postponed or abandoned before tendering stage due to misapprehensions concerning future economic conditions.

Rational expectations of future economic conditions is an aspect of investment decisions that has not been built into this model, inclusion of which may have countered the models' over-estimation of private sector *ex post* forecast of demand.

Another explanation for the *ex post* poor performance of the private sector construction demand models between 1989:1 and 199:4 is the "shock" created by the economic recession at that time. While in principle the models should incorporate the effects of the recession through unemployment and real interest rates, the recession occurred more rapidly than predicted by the models as evidenced by the models' over-prediction of private sector demand. In some case the models didn't support the inclusion of these variables (unemployment and real interest rate) as accounting for the effect of recession.

It should be said however, that the forecasts produced by these models are generated by purely mechanically means. The need to incorporate subjective judgement into a model is likely to be advantageous (see Beltramo, 1988, for example). It is possible that the values produced by a mechanically generated model-based system such as this may be improved by expert adjustment considering such factors as economic "shock", rational expectation of organisations and business confidence level in the economy. As the primary purpose of the models is to support a decision at some level they are a means to an end. There is no reason not incorporate some expert subjective judgement into the procedure. The poor performance of the *ex post* forecast may not necessarily warrant this.

## CONCLUSION

Using quarterly data, both private sectors of construction demand for housing, industrial and commercial works are estimated.

The results indicate that

1. private sector construction demand generally is not responsive to construction price levels except private sector housing works.

2. private sector commercial building demand responds immediately to changes in real interest rates.

3. unemployment is negatively correlated with, and a good leading indicator of, commercial construction demand only.

4. manufacturing industry profitability is positively correlated with commercial and industrial construction demand and leads construction investment by four quarters.

Although additional research into the dynamism of the relationships is needed, the results are generally consistent with our intuitions and established economic theory. Also, the adjusted $r^2$ values of between 0.703 and 0.98 for the three models examined are particularly encouraging.

From a practical viewpoint, understanding these relationships is likely to help in the management of construction firms through the development of private sector construction demand forecasts. The unusually rapid declining construction investment after 1988, compared with the construction investment spending boom up till then, due to the severe recession is the most likely explanation of the rather poor forecasting performance of these models. The next stage of this work will be aimed at explicating the roles of the explanatory variables involved and to investigate further variables that could be included to improve the accuracies of this model. This investigation is being funded by SERC grant at the University of Salford in collaboration with the Department of the Environment.

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# APPENDIX A: QUARTERLY DATA AND SOURCES

**QUARTERLY DATA AND SOURCES**

$Q^d$ Quarterly construction new orders (Construction new orders considered in this paper are private sector industrial (PRID), commercial (PRCM) and Housing (PRHG)). This is a measure of construction demand. Other measures of construction demand include value of building approvals (Runeson, 1988) and gross floor area of construction start (Tan, 1989).

Source: HMSO 1974-1989 "Value at current prices of New-order obtained" *Housing and construction statistics*, December, Part2 pp. 4.

$P$ Quarterly Tender price index (TPI). This measures the trend of contractors' price levels in accepted tenders for new works.

Source: *Building Cost Information Service* (BCIS), 1990 "Indices -introduction" Building cost information service manual. Section ABb6, June.

$Y^d$ Quarterly gross national product (GNP). This measures the actual and the expected changes in sale. When the sales is expected to accelerate, investment increases.

Source: *Economic Trend* annual supplement, 1989 Edt, pp.12.

$r$ Real rate of interest. This is calculated from the nominal interest rate (BBR) and the rate of inflation (FLA) as measured by the quarter to quarter change in retail price index.

Source: (for quarterly nominal interest rate and inflation rate) *Datastream International Ltd On-line*, A company of Dun and Bradstreet corporation.

$M^p$ Manufacturing output price/input cost ratio (MANU). This is used as a measure of profitability of this sector of an economy.

Source: *Datastream International Ltd* On-line, A company of Dun and Bradstreet corporation.

$U^e$ Unemployment (UNEMP) - Unemployment figures refer to numbers claiming unemployment-related benefit at Unemployment Benefit Offices.

Source: *Economic Trend Annual Supplement*, 1990 Edt., pp.112-114.

# APPENDIX B: DATA

TABLES AND FIGURES

*Table 1: Ex post simulation: estimation period 1974:1 to 1988:4 (60 quarters)*

| | PRHG | PRCM | PRID |
|---|---|---|---|
| MPE | 1.23 | 1.05 | 1.24 |
| Std Dev | 15.02 | 11.21 | 16.08 |
| RMSE% | 13.84 | 12.85 | 13.03 |
| MPAE | 12.75 | 7.30 | 11.07 |
| Std Dev | 8.75 | 8.53 | 11.62 |

*Table 2: Ex post forecast period 1989:1 to 1991:4 (12 quarters)*

| | PRHG | PRCM | PRID |
|---|---|---|---|
| MPE | 46.4 | 50.8 | -9.9 |
| Std Dev | 36.0 | 37.7 | 14.9 |
| RMSE% | 44.7587.4 | 21.9 | |
| MPAE | 43.3 | 51.7 | 13.4 |
| Std Dev | 32.5 | 36.8 | 11.7 |

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